Structural modeling for usability attributes on technology acceptance model for smart parking mobile application

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Abstract. Smart parking is a mobile application that is created to overcome parking problems, although there are many smart parking applications developed in the world, only a few have a good interface design. One of the methods to assess the quality of the interface design is by measuring the usability of the application. Also, several studies have explored the relationship between usability and TAM (Technology Acceptance Model). However, is still lacking, especially about smart parking as an object. Due to that, this study focuses on determining usability attributes in smart parking applications and also modelling that usability attributes to TAM. This study using SEM (Structural Equation Model) method for modelling the relationship between Usability and TAM. The goal is the model could be used as a guide by application developers to see what factors must be considered when designing a smart parking mobile application, and for future research, it is expected that the developed model can be used as a guide when measuring the usability of a smart parking application. This research proposed ten hypotheses and findings two hypotheses have no significant effect that would be explained furthermore in the result and discussion section.

1. Introduction

In this world, there are many countries that have developed smart parking application to overcome parking problems that arise. In Canada, smart parking is developed to make the citizen be able to order a parking lot that is still empty, such as Best Parking, Parking Panda, and Spot Hero. In Taiwan, there are iTaipei Parking, Taoyuan Easy GO, Tainan Easy Parking, and many more. And in Indonesia itself, there is Go Parking owned by the government of Surabaya, Cari Parkir owned by PT. Astra and in Sidoarjo Regency there is SPON (Sistem Parkir Online) that is still developed. Although there are many varieties of parking applications that have developed, only a few have a good interface design. Most of these applications are difficult to use because of poor interaction between applications and users.

One of the ways to evaluate the quality of the interface is by conducting usability evaluation. Usability is a well-known and well-defined concept in human-computer interaction (HCI) research, referring to the extent the user and the system can communicate clearly without misunderstanding through the interface [1]. According to the International Organization for Standardization (ISO) defines usability is the extent to which an application can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use [2]. Neglecting usability may result in losing the users' interest, and the users will choose another application that serves its purpose better. Therefore, usability needs to be considered when developing smartphone applications.

In recent years, various studies have used different attributes or variables when evaluated the usability of products. Depends on the device used (smartphone or computer screen) will affect the model and the usability attributes to be selected. In 2013, Harrison, Flood, and Duce [3] studies developed a new usability model named PACMAD (People at the Centre of Mobile Application Development), where the attributes were effectiveness, efficiency, satisfaction, learnability, memorability, errors, and cognitive load. In 2015, Shawgi and Noureldien [4] developed a new usability model to measure website usability that named UMM (Usability Measurement Model). The usability variables consist of
accessibility, understandability, learnability, operability, attractiveness, and navigability. In the following year, Hoehle, Aljafari, and Venkatesh [5] developed and conceptualized mobile application usability by analysing Microsoft mobile usability guidelines to be a model that could be followed by other researchers in the future. The usability model developed is how the relationship between mobile application usability (the attributes were aesthetic graphics, colour, obviousness control, entry points, fingertip-sized controls, fonts, gestalt, hierarchy, subtle animation, and transition) with the outcome variable is continued intention to use a mobile application.

In addition, usability is one of the determining factors of the TAM (Technology Acceptance Model). Where when creating an application, the developer also needs to see how the user's acceptance of the application. Based on previous research, it is known that new technology will not be easily accepted and used by humans. The process of accepting new technology is influenced by several factors. The TAM model is a valid model that is widely accepted and trusted to predict the acceptance of new technology by end-users. The main determinants of the TAM model are Perceived Usefulness (PU), which refers to an individual's belief that a particular system will improve work performance, and Perceived Ease of Use (PE), which refers to an individual's belief that using a particular system will free from effort [6]. Perceived usefulness and perceived ease of use are influenced by relevant external determinants that have an influence on Behavioural Intention to Use (BI) [6]. However, very limited research has been conducted to develop the model between usability attributes and TAM. Some studies that try to see the relationship between the usability attribute and TAM then find a relationship between them are [7] and [8].

Hence, this study intends to contribute a structural design model for the usability attribute to the Technology Acceptance Model (TAM) for smart parking mobile applications. Based on several existing studies, researchers see the absence of structural modelling for usability attributes on TAM for smart parking mobile applications in Indonesia. While in the future the smart parking application can be used by the Indonesian government in solving parking problems that arise and can be an opportunity for application developers in Indonesia to create and design a good smart parking application and have an impact on the desire of the Indonesian people to be interested in using it. Also, the model can be a valuable reference for other researchers when conducting research in the same field.

2. Methodology

This study has a purpose to determine the usability attributes in the smart parking mobile application then explore the relationship between usability attributes and Technology Acceptance Model (TAM). Based on these objectives, the main object in this study is the smart parking mobile application “Cari Parkir” owned by PT. Astra Indonesia. This study conducted several stages, including the research model and hypotheses development, data collection, measurement model, and interpretation of research results.

2.1 Research Model and Hypotheses Development

At this phase, researchers establish the model by study literature about smart parking, usability, Technology Acceptance Model (TAM), and Partial Least Square-Structural Equation Modelling (PLS-SEM). These study literature, [3-9] help researchers to determine the variables and indicators of usability and technology acceptance model (TAM), then connecting each latent variables to construct the model. See Figure 1 about the reflective-formative model proposed.
Based on Figure 1, it can be seen that researcher proposed 10 hypotheses, they are:

H1: Operability has a positive and significant impact on Perceived Usefulness
H2: Operability has a positive and significant impact on Perceived Ease of Use

Operability is “the capability of the software product to enable the user to operate and control it” [10]. Operability in this model as a latent variable contains nine indicators: register [11], search, filtering, booking, navigation, scan QR code, mobile payment, menu bar and use of frames [4]. Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” [6]. And perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" [6]. Based on the definition of each variable, we assume that operability affects on perceived usefulness and perceived ease of use.

H3: Understandability has a positive and significant impact on Perceived Usefulness
H4: Understandability has a positive and significant impact on Perceived Ease of Use

**Figure 1.** Proposed research model.
Understandability is “the capability of the software to allow the user to understand whether the software is suitable, and how it can be used for particular tasks and conditions of use” [10].

**H5: Memorability has a positive and significant impact on Perceived Ease of Use**

Memorability is the ability of a user to retain how to use an application effectively [3]. In [7-8] studies also try to prove that memorability affects on perceived ease of use variable.

**H6: Satisfaction has a positive and significant impact on Behavioural Intention to Use**

Satisfaction is freedom from discomfort and positive attitudes towards the use of the application [3]. Behavioural intention to use is the degree to which a person has formulated a conscious plan to perform or not perform some specified behaviour [12]. Based on the definition of each variable, we assume that satisfaction affects behavioural intention to use.

**H7: Perceived Usefulness has a positive and significant impact on Behavioural Intention to Use**

**H8: Perceived Ease of Use has a positive and significant impact on Behavioural Intention to Use**

**H9: Perceived Ease of Use has a positive and significant impact on Perceived Usefulness**

**H10: Job Relevance has a positive and significant impact on Perceived Usefulness**

The hypotheses for Technology Acceptance Model (TAM) variables in this study are the following TAM 2 model. Where Perceived Usefulness (PU) and Perceived Ease of Use (PE) are the two main variables used to see how people's acceptance of new technology. Whereas the Behavioural Intention to Use (BI) variable is influenced by both main variables. Job Relevance (JR) as an external variable that affects the variable Perceived Usefulness (PU). The next hypothesis is Perceived Ease of Use (PE) influences Perceived Usefulness (PU) [13-14].

2.2 Data Collection Phase

The researcher conducted an online survey by using google docs from 1 May 2020 till 18 May 2020. The number of questionnaires filled in was 100 questionnaires but after we checked the data only 90 questionnaires that we could analyse. We removed 10 respondent because had straight-line pattern responses (dominant answer point 1 or point 6). The data is enough to process and analyse using SmartPLS, based on this rule saying that the minimum sample size should be 10 times the largest number of formative indicators used to measure a single construct [9]. The respondent in this study who is lived in Jabodetabek (Jakarta, Bogor, Depok, Tangerang, and Bekasi), Surabaya, Bandung, Makassar, and has used or familiar using “Cari Parkir” application. The characteristic of the respondent is displayed in Table 1.

2.3 Measurement Model

In this study, researchers applied Partial Least Square – Structural Equation Modelling (PLS-SEM) to assess the measurement and structural model. The measurement model is a model that describes the relationship between latent variables and indicators. Measurement model evaluation conducted to assess the validity and reliability of the model. The measurement model types in this study are divided into two called formative and reflective. For operability, understandability, memorability, and satisfaction variables are formative types. Where the indicators cause the variables. As for the variable perceived usefulness, perceived ease of use, job relevance, and behavioural intention to use are reflective types in which the indicators are caused by the variable. After testing reliability and validity (measurement model), the next step is to evaluate the results of the structural model. The aim is to examine the relationship between structural models represented by hypothetical relationships between constructs that have been built [9].
Table 1. Characteristic of Respondent (n=90).

| Item            | Demographics | Sample | Percentage |
|-----------------|--------------|--------|------------|
| Gender          | Female       | 48     | 53%        |
|                | Male         | 42     | 47%        |
| Age             | 17-20        | 4      | 5%         |
|                | 21-25        | 53     | 59%        |
|                | 26-30        | 28     | 31%        |
|                | 31-35        | 3      | 3%         |
|                | 36-41        | 2      | 2%         |
| Residence       | Jabodetabek  | 54     | 60%        |
|                | Surabaya     | 14     | 15%        |
|                | Makassar     | 9      | 10%        |
|                | Bandung      | 7      | 8%         |
|                | others       | 6      | 7%         |
| Job             | Civil servant| 10     | 11%        |
|                | Public company| 8     | 9%         |
|                | Private company| 41    | 45%        |
|                | Entrepreneur | 6      | 7%         |
|                | College student| 23    | 26%        |
|                | Housewife    | 2      | 2%         |
| Parking frequency| Everyday | 25     | 28%        |
|                | 2 - 3 times in a week | 35 | 39% |
|                | Once in a week                      | 30   | 33%        |

3. Result and Discussion

3.1 Measurement Model Evaluation

Firstly, we evaluate the formative type measurement model (usability variables) from the value of Variance Inflation Factor (VIF) and the significance of the outer weight indicator. Variance inflation factor (VIF) is used to assess the collinearity of the formative type measurement model (the value of VIF should be less than 5.00). While outer weight is used to assess how important formative indicators contribute to forming a construct or variable (level significance 0.05).

In Table 2 we could see that the register, search, navigation, scan QR code, mobile payment, use of frames, language support, help, color, and comment indicators are not significant. However based on reference [9] said that: 1) When the outer weight (w) of an indicator is not significant but the value of outer loading (l) is relatively high (l ≥ 0.50), it is statistically significant (the indicator must be retained). 2) If the value of outer weight (w) is not significant and outer loading (l) is relatively low (l <0.5), the researcher must strongly consider removing formative indicators from the model. Based on that statement, then register, search, navigation, scan QR code, mobile payment, use of frames, help, and color are still significant forming the variables. While the language support and comment indicators are not significant and will be removed from the model.

Based on the observations of researchers, the comment indicator has no effect on the satisfaction variable because the indicator is indeed not available in the “Cari Parkir” application and has been represented by a rating indicator that is both used to provide an assessment of the quality of the application and parking attendant services. Whereas for language support indicators that do not have an influence on the understandability variable, researchers see this because even though the language support feature is not available in the “Cari Parkir” application, the user does not mind it because the language used in the application uses Bahasa, where the respondents in this study are all Indonesian. Maybe the results will be different if there are respondents who are not Indonesian then the application does not provide universal language support, in this case, the English language.
Table 2. Formative measurement.

| Formative variable | Formative indicator | Outer Weight (Outer Loading) | t Value | p Value | Significance (p < 0.05?) | VIF* |
|--------------------|---------------------|------------------------------|---------|---------|--------------------------|------|
| Operability        | Register            | 0.007 (0.535)                | 0.081   | 0.935   | No                       | 1.781|
|                    | Search              | 0.093 (0.685)                | 0.900   | 0.368   | No                       | 1.936|
|                    | Filtering           | 0.245 (0.809)                | 1.992   | 0.046   | Yes                      | 2.896|
|                    | Booking             | 0.340 (0.783)                | 2.995   | 0.003   | Yes                      | 1.994|
|                    | Navigation          | 0.033 (0.652)                | 0.283   | 0.777   | No                       | 1.963|
|                    | Scan QR Code        | 0.060 (0.607)                | 0.523   | 0.601   | No                       | 2.130|
|                    | Mobile Payment      | -0.090 (0.550)               | 0.892   | 0.372   | No                       | 2.037|
|                    | Menu Bar            | 0.393 (0.876)                | 2.971   | 0.003   | Yes                      | 2.738|
|                    | Use of Frames       | 0.154 (0.751)                | 1.274   | 0.203   | No                       | 1.995|
| Understandability  | Language Support    | -0.077 (-0.374)              | 0.798   | 0.425   | No                       | 1.108|
|                    | Help                | 0.080 (0.674)                | 0.460   | 0.645   | No                       | 1.648|
|                    | How it Works        | 0.922 (0.995)                | 6.913   | 0.000   | Yes                      | 1.695|
| Memorability       | Favorite Location   | 0.638 (0.886)                | 5.663   | 0.000   | Yes                      | 1.284|
|                    | E-ticket Parking    | 0.526 (0.827)                | 5.533   | 0.000   | Yes                      | 1.284|
| Satisfaction       | Color               | 0.197 (0.528)                | 0.959   | 0.337   | No                       | 1.329|
|                    | Font                | 0.449 (0.796)                | 2.337   | 0.019   | Yes                      | 1.514|
|                    | Rating              | 0.623 (0.841)                | 4.040   | 0.000   | Yes                      | 1.222|
|                    | Comment             | -0.046 (-0.319)              | 0.249   | 0.803   | No                       | 1.087|

*aVIF: Variance Inflation Factor

Table 3. Reflective measurement.

| Reflective variable                                | Kode | Cronbach’s alpha | CRa | AVEb |
|----------------------------------------------------|------|------------------|-----|------|
| Perceived Usefulness                               | PU   | 0.865            | 0.908| 0.712|
| Perceived Ease of Use                              | PE   | 0.859            | 0.899| 0.643|
| Job Relevance                                      | JR   | 0.922            | 0.950| 0.864|
| Behavioural Intention to Use                       | BI   | 0.789            | 0.876| 0.703|

aCR: Composite reliability
bAVE: Average Variance Extracted

Secondly, for the reflective type measurement model (TAM variables) we calculated internal consistency value: Cronbach’s alpha and composite reliability, and convergent validity: Average Variance Extracted (AVE). The purpose of evaluating the reflective measurement model is to ensure the reliability and validity of the relationship of the variable with its indicators [9]. From the results of running internal consistency: Cronbach’s alpha value and composite reliability of each TAM variable (perceived usefulness, perceived ease of use, job relevance and behavioral intention to use) have values between the range 0.70–0.90 [9]. This means that each TAM variables in the model are reliable. For the results of running convergent validity, it can be seen that the AVE value is greater than 0.50, so it can be interpreted that the four TAM variables are well represented the original data [9].

Last, to examine discriminant validity, we conducted cross-loading criteria and the results are summarized in Table 4. The cross-loading value of each indicator to the variable is must be greater than the value of the cross-loading of other variables. In Table 4 we could see the cross-loading value also obtained good results for each indicator of the TAM variable. It means that the model has good discriminant validity.
Table 4. Discriminant validity (cross-loading).

|       | BI | JR | PE | PU |
|-------|----|----|----|----|
| BI1   | 0.799 | 0.518 | 0.516 | 0.672 |
| BI2   | 0.875 | 0.455 | 0.734 | 0.759 |
| BI3   | 0.839 | 0.387 | 0.507 | 0.620 |
| JR1   | 0.493 | 0.932 | 0.469 | 0.539 |
| JR2   | 0.417 | 0.928 | 0.407 | 0.436 |
| JR3   | 0.577 | 0.928 | 0.566 | 0.585 |
| PE1   | 0.663 | 0.390 | 0.828 | 0.654 |
| PE2   | 0.554 | 0.475 | 0.873 | 0.645 |
| PE3   | 0.491 | 0.590 | 0.725 | 0.633 |
| PE4   | 0.481 | 0.231 | 0.729 | 0.508 |
| PE5   | 0.634 | 0.405 | 0.842 | 0.667 |
| PU1   | 0.574 | 0.503 | 0.669 | 0.827 |
| PU2   | 0.633 | 0.425 | 0.593 | 0.813 |
| PU3   | 0.755 | 0.544 | 0.660 | 0.853 |
| PU4   | 0.787 | 0.442 | 0.703 | 0.881 |

a BI: Behavioral intention to use  
b JR: Job Relevance  
c PE: Perceived ease of use  
d PU: Perceived usefulness

3.2 Structural Model Evaluation  
In structural model evaluation, the researcher inspected the path coefficient to see the accepted and rejected hypothesis. The criteria used to determine hypotheses accepted or rejected are t-value ≥ 1.65 with p-value 0.1.

![Figure 2. The structural model (t-value).](image-url)
In Figure 2 we could see the result of our test of the structural model. The accepted and rejected hypotheses are:

- **Operability** has a positive and significant effect on **Perceived Usefulness** with t-value 4.749 (H1 accepted). It means that users can use and operate smart parking applications properly, thus speed up the driver’s parking process.
- **Operability** has a positive and significant effect on **Perceived Ease of Use** with t-value 3.952 (H2 accepted). It means that users can use and operate smart parking properly, thus drivers feel the convenience to do the parking process.
- **Understandability** has a positive and significant effect on **Perceived Usefulness** with t-value 2.191 (H3 accepted). It means that users feel smart parking application easy to understand so that it speeds up the driver’s parking process.
- **Understandability** has a positive and significant effect on **Perceived Ease of Use** with t-value 1.713 (H4 accepted). It means that the smart parking application has clear guidelines so that it makes the driver easy to do the parking process.
- **Memorability** has a positive and significant effect on **Perceived Usefulness** with t-value 5.292. By this result, we can conclude that smart parking applications make the users easy to remember their frequently visited parking, the last location of parking, the arrival time, and the parking fees so that users feel the convenience during the parking process.
- **Satisfaction** has a positive effect but not a significant relationship on **Behavioral intention to use** with t-value 0.396 (H6 rejected). We can conclude that that application users do not care much about the satisfaction factor (color, font, and rating) as a factor for using the smart parking application, this can be seen from the results, although the positive effect is 0.037 the effect is not significant. These results are the same as the study [9] where the color and font elements of the usability variable for mobile applications do not significantly affect the user’s intention to continue using a mobile application.
- **Perceived Usefulness** has a positive and significant effect on **Behavioral intention to use** with t-value 6.917 (H7 accepted). It means that people who often parked their vehicles felt the benefits of using the smart parking application so they were interested in using smart parking applications.
- **Perceived Ease of Use** has a positive and significant effect on **Behavioral Intention to Use** with t-value 1.757 (H8 accepted). It means that people who often parked their vehicles felt the ease of using the smart parking application so they were interested in using smart parking applications.
- **Perceived Ease of Use** has a positive and significant effect on **Perceived Usefulness** with t-value 2.255 (H9 accepted). It means that people who always parked their vehicles felt the ease of using the application so that users felt the benefits when using it.
- **Job relevance** has a positive effect but not a significant relationship on **Perceived Usefulness** with t-value 1.450 (H10 rejected). We can conclude that the users do not really feel the usefulness and relevance of smart parking application to their work or activities.

Meanwhile, H6 and H10 have no significant relationship (t-value less than 1.65) we considered to remove satisfaction and job relevance from the model. After we removed the variables and rerunning the model, we get the final model (See Figure 3). This final model has Standardized Root Mean Square Residual (SRMR) value 0.093. It means the model has fit based on the references [15] [16] that said value of SRMR must less than 0.10. Next, in figure 3 we could see all the hypotheses finally accepted. H1 (Operability has a positive and significant effect on Perceived Usefulness with t-value 5.299), H2 (Operability has a positive and significant effect on PE with t-value 3.884), H3 (Understandability a positive and significant effect on PU with t-value 2.057), H4 (Understandability a positive and significant effect on PE with t-value 1.683), H5 (Memorability has a positive and significant effect on PU with t-value 5.184), H7 (PU has a positive and significant effect on BI with t-value 7.546), H8 (PE has a
positive and significant effect on BI with t-value 1.757) and H9 (PE has a positive and significant effect on PU with t-value 2.415).

**Figure 3.** The final structural model (t-value).

### 4. Conclusion

This study combines usability attributes and TAM to evaluate smart parking mobile application in Indonesia. The objective of this study is to determine variables and indicators in usability attributes with smart parking as an object. After that, we develop and test a model that explores the relationship between usability attributes and TAM. The data we were collected to test our proposed hypotheses. From running the data, the test result indicates that operability, understandability, and memorability have a positive relationship with TAM variables (see figure 3). And the highest total effect value is the relationship between operability to behavioural intention to use (0.496). It means that drivers need a smart parking application that has more information and easy to operate. The limitation of this study is the participant fairly small. This is due to the lack of users who are familiar with the smart parking application. Therefore, for future research, the researcher can use a larger sample or the researcher can focus on quantitative usability testing (i.e., eye-tracking) by using the usability attribute in this model. For the application developer can pay attention to features or indicators that exist in the operability variable in this model. We suggest the operation of the registration feature must be improved because it has the lowest coefficient value in this model. This could be an indication of why this application is not yet familiar because users have difficulty log in to the application.

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