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RESEARCH ARTICLE

Mobile Application and Customer Effort: A Multigroup Analysis Among Energy Customers in Malaysia

Abdul Rahman Zahari[1]*, Elinda Esa[2]

[1] Department of Business Management, UNITEN Business School, Universiti Tenaga Nasional, Sultan Haji Ahmad Shah Campus, 26700 Bandar Muadzam Shah, Pahang, Malaysia

[2] Department of Accounting and Finance, UNITEN Business School, Universiti Tenaga Nasional, Sultan Haji Ahmad Shah Campus, 26700 Bandar Muadzam Shah, Pahang, Malaysia

ABSTRACT - This study examines the impact of mobile applications (mobile apps) on customer effort across two main customer categories (residential and business) of a prominent energy provider in Malaysia. A questionnaire survey was administered to 951 respondents selected via stratified sampling, and Partial Least Squares Structural Equation Modelling (PLS-SEM), SmartPLS 4.0, was employed to analyse the data using bootstrapping and multigroup analysis. The results indicate that customer effort was influenced by functionality and design quality. Conversely, social trust and information quality negatively impacted customer effort in both customer categories. The multigroup analysis revealed no substantial variances among all variables on customer effort. These findings can assist energy companies in standardising their mobile app services across various customer segments, thus improving customer experience and satisfaction. Future research can expand the study by including other industries for better generalisability of the findings.

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1. INTRODUCTION

According to Degenhard (2024), global smartphone users accounted for 3.94 billion in 2023 and the figure is expected to increase to 6.18 billion in 2029. Subsequently, the number of smartphone mobile network subscriptions worldwide may increase from close to 7 billion in 2023 to approximately 7.7 billion by 2028 (Taylor, 2024). A steady increase in the number of mobile app downloads was also recorded between 2016 to 2023, amounting to a total of 257 billion (Ceci, 2024). These statistics show the tremendous impact of human behaviour on smartphone usage around the world. In Malaysia, more than 48 million registered mobile phones and 45.3 million mobile broadband subscribers were reported in the fourth quarter of 2023 (Malaysian Communications and Multimedia Commission, 2024). To date, the mobile broadband penetration rate stands at 134.5%, with the majority of mobile users engaging in activities such as video streaming (46.1%), social networking (14.6%), web browsing (11.3%), online meetings (3.2%), gaming (1.2%), and other tasks like audio, software updates, peer-to-peer file sharing, and cloud storage (23.5%). Such data indicate that a significant portion of the Malaysian population owns smartphones and is extensively connected to the internet. This information enables companies to develop their mobile apps and leverage such technology as a primary means of communicating with their customers. Numerous studies (Bonfanti et al., 2023; Dunbar et al., 2024; Falloon, 2017; Lei et al., 2022) have explored customer behaviour through firms' mobile apps across various sectors, including retailing, banking, education, and transportation. However, the focus on the energy sector remains limited (Artusi et al., 2022; Caccavale, 2019; Chapaaro-Pelaez et al., 2020; do Nascimento et al., 2022; Kim et al., 2020).

The Malaysian energy sector has perpetually played a crucial role in advancing the national economy and is recognised as a significant industry facilitator. The National Energy Policy 2022-2040 (2022) stated that the energy sector contributed RM400 billion to the gross domestic product (GDP) and provided 4 million employment opportunities to the local workforce in 2021, yielding an average annual income of RM72,000 for employees and catering to over 10 million customers daily. With an increasing customer base, energy providers must establish multiple touchpoints for customer engagement and communication. In the digitalisation era, numerous companies, including those in the energy sector, have implemented diverse online touchpoints, particularly mobile applications, to interact with their customers. However, many utilities lack in adopting mobile technologies. For instance, 30% of the largest utilities in the United States still lack mobile apps, and those that do often face challenges in adoption and customer satisfaction (J.D. Power, 2023). A similar situation exists in Malaysia where only 4.6 million users had registered to the TNB portal and myTNB app in 2020 (Tenaga Nasional Berhad, 2020). This gap presents an opportunity to explore how mobile apps can be optimised to reduce customer effort and enhance service delivery in the energy sector. Hence, the timely response to customer queries is of utmost importance because customers who encounter difficulties addressing their concerns are more inclined to spread negative feedback (Clark & Bryan, 2013). A preliminary study by Richard (1965) demonstrated that minimal effort in acquiring information about a product or service is closely linked to customer contentment and allegiance. Therefore, the provision of efficient mobile application services will enable customers in the energy sector to readily resolve their issues,

***CORRESPONDING AUTHOR | Zahari, A.R.** | ✉ Rahman@uniten.edu.my

thereby enriching the customer experience, fostering loyalty, and boosting revenue growth for the energy industry (Caccavale, 2019; Chapaaro-Pelaez et al., 2020). This further aligns with the urgent call for a specific, more conclusive study on online touchpoints with different customer groups (Ghozali & Mutiara, 2024; Hallikainen et al., 2019; Weiger, 2023).

Therefore, the purpose of this study is to assess the differences between groups (customer segments - residential and business) in terms of the role of mobile apps, provided by the largest energy provider in Malaysia, on customer effort. The findings hope to assist the leading energy provider in Malaysia in providing standardised or tailored mobile app services to the two major customer segments. Additionally, the energy provider will be able to identify the factors that positively influence customer effort, allowing for the right crafting of strategies to enhance the mobile app services. In return, customer satisfaction and loyalty can be developed by improving the customers' experience of using the mobile app. This paper is structured as follows: the first section reviews the relevant literature, followed by a detailed explanation of the research procedures and methodology. The next section discusses the findings before offering a conclusion and recommendations.

2. LITERATURE REVIEW

2.1 Mobile Apps and Customer Effort

In the early 2010s, many companies began to create mobile-friendly websites and apps, which enabled customers and consumers to access information and engage with brands on the go as mobile devices became more prevalent among consumers worldwide (Rahman et al., 2022). According to the World Economic Forum (2023), more than 8.58 billion mobile subscriptions were in use worldwide in 2022 compared to a global population of 7.95 billion. With the advancement of mobile app technology, this touchpoint has helped create a more seamless system and a convenient customer experience as it allows them to engage with the firms regardless of time and place. Rahman et al. (2022) highlighted that the utilisation of online touchpoints, such as mobile apps, led to broader customer reach, improved customer engagement in real-time, personalised support, enhanced customer convenience, and cost-effective marketing, while gathering data on customer behaviour, preferences, and feedback. Similar benefits were also reported through mobile apps usage (Bera & Bhattacharya, 2024).

Using mobile apps as one of the touchpoints to engage customers can provide service firms with valuable insights to improve their services, enhance customer experience, drive revenue growth, and value co-creation (Ardelet & Benavent, 2023). Having the knowledge about customer effort (e.g., physical, mental, and financial resources) is essential for all types of firms because it has a curvilinear effect on customer satisfaction (Ardelet & Benavent, 2023). Early research on customer effort was conducted in the 1940s, and it has been gaining attention from scholars owing to the fierce competition in many sectors (Clark & Bryan, 2013). Sweeney et al. (2015) associate customer effort with the degree of effort that customers exert to integrate resources through various activities of varying levels of perceived difficulty. Nevertheless, only a few studies have discussed the impact of customer effort in relation to using online touchpoints, particularly mobile apps (Hensher & Xi, 2022; Rahman et al., 2022; Weidig et al., 2024).

2.2 Theoretical Background

Several psychological theories are related to the study of customer effort. According to Cardozo (1965), two branches of psychological theory, contrast theory and dissonance theory, have provided the basis for making specific statements about the relationship with customer effort. Due to a few shortcomings associated with these theories, Oliver (1977, 1980) proposed the expectancy-disconfirmation theory (EDT) to assess customer satisfaction. Generally, this theory implies that consumers purchase goods and services with pre-purchase expectations about the anticipated performance. He further explained that the expectation level becomes a standard against which the product or service is judged. Once the product or service has been used, outcomes are compared against expectations. Confirmation will occur if the outcome matches the expectation; otherwise, disconfirmation emerges. A customer is either satisfied or dissatisfied due to positive or negative differences between expectations and perceptions. Thus, when service performance is better than what the customer had initially expected, there is a positive disconfirmation between expectations and performance, which results in satisfaction. Similarly, when service performance is as expected, there is a confirmation between expectations and perceptions, which results in satisfaction. Conversely, when service performance is not as good as the customer expected, there is a negative disconfirmation between expectations and perceptions, which causes dissatisfaction.

Past studies have used EDT to measure customer effort using touchpoints, particularly mobile apps and social media. For instance, Krey et al. (2023) and Meng and Sidin (2020) employed EDT to explore tourists' effort in using touch points. Ojini et al. (2021) used the theory to assess the influence of mobile app touch points among telco users. Therefore, the current study adopted EDT to investigate customer effort in using mobile apps, with a specific focus on energy users.

2.3 Hypotheses Development

Numerous studies have revealed the positive relationship between mobile app elements, such as social trust, design quality, functional quality, and information quality, on customer effort (Berceanu et al., 2023; Berry et al., 2002; Gibbs & Drolet, 2003; Kalista et al., 2022; Olaleye et al., 2024). For instance, Olaleye et al. (2024) found a significant influence of social trust on effort expectancy among 289 Finnish retail mobile app users, while Berceanu et al. (2023) revealed a

positive link between social trust and design quality on customer effort among 331 mobile app respondents in Romania. Similar findings were also reported by Berry et al. (2002) and Gibbs and Drolet (2003). Furthermore, a systematic literature review study by Herr et al. (2012) discovered the positive impact of information and functional quality on customer effort. This aligns with the studies by Herr et al. (2012) and Kalista et al. (2022) involving the use of mobile apps by business-to-business oil and gas customers in Indonesia. Additionally, a bibliographic analysis by Stocchi et al. (2022) revealed the influence of factors like social trust, information quality, functional quality, and design quality towards customer effort and experience. Stocchi et al. (2022) further emphasised that these factors not only influence customer effort and experience but also lead to customer satisfaction and loyalty.

In line with EDT, trust shapes expectations that the mobile app will operate safely and transparently, reducing perceived psychological and functional risks. When these expectations are confirmed, users exert less cognitive and emotional effort to engage with the application (Olaleye et al., 2024). Conversely, a lack of trust may heighten vigilance and information-seeking, thereby increasing perceived effort. According to EDT, users expect mobile apps to deliver clear and reliable information that supports their decision-making. High information quality confirms expectations and minimises disconfirmation, ultimately reducing the mental effort needed to interpret or verify content (Bahtar, 2018; Herr et al., 2012). Conversely, poor information quality leads to expectation disconfirmation, thus increasing perceived effort due to confusion or repeated interactions. EDT posits that users expect mobile applications to perform seamlessly and meet their intended functions. When an app meets or exceeds expectations regarding functionality, users face less friction and lower interaction effort (Kalista et al., 2022). However, when functional shortcomings occur, users will experience negative disconfirmation that leads to increased time, frustration, and effort. Furthermore, well-designed mobile apps must be intuitive, aesthetically pleasing, and easy to use. When these expectations are met, users will experience less cognitive load and friction, thus reducing perceived effort (Parise et al., 2016; Wu & Ho, 2022). In contrast, clunky or confusing designs will disconfirm expectations and elevate perceived effort.

However, a number of past empirical studies have reported inconclusive findings about the role of mobile apps on customer effort compared to various types of customers (e.g., Bera & Bhattacharya, 2024; Calza et al., 2023). More studies are needed to enhance the body of knowledge in this area. Most mobile app studies were conducted in the retailing and financial sectors rather than in other industries (Bonfanti et al., 2023; Dunbar et al., 2024; Lei et al., 2022). The current study aims to address this gap by comparing the impact of customer types on mobile apps and customer effort from the perspective of a leading energy firm in Malaysia. Regarding online touchpoints, most companies use mobile apps as a primary tool to communicate with their customers. With the rapid development of mobile apps, many scholars have empirically studied the quality elements of mobile apps with customer experience in various business sectors (Bahtar, 2018; Hallikainen et al., 2019; Wu & Ho, 2022). For instance, Wu and Ho (2022) found that most quality variables of mobile apps, such as information, design, and functions, significantly differ across various types of customers in Taiwan. Another study by Bahtar (2018) proved that information quality and security helped reduce customer effort and led to customer loyalty. Parise et al. (2016) further claimed that mobile app design and functional quality improved customer effort scores and customer experience. Additionally, trust has been reported as an important factor in mobile apps, but with significant differences in terms of customer types (Rajaobelina et al., 2018). However, the findings disagree with Hallikainen et al. (2019), who found an insignificant difference between mobile touchpoint variables and types of customers. Similarly, Sands et al. (2016) demonstrated no significant difference between customer types and factors in mobile apps.

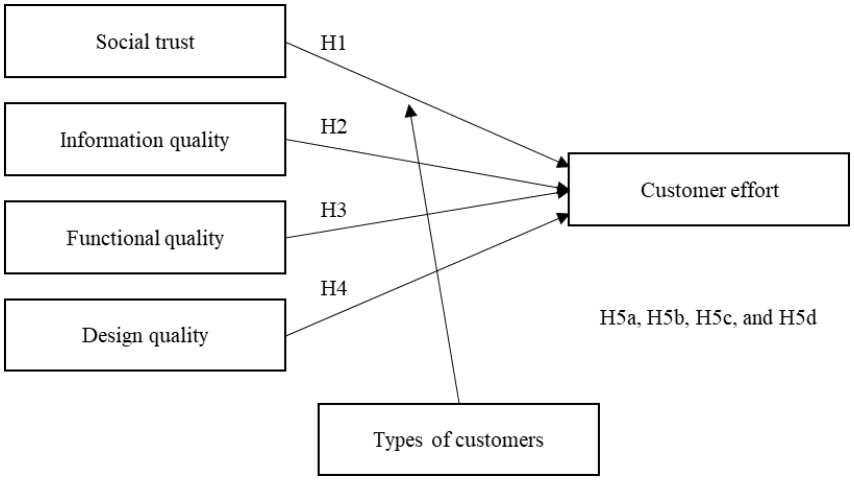

Figure 1. Conceptual framework

The proposed hypotheses are as follows:

H1: There is a positive relationship between social trust and customer effort.

H2: There is a positive relationship between information quality and customer effort.

H3: There is a significantly positive impact of functional quality on customer effort.

H4: There is a significantly positive impact of design quality on customer effort.

H5a: Residential customers are expected to express more social trust than business customers to exhibit customer effort.

H5b: Residential customers are expected to concern more about information quality than business customers to exhibit customer effort.

H5c: Residential customers are expected to feel more functional qualities than business customers to exhibit customer effort.

H5d: Residential customers are expected to express more design qualities than business customers to exhibit customer effort.

Regarding customer effort, a study by Ardelet and Benavent (2022) revealed that low customer effort failed to influence customer satisfaction in various customer segments. However, customer effort was reported to have significant differences with the types of customers (Sweeney et al., 2015) and customer efforts in the business-to-business segment (Harrington & Bryan, 2013). Similar findings were also reported by Asamoah et al. (2024). Finally, Hensher and Xi (2022) highlighted that firms must continue simplifying the process and reducing customer effort to ensure loyalty. They also claimed that numerous customers have significant differences in terms of customer effort. Based on the following evidence, this study compares the roles of mobile apps and customer effort with two customer segments: businesses and residentials. Figure 1 illustrates the conceptual framework used in this study.

3. DATA AND METHODOLOGY

3.1 Sample and Data Collection

A total of 1500 mobile app users (both residential and business customers) of a leading energy firm in Malaysia were selected using a stratified sampling technique based on the sampling frame (companies' owners or managers and residential customers) given by the energy company. An invitation to partake in the study was sent to their respective email addresses, and they were invited to answer an online survey about customers' experiences of using mobile apps via the SurveySparrow platform. The data collection process occurred from June to August 2023 and 951 respondents completed the questionnaire, yielding a 63.4% response rate.

Table 1 shows the characteristics of the research sample, namely their gender, age, race, education level, job position, income, and region. Approximately 50.4% of residential and 49.1% of business respondents were male, while 49.6% of residential and 50.9% of business respondents were female. The gender distribution is relatively balanced between the two groups. The majority of respondents were between the ages of 31 and 40 years old (53.5%), followed by those under 30 (23.9% residential, 29.0% business) and between 41 to 50 (22.6% for both types of customers). Many respondents were Malay (77.7% residential, 76.3% business), followed by Chinese (15.1% residential, 19.1% business), and Indian (7.3% residential, 3.4% business). Their level of education ranged from Bachelor's Degree (62.1% residential, 46.5% business) to Master's or PhDs (17.1% residential, 14.5% business). Many respondents were working in professional roles (24.2% residential, 26.0% business) and middle management and administrative or clerical roles (21.0% residential, 18.7% business). Their monthly stipends were divided across two groups, namely those earning between MYR 3,000 to MYR 6,000 (33.8% residential) and less than MYR 3,000 (38.0% business). Finally, the majority of respondents were from the Central region (36.6% residential, 40.1% business), followed by those from the North and South regions (22.9% residential, 27.2% business).

3.2 Measures

The survey questionnaire comprised two main sections. The first section contained 15 items assessing the customers' experiences of using the mobile app. All items were adapted from Pour et al. (2021) and measured with a 5-point Likert scale (1=Strongly Disagree; 5=Strongly Agree). One additional question, adapted from Dixon et al. (2010), was included to measure the customers' effort using a 5-point Likert scale (1=Very Difficult; 5=Very Easy). Meanwhile, the second section consisted of seven items, which captured the respondents' characteristics. All items were validated by four expert opinions (two academics and two industry managers) and pre-tested by 30 respondents. The data were analysed using a measurement model, structural model, and multigroup analysis via Partial Least Squares Structural Equation Modelling (PLS-SEM), SmartPLS 4, version 4.0.9.8 (Ringle et al., 2022). As the collected data were self-reported, a common method bias could exist and threaten the validity of the findings. Therefore, this study employed Harman's single-factor test to determine whether the data variance was explained by a single factor (Podsakoff et al., 2003). The results revealed that the first factor accounted for less than 50.0% of the total variance (i.e., 35.7%), suggesting that common method bias was unlikely to affect the findings of this study.

Table 1. Sample characteristics (n = 951)

		Residential (n = 385)		Business (n = 566)	
Profile	Sub-profile	Frequency	Percent	Frequency	Percent
Gender	Male	194	50.4	278	49.1
	Female	191	49.6	288	50.9
Age	30 years old and below	92	23.9	164	29.0
	31-40 years old	171	44.4	229	40.5
	41-50 years old	87	22.6	128	22.6
	51-60 years old	28	7.3	40	7.1
	More than 60 years old	7	1.8	5	0.9
Race	Malay	299	77.7	432	76.3
	Chinese	58	15.1	108	19.1
	Indian	28	7.3	19	3.4
	Others	-	-	7	1.2
Education	STPM/SPM and below	21	5.5	91	16.1
	Diploma	57	14.8	127	22.4
	Bachelor's Degree	239	62.1	263	46.5
	Master's or PhD	66	17.1	82	14.5
	Other	2	0.5	3	0.5
Job position	Professional	93	24.2	147	26.0
	Top Management	54	14.0	45	8.0
	Middle Management	81	21.0	93	16.4
	Supervisory	24	6.2	38	6.7
	Administrative or Clerical	30	7.8	106	18.7
	Technical	44	11.4	53	9.4
	Housewife	14	3.6	-	-
	Entrepreneur	29	7.5	77	13.6
	Others	16	4.2	7	1.2
Income	Less than MYR 3,000	52	13.5	215	38.0
	MYR 3,000 - MYR 6,000	55	14.3	205	36.2
	MYR 6,001 - MYR 9,000	23	6.0	88	15.5
	MYR 9,001 - MYR 12,000	66	17.1	25	4.4
	MYR 12,001 - MYR 15,000	130	33.8	13	2.3
	More than MYR 15,000	59	15.3	20	3.5
Regional	East	71	18.4	83	14.7
	South	85	22.1	154	27.2
	North	88	22.9	102	18.0
	Central	141	36.6	227	40.1

4. RESULTS AND DISCUSSION

4.1 Descriptive Analysis

Descriptive analysis was conducted to measure the central tendency between variables in this study. Table 2 shows that the mean and standard deviation values for customer effort are (M=4.21; SD=0.74), (M=4.22; SD=0.74), and (M=4.22; SD=0.74), respectively. Moreover, IQ1 (M=4.21; SD=0.70) and DQ1 (M=4.20; SD=0.74; M=4.19; SD=0.75) recorded the highest mean values for independent variables in residential, business, and complete models.

Table 2. Summary of descriptive analysis

Constructs and items	Residential		Business		Complete	
	Mean	SD	Mean	SD	Mean	SD
Social Trust (ST)	4.12	0.67	4.09	0.70	4.10	0.69
ST1	4.10	0.74	4.09	0.77	4.10	0.76
ST2	4.14	0.70	4.09	0.73	4.11	0.72
Information Quality (IQ)	4.13	0.64	4.11	0.64	4.12	0.64
IQ1	4.21	0.70	4.16	0.73	4.18	0.72
IQ2	4.15	0.73	4.12	0.72	4.13	0.72
IQ3	4.17	0.74	4.17	0.72	4.17	0.73
IQ4	4.16	0.74	4.14	0.74	4.15	0.74
IQ5	3.96	0.79	3.98	0.80	3.97	0.80
Functional Quality (FQ)	4.01	0.67	4.02	0.69	4.02	0.68
FQ1	4.04	0.75	4.04	0.74	4.04	0.74
FQ2	3.91	0.79	3.93	0.80	3.92	0.80
FQ3	4.09	0.76	4.08	0.75	4.09	0.76
Design Quality (DQ)	4.12	0.67	4.12	0.67	4.12	0.67
DQ1	4.18	0.77	4.20	0.74	4.19	0.75
DQ2	4.18	0.74	4.13	0.74	4.15	0.74
DQ3	4.11	0.75	4.11	0.75	4.11	0.75
DQ4	4.06	0.79	4.06	0.81	4.06	0.80
DQ5	4.06	0.78	4.08	0.75	4.07	0.76
Customer Effort (CE) CE1	4.21	0.74	4.22	0.74	4.22	0.74

Note: SD = Standard Deviation

4.2 Measurement Model

In this study, individual reflective indicator reliability was determined by the factor loadings of their respective constructs. A reliability measurement is considered adequate when the factor loading is higher than 0.70 (Chin, 1998; Henseler et al., 2009). Generally, higher average loadings indicate higher reliability (Gerbing & Anderson, 1988). Two separate analyses were conducted, namely an initial PLS run of the measurement model to determine indicator factor loadings and a second PLS run with the bootstrapping procedure of 5000 resamples to generate standard error and t-values for each indicator. The results in Table 3 show that the loading factor values for all items were above 0.70, ranging from 0.79 to 1.00 (residential), 0.81 to 1.00 (business), and 0.80 to 1.00 for the complete model. Therefore, all 16 items were retained because they had loading values greater than 0.70 and were considered significant (Hair Jr. et al., 2017; Ramayah et al., 2016).

Next, the reliability or internal consistency test was conducted according to the guidelines by Henseler et al. (2009). The construct reliability of a block of the reflective indicators measuring a construct was analysed through Cronbach's alpha and Composite Reliability (CR). According to Nunnally and Bernstein (1994), a Cronbach's alpha coefficient value equal to 0.60 or above is considered adequate for constructing reliability. The results in Table 3 show that the Cronbach's alpha values for all constructs were above 0.70, ranging from 0.84 to 0.92 for residential customers and 0.85 to 0.92 for both business customers and the complete model. Meanwhile, the CR values ranged from 0.86 to 0.92 (residential), 0.85 to 0.92 (business), and 0.85 to 0.92 (complete). According to Fornell and Larcker (1981), a CR value of 0.70 or greater is considered acceptable. Therefore, all constructs in this study were considered reliable.

The measurement of convergent validity was achieved using Average Variance Extracted (AVE) as suggested by Fornell and Larcker (1981) and Hair Jr. et al. (2017). AVE measures the variance captured by the indicators relative to measurement error, with a threshold of 0.50 to be accepted (Chin, 2010; Fornell & Larcker, 1981; Henseler et al., 2009). Table 3 shows that the AVE values for all constructs exceeded the accepted value, ranging from 0.75 to 0.86 (residential), 0.75 to 0.87 (business), and 0.75 to 0.87 (complete) (Chin, 2010; Fornell & Larcker, 1981; Henseler et al., 2009). These results indicate that the indicators satisfied the convergent validity requirement of their respective constructs. Subsequently, the Variance Inflation Factors (VIF) were tested to check for multicollinearity issues. As illustrated in Table 4, the VIF values for all constructs ranged from 2.19 to 4.31 (residential), 2.70 to 4.75 (business), and 2.46 to 4.85 (complete model). All these values were below 4, indicating no multicollinearity issue in this study (Hair Jr. et al., 2021).

Table 3. Measurement model results

Constructs and items	Residential				Business				Complete			
	Loading	CA	CR	AVE	Loading	CA	CR	AVE	Loading	CA	CR	AVE
ST		0.84	0.86	0.86		0.85	0.85	0.87		0.85	0.85	0.872
ST1	0.94				0.93				0.94			
ST2	0.91				0.93				0.92			
IQ		0.91	0.92	0.75		0.91	0.92	0.75		0.91	0.92	0.751
IQ1	0.87				0.88				0.88			
IQ2	0.88				0.87				0.87			
IQ3	0.90				0.89				0.90			
IQ4	0.87				0.85				0.86			
IQ5	0.79				0.81				0.80			
FQ		.84	.84	.75		0.88	0.88	0.80		0.86	0.86	0.78
FQ1	0.86				0.89				0.88			
FQ2	0.86				0.89				0.88			
FQ3	0.88				0.91				0.90			
DQ		0.92	0.92	0.77		0.92	0.92	0.77		0.92	0.92	0.77
DQ1	0.89				0.89				0.89			
DQ2	0.87				0.87				0.87			
DQ3	0.91				0.90				0.90			
DQ4	0.86				0.86				0.86			
DQ5	0.83				0.87				0.85			
CE	1.00	*	*	*	1.00	*	*	*	1.00	*	*	*

Note: ST = Social Trust; IQ = Information Quality; FQ = Functional quality; DQ = Design Quality; CE = Customer Effort; Note: * = Not available because customer effort is a single item; CA = Cronbach's Alpha; CR = Composite Reliability; AVE = Average Variance Extracted

Table 4. Variance inflation factor

Constructs	Residential	Business	Complete
	VIF	VIF	VIF
Social trust	2.19	2.70	2.46
Information quality	4.07	4.75	4.85
Functional quality	4.31	4.21	4.24
Design quality	4.15	3.84	3.94
Customer effort	*	*	*

Note: VIF = Variance Inflation Factor; * = Not available because customer effort is a single item

The final test was discriminant validity, which measures the extent to which a construct is truly distinct from other constructs according to empirical standards (Hair Jr. et al., 2017). There are three ways to check discriminant validity: (1) the criteria put forward by Fornell and Larcker (1981), (2) observing cross-loadings (Chin, 1998), and (3) the HTMT ratio of correlations (Henseler et al., 2015). This study measured discriminant validity using two approaches, namely the Fornell and Larcker criterion and the heterotrait-heteromethod ratio correlations (HTMT). The Fornell and Larcker criterion compares the square root of AVE with the correlation of latent constructs (Hair Jr. et al., 2017). The square roots of AVE coefficients are presented in the correlation matrix along the diagonal. Furthermore, the square root of each construct's AVE should have a greater value than the correlations with other latent constructs (Hair Jr. et al., 2017). The Fornell-Larcker results Table 5 show that the square root of AVE values for each latent construct in different groups at the diagonal matrix was larger than its correlation values, thus indicating that the measurement model was validated statistically. In addition, Table 6 denotes that the HTMT values for the three models surpassed the 0.90 threshold (Gold et al., 2001; Teo et al., 2008). Thus, discriminant validity was established for the research constructs.

Table 5. Fornell-Larcker criterion

Constructs/ Customers	Residential					Business					Complete				
	CE	DQ	FQ	IQ	ST	CE	DQ	FQ	IQ	ST	CE	DQ	FQ	IQ	ST
CE	1.00					1.00					1.00				
DQ	0.47	0.87				0.55	0.88				0.52	0.88			
FQ	0.45	0.82	0.87			0.53	0.82	0.89			0.50	0.82	0.88		
IQ	0.44	0.84	0.84	0.86		0.51	0.82	0.83	0.86		0.48	0.83	0.83	0.86	
ST	0.30	0.61	0.69	0.71	0.93	00.44	0.68	0.73	0.77	0.93	0.38	0.65	0.71	0.75	0.93

Note: CE = Customer Effort; DQ = Design Quality; FQ = Functional Quality; IQ = Information Quality; ST = Social Trust

Table 6. HTMT

Variables/ Customers	Residential					Business					Complete				
	CE	DQ	FQ	IQ	ST	CE	DQ	FQ	IQ	ST	CE	DQ	FQ	IQ	ST
CE															
DQ	0.49					0.57					0.54				
FQ	0.49	0.87				0.56	0.89				0.53	0.89			
IQ	0.45	0.88	0.85			0.53	0.88	0.88			0.50	0.88	0.83		
ST	0.32	0.69	0.82	0.81		0.48	0.77	0.84	0.87		0.41	0.74	0.80	0.85	

Note: CE = Customer Effort; DQ = Design Quality; FQ = Functional Quality; IQ = Information Quality; ST = Social Trust; [1] = Residential; [2] = Business; [3] = Complete

4.3 Structural Model

Structural model assessments consist of five criteria, namely structural model path coefficients (β), coefficient of determination (R^2), effect size (f^2), predictive relevance (q^2), and Goodness-of-fit (GoF). The coefficient values in Table 7 revealed that two hypotheses were supported in the residential, business, and complete samples. The results for each customer type were also consistent with those of the complete sample. For example, functional quality → customer effort (β = 0.18, t = 1.69, p = 0.04; β = 0.18, t = 2.52, p = 0.00) was found significant in the sample from residential and business. Therefore, Hypothesis 3 is supported. Additionally, design quality → customer effort (β = 0.28, t = 3.18, p = 0.00; β = 0.31, t = 4.42, p = 0.00) was found significant in the sample from residential and business. Thus, Hypothesis 4 is supported. However, social trust → customer effort (β = -.068, t = .82, p = 0.20; β = 0.03, t = 0.47, p = 0.31; β = -0.00, t = 0.15, p = 0.43) was found insignificant in the sample from residential, business, and complete segments. Therefore, Hypothesis 1 is not supported. Similarly, information quality → customer effort (β = 0.09, t = 0.80, p = 0.21; β = 0.06, t = 0.74, p = 0.22; β =0.07, t = 1.07, p = 0.14) was also found insignificant in the sample from residential, business and complete models. Therefore, Hypothesis 2 is not supported.

The subsequent assessment was the model's explanatory power (R^2). The R^2 values for the endogenous variables ranged between 0.33 and 0.38 across the samples (residential, business, and complete), indicating a moderate correlation (Chin, 1998). Furthermore, the effect size (f^2) ranged from 0.00 (ST → CE; Complete) to 0.03 (DQ → CE; Business), indicating small effects (Hair Jr. et al., 2017). The assessment of predictive relevance revealed that the Q^2 values of the endogenous constructs ranged from 0.21 (Residential) to .30 (Business), which can be described as moderate (Hair Jr. et al., 2017). Finally, the GoF values for the overall hypothesised model were 0.36 (residential), 0.35 (business), and 0.36 (complete), respectively. These results indicate that the model satisfied the global criterion of 0.30 (Henseler & Sarstedt, 2013).

Table 7. Direct relationship

Direct paths and hypothesis	Residential			Business			Complete			Decisions
	B	T	P	B	T	P	B	T	P	
ST → CE (H1)	-0.06	0.82	0.20	0.03	0.47	0.31	-0.00	0.15	0.43	Not supported
IQ → CE (H2)	0.09	0.80	0.21	0.06	0.74	0.22	0.07	1.07	0.14	Not supported
FQ → CE (H3)	0.18	1.69	0.04	0.18	2.52	0.00	0.18	2.91	0.00	Supported
DQ → CE (H4)	0.28	3.18	0.00	0.31	4.42	0.00	0.30	5.43	0.00	Supported

Note: ST/S = Social Trust; IQ = Information Quality; FQ = Functional Quality; DQ = Design Quality; CE = Customer Effort; B = Path Coefficients, T = t-value; P = p-value

4.4 Multigroup Analysis

This study also conducted a multigroup analysis between the two types of customers (residential and business) and mobile app elements (social trust, information quality, functional quality, and design quality) on customer effort. The findings revealed that all differences between the customer segments were found to be insignificant. The multigroup analysis results are summarised in Table 8.

Table 8. Multi-group comparison results

Relationship	Difference (Business - Residential)	p-value	Decisions
Social Trust → Customer Effort (H5a)	0.10	0.17	Not supported
Information Quality → Customer Effort (H5b)	-0.02	0.56	Not supported
Functional Quality → Customer Effort (H5c)	0.00	0.47	Not supported
Design Quality → Customer Effort (H5d)	0.03	0.39	Not supported

The results in Table 7 reveal that only two hypotheses are supported (H3 and H4). It suggests that both types of customers (residential and business) agreed that the functional and design quality of energy mobile apps positively influenced customers' effortlessness in solving energy-related problems. The findings align with Berceanu et al. (2023), Herr et al. (2012), Kalista et al. (2022), and Stocchi et al. (2022), indicating that the energy mobile app's functions, such as providing customers with personalised information based on users' interests, truly facilitate low customer effort. Although the functions of the mobile app positively influence customer effort, the company should not refuse to continuously improve its functions to facilitate a better customer experience (Olaleye et al., 2024). Therefore, obtaining frequent data about customer effort using the mobile app's functions is vital for every business.

Table 7 also shows that two hypotheses (H1 and H2) are not supported. Without doubt, the mobile app's design quality provided by the leading energy firm, such as the ease of access and use, ease of learning, responsive and attractive design, and acceptable response time, contributes towards users' effortlessness. This illustrates the small impact of social trust and information quality on customer effort across all types of customers (residential and business). The findings contradict Berceanu et al. (2023), Herr et al. (2012), Olaleye et al. (2024), and Stocchi et al. (2022), who found a strong connection between social trust and information quality on customer effort. Therefore, the leading energy firm should re-evaluate the social trust and information quality functions of its mobile apps.

Furthermore, the multigroup analysis results in Table 8 denote no significant differences between the two types of customers (residential and business) concerning mobile app functions and customer effort. Such findings highlight the insignificant role of social trust, information quality, functional quality, and design quality between the two types of customers and customer effort while using the mobile app. Thus, Hypotheses 5a, 5b, 5c, and 5d are not supported. The findings disagree with past studies that recorded significant differences across mobile app variables (information, functional, and design quality) with the types of customers engaged with a leading energy firm in Malaysia (Ieva & Ziliani, 2018; Pascucci et al., 2023; Weigner, 2023). In contrast, the multigroup findings obtained in this study support the works of Ardelet and Benavent (2023), Hallikainen et al. (2019), Parise et al. (2016), and Rajaobelina et al. (2018). Therefore, leading energy and energy-related firms must not set a different strategy for the mobile app's functions but rather focus on improving them, which may help lower customer effort in using the mobile app.

The findings of this study offer important insights into the energy sector's mobile app usage, revealing that functional quality and design quality significantly reduce customer effort and enhance customer experience, while social trust and information quality show no significant relationship with customer effort across both residential and business segments. This supports and is partially aligned with EDT, thus adding to the existing literature largely centred on the retail, finance, and education industries. The findings are consistent with past studies by Krey et al. (2023), Meng and Sidin (2020), and Ojini et al. (2021), confirming the critical role of well-functioning and intuitively designed apps in reducing effort while highlighting the need for energy firms to re-evaluate and strengthen social trust and information delivery within their apps. It offers practical suggestions for energy providers to design mobile app features that cater to shared user preferences across segments, thereby increasing engagement, satisfaction, and loyalty.

5. CONCLUSION

5.1 Conclusion

This study set out to compare the role of mobile apps and customer efforts across two types of energy customers (residential and business) in Malaysia. The results indicate that two variables of the mobile app (functional and design quality) were supported, while the remaining two (social trust and information quality) had an insignificant impact on customer effort among energy users. It shows that functional and design quality have a strong influence over customer effort for all customer segments. This situation can be fully leveraged by the companies to increase the customers' experience in using the mobile app. Although social trust and information quality carry insignificant influence on customer effort, these variables can remain critical. Thus, the energy firm should consider reassessing and improving these functions to ensure they can also positively impact customer effort. Finally, the multigroup analysis revealed that

no variable has a significant difference in customer effort when tested using two major types of energy customers (residential and business).

5.2 Research Implications

The findings of this study provide valuable insights into the body of knowledge, in which only two variables (functional and design quality) are associated with customer effort among energy mobile app users in Malaysia. It shows that the functional and design qualities of a mobile app are indeed essential to establish lower customer effort, leading to enhanced customer experience and satisfaction. On the other hand, two elements of mobile apps, namely social trust and information quality, have no link with customer effort across all types of customer segments and the complete model. Moreover, the current work cannot prove the significant difference between all variables and the dependent variable in all customer types (residential and business). The results extend the knowledge of mobile apps and customer efforts in different sectors (energy) because most previous studies have focused on the retail, finance, transportation, and education sectors. Additionally, the empirical evidence in this study relates to the goal theory by demonstrating partial support towards EDT.

This study hopes to assist energy firms in improving their mobile app quality and customer effort. By understanding the significant differences in social trust, information, functionality, and design quality with customer types, practitioners can design their mobile app features and services to meet the common needs and preferences of different customer segments. This can improve customer engagement and loyalty, ultimately imposing a positive impact on the company's bottom line. Furthermore, the findings also revealed the weak role of social trust and information quality in customer effort between the two groups of customer segments. Practitioners should find ways to incorporate these two functions in their mobile apps while consistently managing the existing functions and design to ensure that it can have positive impacts on customer effort, ultimately achieving better customer experience and satisfaction across various types of customers.

5.3 Limitations and Future Suggestions

The focus of this study is limited to one leading energy firm in Malaysia. Future research should expand the research by comparing the impact of mobile apps on customer effort in other energy firms. The inclusion of a greater sample size from different energy firms will provide practitioners or managers with a comparative study. This study also concentrates on one type of online touchpoint. This can be extended in the future by including several types of touchpoints that will lead to customer focus. Finally, future research may consider having a comprehensive study of omnichannel (offline and online) touchpoints provided by the firms. Companies must focus on a suitable touchpoint to engage with their customers, which will benefit customer satisfaction and loyalty.

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AUTHORS' CONTRIBUTION

Abdul Rahman Zahari (Conceptualisation; Methodology; Formal analysis; Writing - original draft; Supervision);
Elinda Esa (Methodology; Data curation; Writing - review & editing; Resources)

AVAILABILITY OF DATA AND MATERIALS

The data supporting the research findings are available on request from the corresponding author.

ETHICS STATEMENT

This research complies with ethical standards, ensuring informed consent, confidentiality, and the privacy of all participants.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

GENERATIVE ARTIFICIAL INTELLIGENCE DECLARATIONS

The author(s) declare that no generative AI or AI-assisted technologies were used in the writing of this manuscript. All content, including text, figures, and tables, was created by the author(s).

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