IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received December 25, 2019, accepted February 16, 2020, date of publication February 28, 2020, date of current version March 11, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.2977060

An Empirical Study of the Acceptance of IoT-Based Smart Meter in Malaysia: The Effect of Electricity-Saving Knowledge and Environmental Awareness

GAMAL ABDULNASER ALKAWSI, NOR'ASHIKIN ALI, AND YAHIA BAASHAR
College of Graduate Studies, The Energy University (UNITEN), Kajang 43000, Malaysia

Corresponding author: Gamal Abdulnaser Alkawsi (jamalmail@gmail.com)

This work was supported in part by The Energy University (UNITEN), Malaysia, through YCU Research, under Grant 201901001YCU/22, and in part by the the Innovative Research Management Center (iRMC) UNITEN.

ABSTRACT Today's increasing demand for electricity requires solutions that better align with energy demand and supply. Innovative technological solutions such as smart metering applications are gaining popularity among electricity providers. Despite numerous benefits, smart meters, a part of the technology on the Internet of Things (IoT), continue to struggle for widespread consumer acceptance due to limited knowledge on electricity savings and environmental awareness. These factors were examined in isolation and have not been theoretically incorporated or examined. Hence, this study investigates the factors that influence residential consumers' acceptance of smart meters by integrating electricity-saving knowledge and environmental awareness with the second generation of "unified theory of acceptance and use of technology" (UTAUT2). The literature revealed an important link between users' behavioural intention and users' use behaviour. Well-established theories of acceptance like "technology acceptance model" (TAM) and UTAUT, incorporate the behavioural intention variable in the nomological network of technology adoption determinants. This study highlighted the impact of users' behavioural intention on users' use behaviour, which was not examined previously by any of the smart meter acceptance models. The data were collected from 318 consumers of residential smart meters in Putrajaya and Malacca, the cities in Malaysia, and were statistically tested using SME-PLS The study confirms that adding electricity-saving knowledge and environmental awareness to the UTAUT2 leads to a significant increase in the explained variance in consumer acceptance of smart meter.

INDEX TERMS Acceptance model, IoT, smart meter, UTAUT2.

I. INTRODUCTION

The components of the power grids are connected to form smart grids via communication networks that use sensors and the Internet. The smart meter is a vital component of smart grids. The smart meter has been introduced to the public as an alternative to traditional electricity meters. Traditional electricity meters must be separately inspected by metering workers from the energy provider companies. On the other hand, smart meters that employ the Internet of Things (IoT) technology enable consumers to monitor and regulate energy consumption remotely and get accurate automated meters [1], [2]. Smart meters can promote extensive and economical customer involvement in the utility segment and increase the involvement of the end-user in energy conservation [3]–[5]. Besides that, smart meters can support a wide range of goals geared toward reducing climate change and provide energy security. Therefore, the rise of smart meters has gained wide attention [6]. Driven by various initiatives, such as liberalised markets, market competition, service quality, operations, and customer choice, utility providers are investing in smart meter systems [7], [8] to facilitate and promote energy-efficient lifestyles by reducing CO2 emissions and energy consumption, as well as increasing renewable energy. A report on smart meter deployment stated the number of installed smart meters has increased by over 100 per

The associate editor coordinating the review of this manuscript and approving it for publication was Guangya Yang.

cent from 2012 to 2013 across 35 countries in Southeast Asia, Latin America, Central/Eastern Europe, Eurasia, South Africa, and the Middle East/North Africa [9].

Meanwhile, in Malaysia, the first phase of the smart meter programme arrived upon 1000 effective rollouts of smart meters in 2016. Tenaga Nasional Berhad (TNB), the major energy suppliers in Malaysia, plans to install smart meters in 8.3 million homes all over the nation by the year 2021. Additionally, TNB reported the low usage rate of the smart meter application in its smart billing project [10]. Statistics from systems' logs indicated that only 10 per cent of the users actively and regularly used the service. The low usage rate of the application is an indication of the users' low acceptance level of using smart meter systems. While many technological developments benefit society, sometimes they introduce new risks [11] that are generally influenced by public controversies and concerns [12]. For example, consumers' backlash against smart meter deployment can be incited by issues such as privacy violation, influence on physical wellbeing due to radiation from the radio frequency of smart meters, and higher utility bills [13]. Negative reactions from consumers may impede the implementation of smart meters, as seen in the United States and several European countries [14]–[18]. Because consumers are the actual end-users of the systems, their acceptance has a major impact on the effective implementation of smart meter systems. Therefore, a deeper insight into the factors that contribute to consumers' acceptance can facilitate the widespread implementation of smart meters and realise all their potential benefits. Furthermore, the proactive effort to address consumers' concerns may deter utility companies from bearing costly consequences of rejection and backlash by consumers after installation, which may result in a slow diffusion of the new technology. When attempting to predict users' acceptance toward smart meters, it is very important to consider the related attributes of environmental awareness and electricity-saving knowledge that could affect the acceptance of several meters. For example, several scholars have suggested that environmental awareness [19]–[21] could affect the users' acceptance of smart meters, while other scholars have suggested that electricity-saving knowledge [22]–[24] would have an effect on users' acceptance of smart meter. However, these constructs were examined in isolation and have not been theoretically incorporated. Furthermore, the findings of the effect of these constructs on the acceptance of smart meters were inconsistent and required further research.

Hence, this study aims to investigate the factors that influence the acceptance of smart meter systems in Malaysia, specifically Putrajaya and Malacca as the residentials of these cities have installed the IoT-based smart meters. The underlying theory for this study is UTAUT2 [25], a theory that has been developed to adapt the first generation theory pertaining to users' use behaviour. For this purpose, the UTAUT2 model has been modified and extended to include the two factors of environmental awareness and the knowledge of electricity-saving. These are integrated within the variables of UTAUT2 such as performance expectancy, effort expectancy, social influence, habit, and facilitating conditions. These extensions of the UTAUT2 promote the generalisability of the UTAUT2 model to different technologies, which, in this case, is the users' use of smart meters. This study may enhance the understanding of consumers' readiness to accept smart meters hence, become a guide to utility companies in the effective deployment of smart meters.

II. LITERATURE REVIEW

Past studies have used a range of theoretical models to explore the factors that influence consumers' acceptance of smart meters. Few studies focused on rational factors by employing the technology acceptance model (TAM) or its combination with other theories. The reference [26] shows a survey-based study conducted online, applied TAM and included an additional variable, which was subjective control (referring to how it can control a technology), besides its perceived ease of use and usefulness. The regression approach identified that all the three variables, perceived usefulness, ease of use, and subjective control had significantly affected the users' perception regarding usage. In another study by [27], TAM was used to investigate the factors that influence the consumers' intentions of continuing to use smart metering technology. They surveyed 212 smart meter customers in southern Germany. The partial least square data analysis revealed that perceived usefulness, ease of use, subjective control, and the users' attitude toward the use of smart meter were found to have an important influence on the users' intention of usage. Reference [28] analysed the effect of social barriers, which impede the implementation and diffusion of smart home technologies. They found that the public's main concerns in the smart home installation were related to the inability to manage and were also connected to factors such as trust, cost, reliability, data security, privacy, and apathy. The reference [29] adopted a quantitative approach and conducted experiments to determine the motivation, the process, and the outcome of the smart grid development in South Korea. They have identified how macroeconomic policy is connected to the role of the government. They also discovered that smart grid technologies were endorsed by participants as a solution to climate change and energy issues. These participants, therefore, preferred renewable energy and energy-saving policies that help address problems pertaining to climate change. Following the same line of inquiry, the reference [13] adopted the methods in behavioural decision studies to determine the perceptions of users in Korea concerning smart meters and found that participants liked the smart meters and expected to obtain instant savings. In addition, the researchers viewed the threats, which include lower control over their use of power, privacy breaches, and enhanced expenses.

III. THEORETICAL FRAMEWORK

A. ELECTRICITY-SAVING KNOWLEDGE (ESK)

"Knowledge of electricity saving" refers to an individual's possession of information regarding electricity savings.

A positive correlation is expected between electricity-saving knowledge and electricity-saving behaviour. In relation to this, the cognitive variables that have an influence on environmental behaviours have a basis in the cognition-attitude-behaviour psychological framework explained by [30], which indicated that knowledge influences environmental behaviour via attitude. This subsection specifies prior studies' findings on the effect of users' concern for energy saving on the acceptance of smart meters. The reference [22] found that users' concern for saving electricity influenced the continuance of behaviours to utilise resources and save electricity [22]. This confirms that if consumers are concerned about saving electricity, they will intend to use the smart meter system. The immediate data on energy use from smart meters can be utilised to compute electricity usage and help in planning for saving. Based on previous literature and empirical support, this study describes ESK as a category of information, which is related to electricity-saving, in which a consumer holds toward electricity-saving behaviour. As such, ESK is predicted to influence the users' behavioural intention of using the smart meter system. Therefore, the proposed hypothesis is presented below:

H1. Electricity-saving knowledge positively affects users' behavioural intention in using a smart meter system.

B. ENVIRONMENTAL AWARENESS

Environmental awareness refers to the capability of a person to understand the relationship between human actions and the present status of environmental quality [31], [32], and their inclination toward participating in environmental activities [33]. The behaviour of using a smart meter system is a type of behaviour that supports the environment, given that electricity consumption may have adverse consequences on the environment in the future [34]. However, [35] confirmed that self-power savings of up to 10 per cent could be achieved by using only smart meters without changing the tariff or controlling the appliances. Thus, implementing smart meter systems may lead to the minimisation of the negative impacts on the environment in the long run, which, in turn, may lead to pro-environmental behaviours. Additionally, several researchers have discovered that environmental awareness is related to pro-environmental behaviours [34]–[39]. This perspective has been further supported by [40], who contends that people who are cognizant of the changes in the climate are more motivated to participate in energy conservation and renewable energy. Therefore, consumers who are conscious of the adverse effects of using electricity, in the long run, will probably feel morally obligated to save electricity. Previous studies also highlighted the considerable consequences of an individual's behaviour to save electricity based on the awareness of its negative effects [34], [36], [39]. Other researchers assumed that environmental awareness would be positively related to smart meter adoption if smart meters are perceived primarily as pro-environmental technology [19], [20]. Hence, the proposed hypothesis is presented below:

H2. Environmental awareness gives a strong influence on users' behavioural intention in using the smart meter system.

C. PERFORMANCE EXPECTANCY

Smart meters have other uses beyond allowing consumers to occasionally view their electricity usage. For example, consumers can receive hourly alerts of their consumption data, and therefore, potentially empowering them to change or mitigate their overall usage of electricity. Subsequently, this could support their goals by lowering energy bills and protecting the environment.

Besides that, consumers' ability to access such facilities through a smart meter could incentivise them to accept the meter and achieve satisfaction when they reach their goals. In other words, performance expectancy is anticipated to favourably affect the acceptance of smart meters among consumers. Therefore, when there is a high sense of smart meter performance expectancy, their inclination to implement and adopt the technology is likely high. The integration of performance expectancy in the research model can be investigated regarding whether there could be incentives for consumers' acceptance of a smart meter. The next hypothesis is therefore proposed:

H3. Performance expectancy positively affects the users' behavioural intention of using the smart meter system.

D. EFFORT EXPECTANCY

With the traditional automated electricity meters, there is practically no communication required by house occupants apart from an occasional meter check to relay information to the utility firm. With smart meters, consumers have more interaction. They can, therefore; view in-home displays and web applications to determine detailed information. Consequently, the issue of effort expectancy can be applied as a possible predictor of the consumers' use and acceptance of smart meters. Moreover, if effort expectancy is shown to have a major effect in predicting users' acceptance, the direction of influence must be determined. In view of the foregoing discussion, the present study argues that the intention to accept a smart meter system would be significantly affected by the supposed convenience of understanding and convenience of usage. Users may accept services that do not need to be prepared or familiarised extensively. This leads to the following:

H4. Effort expectancy positively affects the users' behavioural intention of using a smart meter system.

E. SOCIAL INFLUENCE

In recent studies, a significant direct impact on social influences was found to predict users' behavioural intention to accept new technology such as near-field communication (NFC), radio frequency identification (RFID) or IoT-based technology [41]–[43]. The reference [43] noticed that new IoT users might have insufficient information regarding the implementation of the technology. Therefore, the individuals' perception of technology in a social network may play a vital role in determining their acceptance. In this research, the impact of social influence is measured based on an assessment in which consumers believe that they should or will use a smart meter if they are convinced that it is important to their social network. This contrasts with the way social influence was measured in the case of the IT system. The case study on the IT system revealed that users' behaviour (to adopt or refrain from adopting a new IT system) was affected by the people who they believed were important to them. Based on the theoretical review and empirical support, predictions showed that social influence affected consumers' behavioural intention to accept the smart meter system. Thus, the proposed hypothesis is stated below:

H5. Social influence positively affects users' behavioural intention of using a smart meter system.

F. HABIT

This study defines a habit as the extent to, which a consumer performs a particular behaviour automatically or instinctively as a result of experience. The present study argues that the habit of using applications that are similar to the smart meter system would influence users' behavioural intention of using the smart meter. Other research has verified that a habit can be transferred from one scenario to a similar scenario. Reference [44] performed a study on consumers' intentions to use NFC mobile payments in hotels. The study indicated that the use of mobile devices beyond hotel grounds (for example at home) could be regarded as habitual. Since the home and hotel share a similar environment, hence, it can be deduced that a habit formed at home may facilitate the transfer of behaviour to a related context. Therefore, users with a habit of using mobile applications, in general, may be more likely to use an individual mobile application [44], [45]. Thus, the habit of using mobile apps may transfer the users' behaviour to a particular application, such as a meter system, to become easier. Hence, the proposed hypotheses are as follows:

H6. Users' habits of using smart mobile applications positively affect their behavioural intention of using a smart meter system.

H7. Users' habits of using smart mobile applications positively affect their use of a smart meter system.

G. FACILITATING CONDITIONS

The smart meter system is inventive and recent and therefore, most electricity consumers are probably not accustomed to it. Smart meter systems require users to be able to configure and operate the in-home displays and use a computer to set up and activate a user's account. If users do not have the required operational skills, they may not adopt the smart meter system. This research model considers the facilitating conditions as the direct antecedents of behavioural intention. Therefore, consumers' perception of technical support will influence their behavioural intention and behavioural use in agreeing to the use of a smart meter system. Based on the theoretical review and empirical support, facilitating conditions are hypothesised as the following:

H8. Facilitating conditions positively affect users' behavioural intentions of using a smart meter system.

H9. Facilitating conditions positively affect users' use behaviour of a smart meter system.

H. BEHAVIOURAL INTENTION AND USE BEHAVIOUR

Findings from past research revealed an important link between users' behavioural intention and users' use behaviour. Well-established theories of acceptance like TAM and UTAUT, incorporate the behavioural intention variable in the nomological network of technology adoption determinants [46], [47]. The reference [48] regarding the part of behavioural intention for the use of a system, revealed the necessity to determine the related group of outside influences, which will affect the users' behavioural intention in the adoption models (such as the UTAUT and the TAM) that focus on triggers of behaviour that is cantered on technology, such as using a smart meter. In this case, users' behavioural intention acts as a mediator for the influence of various variables on users' user behaviour. It is also notable that users' behavioural intention is more predictive of users' behavioural use in cases where individuals are experienced in using technology in general [49]. Several researchers have conducted technology acceptance studies, observing users' behavioural intention [50]–[52]. Users' behavioural intention plays a crucial role as a predictor of future use. Considering this, the proposed conceptual model includes the effects of behavioural intention upon users' behaviour. Hence, the proposed hypothesis is as follow:

H10. Users' behaviour intention positively affects a users' use behavioural of a smart meter system.

IV. METHOD

A. RESEARCH MODEL

In connection with this conceptual model, the associations of the constructs were adapted from the literature concerned on the subject. Figure 1 presents the proposed diagram, which encompasses performance expectancy, effort expectancy, social influence, habit, and facilitating conditions [25], environmental awareness [53], and electricity-saving knowledge [34]. Such a conceptual model evaluated the connections observed between the constructs mentioned above and offered a series of 10 hypotheses to be tested.

B. SURVEY DESIGN

A 29-item survey form was one of the instruments that had been developed in this study. Based on the research methods of the information system, a multi-item Likert scale was utilised for evaluation [46], [54]. A 10-point Likert scale that ranged from (1) "strongly disagree" to (10) "strongly agree" was employed to gauge the constructs. In IS research, particularly in IS/IT adoption and acceptance, a similar scale had been used. Reference [55] found that a 10-point Likert

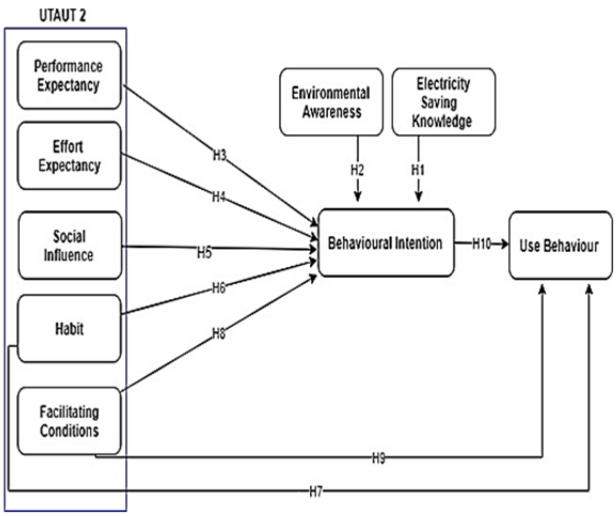


FIGURE 1. Research model.

TABLE 1. Respondents' demographic characteristics.

Demographic Item	Categories	Frequency	Percentage
Gender	Female	109	34.3
	Male	209	65.7
Age	25–34 years	54	17.0
	35–44 years	116	36.5
	45–54 years	124	39.0
Education	High School	13	4.1
	Diploma	42	13.2
	Bachelor's degree	194	61.0
	Master's degree	59	18.6
	PhD	10	3.1
Location	Malacca	205	64.5
	Putrajaya	90	28.3
	Others	23	7.2
Experience of using smart meter	Never	8	2.5
	1–6 Months	22	6.9
	One year	35	11.0
	Two years	76	23.9
	Three years	36	11.3
	More	141	44.3

scale is preferred over a 5-point Likert scale or a 7-point Likert scale; both measurement and structural models can expect more success in determining the construct validity with a more nuanced scale. Reference [56] listed the benefits of using a 10-point Likert scale: (1) it offered a better possibility to detect changes and clarify different perspectives; (2) it provided more diversity than smaller Likert scales, and (3) it gave greater measurement accuracy. However, since most participants were Malay speakers, the survey forms have been converted from English to Malay. The Malay version of the instrument was validated using the back-translation technique, a widely implemented approach in different intercultural surveys [57].

C. SURVEY DISTRIBUTION AND COLLECTION

Based on the accessible information of the consumers and their availability, an online survey and a self-managed survey were used to gather the data. The survey was conducted from October 2017 to March 2018 based on the households in Malacca and Putrajaya that used the smart meters. Out of the 898 questionnaires, 698 were distributed via email to registered consumers and 200 were distributed by the personal-administered distribution. Nevertheless, 85 questionnaires remained undelivered because of incorrect or invalid email addresses. After follow-ups, 179 email responses were returned and the response rate continuously increased after every follow-up. Out of the 200 personally administered surveys, 159 responses were retrieved. Overall, among the total of 338 questionnaires that were retrieved, 20 were blank or had missing data, Therefore, overall the sample consisted of 318 usable questionnaires—208 from Malacca, 93 from Putrajaya, and 17 from other locations— rendering 39.1 per cent response rate. According to [58] and [59], a rate of response at 20 per cent or higher can be accepted in the IS research. Table I illustrates the respondents' demographics.

V. RESULTS

A structural equation modelling (SEM) based on partial least squares (PLS) was employed to examine the research model suggested for this study. The two-stage analytical approach suggested by [60] and [61] was applied. It involved an evaluation of the current measurement model in the first stage and an evaluation of the current structural models in the second stage. The measurement model presented the measurements of constructs, and the structural model defined the connection between the constructs in the structural model [61]. This dual-stage analytical approach was superior to a one-step evaluation [62].

A. DESCRIPTIVE ANALYSIS

Table I shows that female accounts for 109 of the total respondents (34.3 per cent) and male accounts for 209 of the total respondents (65.7 per cent). Most respondents (39 per cent) were in the 45–54 age groups and the majority of the respondents (61 per cent) held a bachelor's degree. The analysis showed that most of the respondents were from Malacca (64.5 per cent), while only 28.3 per cent of them were from Putrajaya. The rest were from various other locations (7.2 per cent). Finally, the lower portion of Table I shows the respondents' experiences in using a smart meter application. The mean length of experience is 4.7 years (SD = 1.43 years).

TABLE 2. Measurement assessment results.

Construct	Item	Loading (> 0.5)	α (> 0.7)	CR (> 0.7)	AVE (> 0.5)
Performance Expectancy	PE1	0.967	0.972	0.982	0.947
	PE2	0.970			
	PE3	0.974			
Effort Expectancy	EE1	0.971	0.980	0.985	0.942
	EE2	0.971			
	EE3	0.971			
	EE4	0.969			
Social Influence	SI1	0.971	0.962	0.975	0.93
	SI2	0.971			
	SI3	0.967			
Habit	H1	0.972	0.967	0.979	0.938
	H2	0.964			
	H3	0.969			
Facilitating Conditions	FC1	0.959	0.970	0.978	0.918
	FC2	0.963			
	FC3	0.958			
	FC4	0.953			
Environmental Awareness	EA1	0.973	0.958	0.970	0.891
	EA2	0.966			
	EA3	0.967			
	EA4	0.865			
Electricity-saving Knowledge	ESK1	0.981	0.982	0.988	0.966
	ESK2	0.984			
	ESK3	0.983			
Behavioural Intention	BI1	0.973	0.971	0.981	0.945
	BI2	0.965			
	BI3	0.978			
Use Behaviour	UB1	0.989	0.976	0.988	0.977
	UB2	0.988			

B. ASSESSMENT OF THE MEASUREMENT MODEL

The measurement model was evaluated by applying the construct validity and reliability, including discriminant validity as well as convergent validity. According to [63], [64], to determine the item's reliability, the threshold value for an individual Cronbach's alpha coefficient should be more than 0.7. In the present study, the Cronbach's alpha coefficients for all 29 items exceeded the threshold value, indicating that the survey instrument was adequate to measure each individual construct. The item loadings, as presented in Table II, ranged from 0.865 to 0.989, and all of them indicated statistical significance. In addition, the internal consistency and reliability were assessed by determining the composite reliability (CR) values, which, as presented in Table II, were all above 0.9 (exceeded the minimum value of 0.7) [65], [66]. This indicated that the constructs' reliability was satisfied, as, for all constructs, the CR and Alpha Cronbach were relatively error-free. Factor loading values were used to assess the indicator's reliability. According to [62], values that are more than 0.70 indicated significant factor loadings. Table II illustrates that each item in the present research model had a series of factor loadings that were more than the recommended value of 0.7. The average variance extracted (AVE) value was utilised to assess the convergent validity. The AVE showed a positive match between the measures and the similar alternative measures of the same construct. The AVE value should exceed 0.50, as suggested by [62]. In this model, the AVE values were all between 0.891 and 0.977, which indicated that all constructs fulfilled the requirements of the convergent validity. Next, the Fornell-Larcker criteria and cross-loading were utilised to examine discriminant validity. This step was considered essential in testing indicators' discriminant validity [67]. As illustrated in Table III, the external loadings on various construct indicators were beyond the external loadings of all the cross-loadings with additional constructs. Therefore, the cross-loading criterion fulfilled the discriminant validity satisfactorily.

TABLE 3. Fornell–Larcker criterion results.

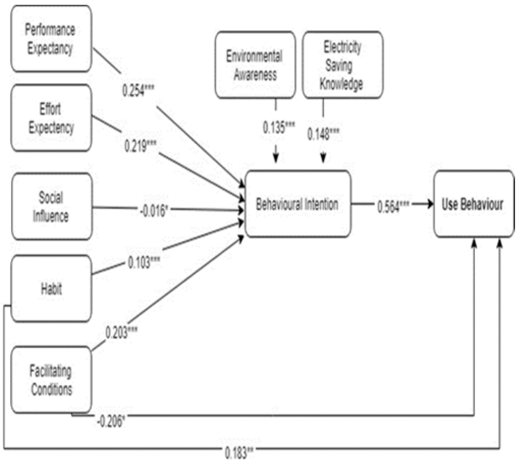
	BI	EE	ESK	EA	FC	H	PE	SI	UB
BI	0.972								
EE	0.924	0.971							
ESK	0.909	0.854	0.983						
EA	0.927	0.881	0.944	0.944					
FC	0.900	0.838	0.819	0.850	0.958				
H	0.828	0.789	0.764	0.787	0.766	0.969			
PE	0.916	0.863	0.837	0.853	0.831	0.747	0.973		
SI	0.753	0.724	0.666	0.699	0.748	0.755	0.741	0.964	
UB	0.530	0.518	0.500	0.506	0.441	0.492	0.468	0.409	0.988

Note: BI = Behavioural Intention, EE = Effort Expectancy, ESK = Electricity-saving knowledge, EA = Environmental Awareness, FC = Facilitating Conditions, H = Habit, PE = Performance Expectancy, SI = Social Influence, and UB = Use Behaviour.

The Fornell–Larcker criterion was employed to assess the discriminant validity, as shown in Table III. The square roots of the AVE values upon the diagonals (as presented in bold) had been discovered to have exceeded those concerning the correlations between the constructs (respective rows and columns). This indicated the strong correlations between the constructs and their corresponding indicators, compared to other constructs in the model [68], [69]. According to [61] such findings indicated good discriminant validity. Hence, all constructs had satisfactorily fulfilled the requirements of the discriminant validity.

C. ASSESSMENT OF STRUCTURAL MODEL

The structural model was assessed by computing R^2, beta (β), and the corresponding t-values via the bootstrapping



Note: ***: p < 0.01; **: p < 0.05; *: p < 0.1.

FIGURE 2. Results of structural model assessment.

technique, which applied 500 samples and 5000 resamplings as suggested by [61]. Moreover, reference [61] emphasised the importance of predictive relevance (Q^2) and effect sizes (f^2).

D. HYPOTHESIS TESTING

The results are shown in Figure 2 and Table IV illustrates the structural modelling assessments, presenting the findings of the different hypotheses tests. First of all, electricity-saving knowledge predicted behavioural intention; therefore, H1 is accepted, given that $\beta = 0.148$, $t = 3.274$, and $p = 0.001$. Environmental awareness predicted behavioural intention, confirming H2 (with $\beta = 0.135$, $t = 3.078$, and $p = 0.002$). These findings were like those obtained for performance expectancy and effort expectancy, in which both predicted consumers' behavioural intention to use a smart meter. Hence, both H3 and H4 were respectively proven (with $B = 0.254$, $t = 7.888$, and $p = 0.000$; and $\beta = 0.219$, $t = 5.241$, $p = 0.000$, respectively). The social influence could not anticipate behavioural intention, and therefore, H5 was not confirmed. Habit predicted behavioural intention and users' use behaviour in turn; hence, both H6 and H7 were respectively verified (with $\beta = 0.103$, $t = 3.651$, and $p = 0.000$; and $\beta = 0.138$, $t = 2.329$, and $p = 0.020$, respectively). Similarly, facilitating conditions predicted behavioural intention but not users' behaviour. Therefore, H8 was proven (with $\beta = 0.203$, $t = 6.277$, and $p = 0.000$); however, H9 was not confirmed. Finally, behavioural intention also meaningfully predicted the users' behaviour; therefore, H10 was confirmed (with $\beta = 0.564$, $t = 4.227$, and $p = 0.000$).

The effect size (f^2) specified the effect level of exogenous latent constructs (whether weak, moderate, or substantial) on the endogenous latent constructs [70]. On the basis of Cohen (1988), the obtained f^2 value of 0.02 signified a small influence; 0.15 represented a medium influence, and

TABLE 4. Structural assessment results.

H	Relation	Std Beta	Std Err	t-value	p-value	Decision	F²
H1	ESK → BI	.148	0.045	3.274	0.001	S	.045
H2	EA → BI	.135	0.044	3.078	0.002	S	.030
H3	PE → BI	.254	0.032	7.888	0.000	S	.245
H4	EE → BI	.219	0.042	5.241	0.000	S	.155
H5	SI → BI	-.016	0.027	0.575	0.566	NS	.002
H6	H → BI	.103	0.028	3.651	0.000	S	.060
H7	H → UB	.138	0.079	2.329	0.020	S	.015
H8	FC → BI	.203	0.032	6.277	0.000	S	.170
H9	FC → UB	-.206	0.119	1.737	0.083	NS	.011
H10	BI → UB	.564	0.133	4.227	0.000	S	.065

H: Hypothesis, S: Supported, NS: Not supported

TABLE 5. Variance explained and predictive relevance.

Construct	R^2	Q^2
Behavioural Intention	0.85	0.84
Use Behaviour	0.29	0.27

0.35 signified a large influence. As shown in Table IV, every f^2 result followed the size of the effects. Three of the relationships had a medium effect, and all of the remaining associations had a small effect. As evident from Table V, the research model managed to describe 85 per cent of the behavioural intention variation toward smart meters. On the other hand, it explained 29 per cent of the total smart meter use behaviour variation. The variance explained revealed that all of the dependent variables, except for the use of technology (29 per cent of variance explained) exceeded 10 per cent. This proved the cut-off for a good explanatory power established by [72]. Nonetheless, the use of technology recorded a value of 19 per cent and above the cut-off established by [73]. The amount of variance explained for the model variables illustrated a good overall model fit.

The blindfolding technique was used to evaluate the predictive relevance of the proposed research model. Reference [61] asserted that this approach was most suitable to be utilised on endogenous constructs that solely employ reflective measurements. Therefore, the following are the rules of thumb for the selected endogenous construct in relation to their values: 0.02 depicted weak predictive relevance; 0.15 depicted moderate relevance and 0.35 depicted large relevance. The Q^2 value of behavioural intention toward the system used had a large predictive relevance value and users' use behaviour had medium predictive relevance value (refer to Table V).

VI. DISCUSSION

This study found that environmental awareness and electricity-saving knowledge had a meaningful and favourable impact on the consumers' behavioural intention when it came to the use of smart meters. Therefore, this implied that consumers with greater awareness regarding the environment and greater knowledge about electricity-saving had greater intent to use smart meters. Moreover, the findings revealed that the performance expectancy significantly affected the behavioural intention This implied that the greater the performance expectancy of the smart meter, in terms of its usefulness, ability to function, and degree of response in disseminating complete, new, applicable, and correct information, the greater the intention of consumers to use smart meters because they align with their needs. This aligned with past research [14], [41], [42], [74], [75]. Similarly, effort expectancy had a meaningful effect on behavioural intention. Hence, this implied that the higher the effort expectancy of the smart meter based on the convenience of usage, the greater the consumers' behavioural intention of using the smart meters. This result concurred with that of the earlier studies— [27], [76]–[78]. As for social influence, this research found that it had no influence on the behavioural intention of consumers in Malaysia. This finding aligned with prior findings on smart meter adoption [76] and IoT [79]. Prior studies revealed that modern users had a greater tendency to be independent in their decisions and were not swayed even by those who were important to them and held a special place in their lives (e.g., family members, friends, or neighbours). Habit had a positive influence on users' behavioural intention and users' use behaviour of the smart meter system. This revealed that a habitual user of smart mobile applications had the tendency to use a smart meter system more than users who did not have the habit of using smart mobile applications. Prior works supported this result, including those by [44], [79], [80]. It was also shown in this research that the facilitating conditions of the smart meter systems influenced users' behavioural intention of using the system. This was evidenced by the significant path coefficients of the facilitating conditions—a result that aligned with the literature [76]. However, facilitating conditions did not significantly affect users' use behaviour, which was also consistent with prior studies [81]–[83]. The reference [84] had revealed that users had experienced using the smart system, however, the facilitating conditions were not a major element with regards to consumers' acceptance of smart meters. This was reflected in the results, which showed that experience had a minor influence on the facilitating conditions. Perhaps greater experience eliminated reliance on a facilitating infrastructure toward the use of technology = [84]. While other studies found that users' behavioural intention did not affect users' use behaviour [85]–[88], this study corresponded with prior research, which examined the effects of user's behavioural intention on users' use behaviour [50]–[52], [89]. Regarding smart meter systems, the users' behavioural intention had a significant impact on the users' use behaviour. This study highlighted the impact of users' behavioural intention on users' use behaviour, which was not examined previously by any of the smart meter acceptance models. Most importantly, this result contributed to the conceptualisation of user behaviour in the research on the acceptability of smart meter, which may be a guide for future studies on IoT technology.

VII. IMPLICATIONS

A. IMPLICATIONS FOR RESEARCH

This study tested the feasibility of the UTAUT2 by examining the model in an energy-saving context. Here, the UTAUT2 was extended to investigate the use of smart meters by electricity consumers and their intention to accept this technology as an energy-saving tool. The existing constructs of the UTAUT2 were modified, and two new constructs from an energy-saving perspective were introduced. This study is one of the first to use UTAUT2 to investigate the acceptance of smart meters. Furthermore, it is the first to examine the real usage of the smart meter systems in an energy-saving context. Therefore, this study will probably provide the groundwork for upcoming studies. The additional constructs on the basis of the nature of the technology (smart meters) and the context (energy) of the UTAUT2 model enhanced the descriptive potential of the current theories on the acceptability of the technology through the incorporation of the latest intrinsic features into smart meters systems. For example, the personal attitude towards energy saving was inclusive of environmental awareness and knowledge about saving electricity.

B. IMPLICATIONS FOR PRACTICE

The most influential factor in the research model was performance expectancy. Based on the outcome, it is imperative to develop performance interfaces with users so that user expectations are met. The following suggestions are directed to electricity providers, smart meter manufacturers, governments, and system developers regarding specific approaches.

Electricity providers should use the smart meter acceptance model developed in this study to update consumer requirements into the system. This would eventually increase the consumers' acceptance level. The empirically significant factors in the model will become the users' requirements for smart meter systems. Therefore, electricity providers should work to increase the level of electricity-saving knowledge and environmental awareness within their customers.

Smart meter manufacturers can support consumers' acceptance of smart meter systems. Smart meter devices and in-home displays (IHDs) are essential components of a smart meter system. These devices allow users to interact directly with the system. Most of the factors that affected the smart meter system acceptance (e.g. performance expectancy and effort expectancy) were related to the smart meter devices and IHDs. To ensure the significant performance level, which will fulfil the consumers' confidence, the smart meter makers need to create these gadgets carefully for functionality and operational ease. IHDs for smart meters, which improve the consumer feedback, will increase the acceptance level of smart meter systems. Manufacturers can use multiple channels, including mobile applications, web applications, and IHDs to display consumption data in a timely and diverse manner. Consumption feedback can include comparisons of customised saving plans, forecast scenarios, neighbourhood consumption data, and eco-alerts to maintain consumption at desirable levels. In summary, adopting the smart meter acceptance model could guide makers in developing meters that can better satisfy users' requirements, which will increase the level of consumers' acceptance.

Developers must understand users' requirements. The determinants ascertained in the present study for the acceptance of the devices offer useful knowledge to developers. During the early stage, developers must understand individual perceptions, perceptions within the energy sector, and those in the IoT environment toward smart meters. Indeed, the proposed model can help developers to create new methods and update their strategies in managing and introducing the service. For example, this study showed the importance of environmental awareness and electricity-saving knowledge on consumers' intentions to use the smart meter system. These factors can inspire developers to design functions and interfaces that offer informative icons that can maintain the consumption and allow the comparison between electricity usage and usage and the connected devices or among neighbours. Additionally, they can support user knowledge by designing interfaces that include saving plans, tricks, and forecasting scenarios.

C. STUDY LIMITATIONS

Firstly, those who participated in the present study provided self-reported answers regarding their use and acceptance of smart meter systems. Biasness could occur as a result of the various adverse factors such as participants' dishonesty or inability to provide the right responses. Another constraint was related to methodological. This research used a cross-sectional method, and therefore, no empirical evidence could distinguish the cases from the effects. Therefore, the upcoming studies should focus on gathering longitudinal data to facilitate the prediction of behavioural intention over time and improve the knowledge of causality, and the interconnections between variables, which are important for consumers to accept the smart meter system.. Finally, this study omitted the UTAUT2 moderators of experience, gender, and age. Although this omission was justified and was in line with the previous literature, the initiative to investigate further and determine the proposed model would be interesting.

VIII. SUMMARY AND CONCLUSION

The aim of this research was to explore determinants that affect individuals' decisions to agree and use smart meter systems in the sector of electricity consumption. Hence, a research model was formulated based on the UTAUT2 model developed by [25]. Additionally, a cross-sectional survey was conducted to test the research model. The research participants were electricity consumers, primarily from the cities of Malacca and Putrajaya in Malaysia. The research model was tested by fitting the data obtained in the survey via PLS-SEM. It was found that the performance expectancy, effort expectancy, and habit affected respondents' behavioural intention of using smart meter systems. The present study did not find any imperative implications of social influence on consumers' behavioural intention. Nonetheless, this study observed the slight outcomes of the facilitating conditions on consumers' behavioural intention. Facilitating conditions evidently did not affect the use of technology. In contrast, habit exerted an effect. Moreover, apart from the UTAUT2 factors, the knowledge about saving electricity and environmental awareness were the two other factors that helped form consumers' attitudes toward the use of smart meter systems. Additionally, these two factors also affected consumers' behavioural intention.

This research verified the viability of the UTAUT2 model in terms of smart meter systems' acceptance and the importance of including other related factors. Implications for practice suggested that the electricity providers use the smart meter acceptance model to update consumers' requirements into their systems, thereby increasing the acceptance levels. Adopting the proposed model could guide the manufacturers of smart meters to develop products with better user requirements, which would increase user engagement. Meanwhile, governments should set standards for using consumer data to protect consumer privacy and reduce anxieties on the usage of the smart meters.

ACKNOWLEDGMENT

This work was supported in part by The Energy University (UNITEN), Malaysia, through YCU Research, under Grant 201901001YCU/22, and in part by the the Innovative Research Management Center (iRMC) UNITEN.

REFERENCES

[1] E. Ahmed, I. Yaqoob, A. Gani, M. Imran, and M. Guizani, "Internet-of-Things-based smart environments: State of the art, taxonomy, and open research challenges," *IEEE Wireless Commun.*, vol. 23, no. 5, pp. 10–16, Oct. 2016.

[2] J. Lloret, J. Tomas, A. Canovas, and L. Parra, "An integrated IoT architecture for smart metering," *IEEE Commun. Mag.*, vol. 54, no. 12, pp. 50–57, Dec. 2016.

[3] C. C. Fung, S. C. Tang, and K. P. Wong, "A proposed study on the use of ICT and smart meters to influence consumers' behavior and attitude towards renewable energy," in *Proc. IEEE PES Gen. Meeting*, Jul. 2010, pp. 1–5.

[4] H. H. Lean and R. Smyth, "Will policies to promote renewable electricity generation be effective? Evidence from panel stationarity and unit root tests for 115 countries," *Renew. Sustain. Energy Rev.*, vol. 22, pp. 371–379, Jun. 2013.

[5] J. Stromback, C. Dromacque, M. H. Yassin, and G. E. T. T. VaasaETT, "The potential of smart meter enabled programs to increase energy and systems efficiency: A mass pilot comparison Short name: Empower Demand," Vaasa ETT, Helsinki, Finland, Tech. Rep., 2011.

[6] A. Malhotra, N. P. Melville, and R. T. Watson, "Spurring impactful research on information systems for environmental sustainability," *MIS Quart.*, vol. 37, no. 4, pp. 1265–1274, 2013.

[7] P. Koponen. (2008). Definition of smart metering and applications and identification of benefits. Deliv. D3 Eur. Smart Metering Alliance ESMA. [Online]. Available: https://www.esma-home.eu

[8] L. O. Alabdulkarim and Z. Lukszo, "Smart metering for the future energy systems in The Netherlands," in *Proc. 4th Int. Conf. Crit. Infrastruct.*, Apr. 2009, pp. 1–7.

[9] *Emerging Markets to More Than Double Smart Meter Growth in 2013, 56bn Market by 2022*, Northeast Group, LLC, Aliso Viejo, CA, USA, 2012.

[10] G. A. Alkawsi, N. Ali, and A. Alghushami, "Toward understanding individuals' acceptance of Internet of Things–based services: Developing an instrument to measure the acceptance of smart meters," *J. Theor. Appl. Inf. Technol.*, vol. 96, no. 13, pp. 4265–4281, 2018.

[11] V. J. Gunter and C. K. Harris, "Noisy winter: The DDT controversy in the years before silent spring," *Rural Sociol.*, vol. 63, no. 2, pp. 179–198, 1998.

[12] H. Farhangi, "A road map to integration: Perspectives on smart grid development," *IEEE Power Energy Mag.*, vol. 12, no. 3, pp. 52–66, May 2014.

[13] T. Krishnamurti, D. Schwartz, A. Davis, B. Fischhoff, W. B. de Bruin, L. Lave, and J. Wang, "Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer expectations about smart meters," *Energy Policy*, vol. 41, pp. 790–797, Feb. 2012.

[14] C.-F. Chen, X. Xu, and L. Arpan, "Between the technology acceptance model and sustainable energy technology acceptance model: Investigating smart meter acceptance in the united states," *Energy Res. Social Sci.*, vol. 25, pp. 93–104, Mar. 2017.

[15] D. Castro, J. New, and A. McQuinn, "How Is the federal Government using the Internet of Things?" Center Data Innov., Brussels, Belgium, Tech. Rep., 2016.

[16] *The One-Word Description of the Enterprise Internet-of-Things: Deliberate*, RedHat, Raleigh, NC, USA, 2015.

[17] S. Preeti. (Apr. 9, 2015). Why IoT opportunities are high, adoption rates low. India. https://www.cxotoday.com

[18] M. Hoover, "Study: IoT adoption still slow for government agencies," Washington Technol., Washington, DC, USA, Tech. Rep., 2016.

[19] J. Kranz and A. Picot, "Is it money or the environment? An empirical analysis of factors influencing consumers' intention to adopt the smart metering technology," in *Proc. AMCIS*, 2012, pp. 1–9.

[20] T. J. Gerpott and M. Paukert, "Determinants of willingness to pay for smart meters: An empirical analysis of household customers in germany," *Energy Policy*, vol. 61, pp. 483–495, Oct. 2013.

[21] D. Bugden and R. Stedman, "A synthetic view of acceptance and engagement with smart meters in the united states," *Energy Res. Social Sci.*, vol. 47, pp. 137–145, Jan. 2019.

[22] H. C. Lai, Y. C. Yu, and Y. M. Tuan, "Electricity-saving behavior antecedents: Electricity-saving motivations, constraints, knowledge and beliefs," in *Proc. IEEE Int. Conf. Ind. Eng. Eng. Manage. (IEEM)*, Dec. 2016, pp. 567–571.

[23] T. Yue, R. Long, and H. Chen, "Factors influencing energy-saving behavior of urban households in jiangsu province," *Energy Policy*, vol. 62, pp. 665–675, Nov. 2013.

[24] B. Mack, K. Tampe-Mai, J. Kouros, F. Roth, O. Taube, and E. Diesch, "Bridging the electricity saving intention-behavior gap: A German field experiment with a smart meter Website," *Energy Res. Social Sci.*, vol. 53, pp. 34–46, Jul. 2019.

[25] V. Venkatesh, J. Y. L. Thong, and X. Xu, "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology," *MIS Quart.*, vol. 36, no. 1, pp. 157–178, 2012.

[26] J. Kranz, J. Gallenkamp, and A. Picot, "Exploring the role of control—Smart meter acceptance of residential consumers," in *Proc. 16th Amer. Conf. Inf. Syst. (AMCIS)*, vol. 4, 2010, pp. 2639–2648.

[27] P. Wunderlich, D. Veit, and S. Sarker, "Examination of the determinants of smart meter adoption: An user perspective," in *Proc. Int. Conf. Inf. Syst. (ICIS)*, vol. 3, 2012, pp. 1941–1957.

[28] N. Balta-Ozkan, R. Davidson, M. Bicket, and L. Whitmarsh, "Social barriers to the adoption of smart homes," *Energy Policy*, vol. 63, pp. 363–374, Dec. 2013.

[29] D. Mah, J. M. van der Vleuten, J. C.-M. Ip, and P. R. Hills, "Governing the transition of socio-technical systems: A case study of the development of smart grids in Korea," *Energy Policy*, vol. 45, pp. 259–277, Jan. 2012.

[30] Z. Wang, B. Zhang, and G. Li, "Determinants of energy-saving behavioral intention among residents in beijing: Extending the theory of planned behavior," *J. Renew. Sustain. Energy*, vol. 6, no. 5, Sep. 2014, Art. no. 053127.

[31] X. Liu, A. Vedlitz, and L. Shi, "Examining the determinants of public environmental concern: Evidence from national public surveys," *Environ. Sci. Policy*, vol. 39, pp. 77–94, May 2014.

[32] N. S. Mei, C. W. Wai, and R. Ahamad, "Environmental awareness and behaviour index for Malaysia," *Procedia-Social Behav. Sci.*, vol. 222, pp. 668–675, Jun. 2016.

[33] M. L. Umuhire and Q. Fang, "Method and application of ocean environmental awareness measurement: Lessons learnt from university students of China," *Mar. Pollut. Bull.*, vol. 102, no. 2, pp. 289–294, Jan. 2016.

[34] Z. Wang, B. Zhang, J. Yin, and Y. Zhang, "Determinants and policy implications for household electricity-saving behaviour: Evidence from Beijing, China," *Energy Policy*, vol. 39, no. 6, pp. 3550–3557, Jun. 2011.

[35] T.-S. Choi, K.-R. Ko, S.-C. Park, Y.-S. Jang, Y.-T. Yoon, and S.-K. Im, "Analysis of energy savings using smart metering system and IHD (in-home display)," in *Proc. Transmiss. Distrib. Conf. Expo., Asia Pacific*, Oct. 2009, pp. 1–4.

[36] S. Fujii, "Environmental concern, attitude toward frugality, and ease of behavior as determinants of pro-environmental behavior intentions," *J. Environ. Psychol.*, vol. 26, no. 4, pp. 262–268, Dec. 2006.

[37] D. Arlt, I. Hoppe, and J. Wolling, "Climate change and media usage: Effects on problem awareness and behavioural intentions," *Int. Commun. Gazette*, vol. 73, nos. 1–2, pp. 45–63, Jan. 2011.

[38] A. H. L. Aman, A. Harun, and Z. Hussein, "The influence of environmental knowledge and concern on green purchase intention the role of attitude as a mediating variable," *Brit. J. Arts Social Sci.*, vol. 7, no. 2, pp. 145–167, 2012.

[39] Y. Zhang, Z. Wang, and G. Zhou, "Antecedents of employee electricity saving behavior in organizations: An empirical study based on norm activation model," *Energy Policy*, vol. 62, pp. 1120–1127, Nov. 2013.

[40] N. Zografakis, E. Sifaki, M. Pagalou, G. Nikitaki, V. Psarakis, and K. P. Tsagarakis, "Assessment of public acceptance and willingness to pay for renewable energy sources in crete," *Renew. Sustain. Energy Rev.*, vol. 14, no. 3, pp. 1088–1095, Apr. 2010.

[41] K. K.-K. Fong and S. K. S. Wong, "Factors influencing the behavior intention of mobile commerce service users: An exploratory study in Hong Kong," *Int. J. Bus. Manage.*, vol. 10, no. 7, p. 39, Jun. 2015.

[42] V. Dutot, "Factors influencing near field communication (NFC) adoption: An extended TAM approach," *J. High Technol. Manage. Res.*, vol. 26, no. 1, pp. 45–57, 2015.

[43] L. Gao and X. Bai, "A unified perspective on the factors influencing consumer acceptance of Internet of Things technology," *Asia Pacific J. Marketing Logistics*, vol. 26, no. 2, pp. 211–231, Apr. 2014.

[44] C. Morosan and A. DeFranco, "It's about time: Revisiting UTAUT2 to examine consumers' intentions to use NFC mobile payments in hotels," *Int. J. Hospitality Manage.*, vol. 53, pp. 17–29, 2016.

[45] S. Orbell, C. Blair, K. Sherlock, and M. Conner, "The theory of planned behavior and ecstasy use: Roles for habit and perceived control over taking versus obtaining substances," *J. Appl. Social Psychol.*, vol. 31, no. 1, pp. 31–47, Jan. 2001.

[46] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.*, vol. 13, no. 3, p. 319, Sep. 1989.

[47] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "Acceptance of information technology: Toward a unified view," *MIS Quart.*, vol. 27, no. 3, pp. 425–478, 2003.

[48] V. Venkatesh, S. A. Brown, L. M. Maruping, and H. Bala, "Predicting different conceptualizations of system use: The competing roles of behavioral intention, facilitating conditions, and behavioral expectation," *MIS Quart.*, vol. 32, no. 3, p. 483, 2008.

[49] S. Taylor and P. A. Todd, "Understanding information technology usage: A test of competing models," *Inf. Syst. Res.*, vol. 6, no. 2, pp. 144–176, Jun. 1995.

[50] G. Baptista and T. Oliveira, "Understanding mobile banking: The unified theory of acceptance and use of technology combined with cultural moderators," *Comput. Hum. Behav.*, vol. 50, pp. 418–430, Sep. 2015.

[51] A. Tarhini, M. El-Masri, M. Ali, and A. Serrano, "Extending the UTAUT model to understand the customers' acceptance and use of Internet banking in Lebanon: A structural equation modeling approach," *Inf. Technol. People*, vol. 29, no. 4, pp. 830–849, Nov. 2016.

[52] Y. K. Dwivedi, N. P. Rana, A. Jeyaraj, M. Clement, and M. D. Williams, "Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model," *Inf. Syst. Frontiers*, vol. 21, no. 3, pp. 719–734, Jun. 2017.

[53] S. C. Lillemo, "Measuring the effect of procrastination and environmental awareness on households' energy-saving behaviours: An empirical approach," *Energy Policy*, vol. 66, pp. 249–256, Mar. 2014.
[54] G. C. Moore and I. Benbasat, "Development of an instrument to measure the perceptions of adopting an information technology innovation," *Inf. Syst. Res.*, vol. 2, no. 3, pp. 192–222, Sep. 1991.
[55] Z. Awang, A. Afthanorhan, and M. Mamat, "The Likert scale analysis using parametric based structural equation modeling (SEM)," *Comput. Methods Soc. Sci.*, vol. 4, no. 1, p. 13, 2016.
[56] D. R. Wittink and L. R. Bayer, "The measurement imperative," *Marketing Res.*, vol. 6, no. 4, p. 14, 1994.
[57] W. Maneesriwongul and J. K. Dixon, "Instrument translation process: A methods review," *J. Adv. Nursing*, vol. 48, no. 2, pp. 175–186, Oct. 2004.
[58] T. Cornford and S. Smithson, *Project Research in Information Systems: A Student's Guide*. Springer, 2005.
[59] J. Yu and H. Cooper, "A quantitative review of research design effects on response rates to questionnaires," *J. Marketing Res.*, vol. 20, no. 1, pp. 36–44, 2007.
[60] J. C. Anderson and D. W. Gerbing, "Structural equation modeling in practice: A review and recommended two-step approach," *Psychol. Bull.*, vol. 103, no. 3, pp. 411–423, May 1988.
[61] J. F. Hair, Jr., G. T. M. Hult, C. Ringle, and M. Sarstedt, *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Newbury Park, CA, USA: SAGE, 2016.
[62] J. F. J. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, *Multivariate Data Analysis*, 7th ed. New York, NY, USA: Pearson, 2010.
[63] V. Kannan, "Just in time, total quality management, and supply chain management: Understanding their linkages and impact on business performance," *Omega*, vol. 33, no. 2, pp. 153–162, Apr. 2005.
[64] J. C. Nunnally, I. H. Bernstein, and J. M. F. T. Berge, *Psychometric Theory*, vol. 226. New York, NY, USA: McGraw-Hill, 1967.
[65] C. E. Werts, R. L. Linn, and K. G. Jöreskog, "Intraclass reliability estimates: Testing structural assumptions," *Educ. Psychol. Meas.*, vol. 34, no. 1, pp. 25–33, 1974.
[66] R. B. Kline, *Principles and Practice of Structural Equation Modeling*. New York, NY, USA: Guilford, 2015.
[67] J. F. Hair, Jr., M. Sarstedt, L. Hopkins, and V. G. Kuppelwieser, "Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research," *Eur. Bus. Rev.*, vol. 26, no. 2, pp. 106–121, Mar. 2014.
[68] C. Fornell and F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *J. Marketing Res.*, vol. 18, no. 1, pp. 39–50, 1981.
[69] W. W. Chin, *The Partial Least Squares Approach for Structural Equation Modeling*, G. A. Marcoulides, Ed. London, U.K.: Lawrence Erlbaum Associates, 1998, pp. 236–295.
[70] D. Gefen, E. E. Rigdon, and D. Straub, "Editor's comments: An update and extension to SEM guidelines for administrative and social science research," *MIS Quart.*, vol. 35, no. 2, pp. 3–14, 2011.
[71] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, vol. 2. Hilsdale, MI, USA: NJ Lawrence Earlbaum Associates, 1988.
[72] R. F. Falk and N. B. Miller, *A Primer for Soft Modeling*. Akron, OH, USA: Univ. of Akron Press, 1992.
[73] W. W. Chin, "The partial least squares approach to structural equation modeling," *Mod. methods Bus. Res.*, vol. 295, no. 2, pp. 295–336, 1998.
[74] C. Series, R. Donaldson, M. Hashemi, M. Azizinezhad, V. Najafi, and A. J. Nesari, "Student acceptance of mobile learning," *Procedia-Soc. Behav. Sci.*, vol. 8, no. 2, pp. 2477–2481, 2011.
[75] B. Pardamean and M. Susanto, "Assessing user acceptance toward blog technology using the UTAUT model," *Int. J. Math. Comput. Simul.*, vol. 1, no. 6, pp. 203–212, 2012.
[76] Indrawati and L. M. Tohir, "Predicting smart metering acceptance by residential consumers: An indonesian perspective," in *Proc. 4th Int. Conf. Inf. Commun. Technol. (ICoICT)*, vol. 4, May 2016, pp. 1–6.
[77] M. Kranz, P. Holleis, and A. Schmidt, "Embedded interaction: Interacting with the Internet of Things," *IEEE Internet Comput.*, vol. 14, no. 2, pp. 46–53, Mar. 2010.
[78] C.-K. Park, H.-J. Kim, and Y.-S. Kim, "A study of factors enhancing smart grid consumer engagement," *Energy Policy*, vol. 72, pp. 211–218, Sep. 2014.
[79] G. W. Leong, T. A. Ping, and R. Muthuveloo, "Antecedents of behavioural intention to adopt Internet of Things in the context of smart city in Malaysia," *Global Bus. Manag. Res.*, vol. 9, 2017.
[80] K.-Y. Chen and C.-F. Yeh, "Factors affecting adoption of smart meters in the post-Fukushima era in taiwan: An extended protection motivation theory perspective," *Behav. Inf. Technol.*, vol. 36, no. 9, pp. 955–969, Apr. 2017.
[81] H. San Martín and Á. Herrero, "Influence of the user's psychological factors on the online purchase intention in rural tourism: Integrating innovativeness to the UTAUT framework," *Tourism Manage.*, vol. 33, no. 2, pp. 341–350, Apr. 2012.
[82] E. L. Slade, M. D. Williams, and Y. Dwivedi, "Extending UTAUT2 To explore consumer adoption of mobile payments," in *Proc. UKAIS*, 2013, p. 36.
[83] J. A. Gaitán, B. P. Peral, and M. R. Jerónimo, "Elderly and Internet banking: An application of UTAUT2," *J. Internet Banking Commerce*, vol. 20, no. 1, pp. 1–23, 2015.
[84] S. S. Al-Gahtani, G. S. Hubona, and J. Wang, "Information technology (IT) in Saudi Arabia: Culture and the acceptance and use of IT," *Inf. Manage.*, vol. 44, no. 8, pp. 681–691, Dec. 2007.
[85] S. Dasgupta and B. Gupta, "Organizational culture and technology use in a developing country: An empirical study," in *Proc. AMCIS*, 2010, p. 565.
[86] P. Duyck, B. Pynoo, P. Devolder, T. Voet, L. Adang, D. Ovaere, and J. Vercruysse, "Monitoring the PACS implementation process in a large university hospital—Discrepancies between radiologists and physicians," *J. Digit. Imag.*, vol. 23, no. 1, pp. 73–80, 2010.
[87] C. E. Koh, V. R. Prybutok, S. D. Ryan, and Y. Wu, "A model for mandatory use of software technologies: An integrative approach by applying multiple levels of abstraction of informing science," *Informing Sci., Int. J. Emerg. Transdiscipline*, vol. 13, pp. 177–203, 2010.
[88] J. C. Sánchez-Prieto, S. Olmos-Migueláñez, and F. J. García-Peñalvo, "MLearning and pre-service teachers: An assessment of the behavioral intention using an expanded TAM model," *Comput. Hum. Behav.*, vol. 72, pp. 644–654, Jul. 2017.
[89] V. Bhatiasevi, "An extended UTAUT model to explain the adoption of mobile banking," *Inf. Develop.*, vol. 32, no. 4, pp. 799–814, Jul. 2016.

GAMAL ABDULNASER ALKAWSI was born in Yemen. He received the B.S. degree in software engineering and the master's degree in management information systems from Coventry University, INTI, Malaysia, and the Ph.D. degree in information communication technology from The Energy University (UNITEN), Malaysia, in 2019. He is currently a Postdoctoral Researcher with The Energy University (UNITEN). He has published in journals and conferences. His research interests include emerging technology acceptance, user behavior, adoption of information systems in organizations, the IoT, artificial intelligence, and machine learning.

NOR'ASHIKIN ALI received the B.S. degree in computer science from Texas State University, USA, the M.Sc. degree in IT from the University of Lincolnshire–Humberside, U.K., and the Ph.D. degree from Massey University, New Zealand. She has published in journals and conferences. Her research interests are in knowledge management, adoption of information systems in organizations, and acceptance of emerging technologies.

YAHIA BAASHAR received the B.S. degree in network computing from Coventry University, in 2008, and the M.S. degree in MIS from the INTI International University and College, Malaysia, in 2010. He is currently pursuing the Ph.D. degree in industrial science with The Energy University (UNITEN), Malaysia. His research interests include technology acceptance, medical informatics, e-health, artificial intelligence, and machine learning.