A PERCEPTUAL MEASURE OF MOBILE ADVERTISING USING FUZZY LINGUISTIC PREFERENCE RELATION

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Abstract. The purpose of this study has been concretized in terms of impact of mobile advertising on the purchase decision of the consumer and aimed to answer to research questions: which is the underlying structure of criteria in mobile advertising? And which criteria are important for consumers in evaluating mobile advertising? A sample of consumers in Taiwan was surveyed and using fuzzy judgment to determine the vague perception of consumers. In addition, the proposed fuzzy linguistic preference relation (FLPR) is used to express the subjective preferences of consumers with respect to the considered criteria of mobile advertising, and also use the criterion gauges to evaluate the implementation of mobile advertising strategies. Finally, an empirical study is illustrated to demonstrate that the proposed method is more suitable than the traditional method, especially when the consumer judgments are likely be inconsistent in pair-wise comparison. The presented fuzzy linguistic preference relation method is an easy and practical way to provide a mechanism for improving consistency in perceptual measure of mobile advertising.

1. Introduction

Mobile advertising, which is an area of mobile commerce, is a form of advertising that targets users of handheld wireless devices such as mobile phones and Personal Digital Assistants (PDAs). In comparison with traditional advertising, the main advantage of mobile advertising is that it can reach the target consumers anywhere and anytime. In order to promote the selling of products or services, all the activities required to communicate with the consumers are transferred through mobile devices [17]. Combining with the consumers' user profile and context situation, advertising companies can provide the target customers exactly the advertisement information the desire, not just "spam" them with advertisements they are not interested in.

Mobile media transcend traditional communication and support one-to-one, many-to-many, and mass communication. Phones and personal digital assistants increase the availability, frequency, and speed of communication. Yet the technology associated with these devices, which let marketers personally communicate with consumers, continues to evolve. The most popular mobile application is referred to as text messaging or Short Message Service (SMS). Advertisements take the form of short textual messages and are sent to customers as a form of one-to-one marketing.

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The rising popularity of SMS has created a new channel for mobile advertising [5]. In terms of the types of messages sent, pull SMS advertisements are displayed to consumers who have previously indicated an interest in receiving such messages and who can then decide whether to access further information [36]. Therefore, it is important and necessary to use interactive wireless advertisements to improve consumer response and acceptance rates for mobile advertising. Enpocket [11], the Intelligent Mobile Marketing Company, conducted an advertising study with more than 1200 mobile Internet users across the United States, Europe, and India, which revealed that consumers were far more accepting of mobile advertising when it was made relevant. Studies on this new advertising medium indicate that mobile advertising campaigns can generate responses that are as high as 45 percent, compared to a 5 percent response rate through direct mail and 3 percent through internet banner ads [20].

Analyzing marketing communication from the consumers' perspective, the issue of media effectiveness becomes challenging. The increased number of media has led to a harder competition for consumers' attention. Attention and time are increasingly becoming scarce resources for consumers in the information age. It has been argued that the information age empowers consumers and creates immediate 24-hour access, which changes consumers' behavior [24]. Many consumers have attitudes, aspirations, and purchasing patterns that are different compared to what companies have been used to. Today's consumers are claimed to be independent, individualistic, involved, and informed [13], which makes it harder than ever to conduct interruption-based communication.

A key issue is the responsiveness of the consumer to marketing communication. Responsiveness depicts the consumer's willingness to receive and respond to marketing communication and can be viewed as a function of the content and context of the message. Consumer responsiveness is potential highly subjective to their cognitions and related to vague perceptions [14]. Effectiveness for the purpose of this study has been concretized in terms of impact of mobile advertising on the purchase decision of the consumer. Further, an attempt has been made to analyze variations in consumer preference of responsiveness towards mobile advertising using fuzzy linguistic preference relation. Fuzzy set theory is a useful mathematical tool for dealing with the ambiguity or uncertainty of messages [44], as well as the mobile advertising analysis of consumer perceptual phenomena. This study proposes an analytic model based on the reciprocal additive consistent fuzzy preference relations to help the companies become aware of the essential factors affecting the mobile advertising implementation. Finally, we broadly concretize some features enhancing the utilitarian benefits drawn (or expected) from mobile advertising. This enhancement of benefits can be implemented by incorporating the proposed method.

The rest of this study is organized as follows. Section 2 reviews mobile advertising and goes over the key concepts of Fuzzy preference relation. An evaluation model for mobile advertising is constructed in section 4. Section 5 provides an empirical study of consumers in evaluating the effectiveness of mobile advertising. Some concluding remarks are made in the last section.

2. Literature Review

2.1. **Mobile Advertising.** Countries such as Japan, New Zealand, Germany, and the UK, which have cost-effective and interoperable wireless structures, a high penetration of mobile phones, and a relatively low cost for SMS (Short Message Service), have experienced remarkable success with the SMS application [4]. SMS has become a new technological buzzword in transmitting business-to-customer messages to such wireless devices as cellular telephones, pagers, and personal data assistants. Many brands and media companies include text message numbers in their advertisements to enable interested consumers to obtain more information [26]. Mobile advertising is predicted to be an important source of revenue for mobile operators in the future [7] and has been identified as one of the most promising potential business areas [21]. However, mobile advertising may even step over the line of discretion and invade consumers' privacy because of the personal nature of the mobile device. Li, Edwards and Lee [23] discuss how negative reactions like irritation arise through intrusive advertising.

The mobile advertising influences consumer responsiveness to marketing communication by being perceived as either disturbing or acceptable [30]. If the consumer considers marketing communication via a mobile advertising as disturbing, it may negatively affect the attention to and perception of the message. In contrast, the mobile advertising may also enhance the acceptance of the marketing communication if it is perceived as appropriate for the specific marketing communication. Also, some consumers may perceive the mobile advertising as neutral, i.e., it is neither disturbing nor accepted [9]. Mobile advertising provides a good platform for personalization since mobile devices usually carry the user's assigned identity [1]. If marketers employ mobile devices for their advertising activities, they can use consumer feedback to customize their messages and collect information about consumers' preferences to improve future offerings of products and services [2, 25]. This provides an exceptional advantage to marketers because it enables them to reach their potential consumers in an individual way and thus improves their relationship with consumers.

One of the main challenges and opportunities for mobile advertising companies is to understand and respect the personal nature of the usage of mobile phones [5, 29, 37]. The key is to use interactive wireless media to provide customers with time- and location-sensitive, personalized information that promotes goods, services, and idea, thereby generating value for all stakeholders [28]. The mobile advertising relevance can be influenced by the contextualization [19, 43] of advertising messages. Barwise and Strong [5] take up the flexibility and time-based nature of mobile advertisements and also explore the fact that the small screens restrict the length of the message. Barnes [3] stresses on the interactive nature of mobile advertising and the ability to use contextual information for targeting the messages to individual receivers, in other words, to personalized the messages.

Many internal and external factors affecting the success of mobile advertising implementation indicate that the issue is a multiple attribute decision making problem. Specially, before the companies can realize the benefit associated with

mobile advertising initiatives, a fundamental question must be asked: "What influences must be considered to ensure that mobile advertising implementation can successfully help the company increase revenues and achieve competitive competency?" In Taiwan, Tsang, Ho, and Liang [34] found the attributes of SMS (Short Messaging Service) advertising (e.g., entertainment, credibility, irritation, and informativeness) were directly related to attitudes toward mobile advertising. In a study conducted among China mobile phone users, advertising value, "a subjective evaluation of the relative worth or utility of advertising to consumers," was influenced by message characteristics [41]. In order to understand consumers' subjective perception of mobile advertising, the fuzzy linguistic preference relation is applied to solve such a problem which the lack of consistency in subjective decision making can lead to inconsistent conclusions. This study applies fuzzy linguistic preference relation to construct a pairwise comparison matrix with additive reciprocal property and consistency to alleviate inconsistencies, which is an easy and practical way to provide a mechanism for improving consistent evaluation in mobile advertising.

2.2. **Fuzzy Preference Relation.** Fuzzy preference relation enables respondents to give values for a set of criteria and a set of alternatives. The value represents the degree of the preference for the first alternative over the second alternative. Two major kinds of preference relations apply:

(a) Multiplicative preference relations [27, 12, 15, 40]: A multiplicative preference relation R in terms of a set of alternatives A is represented by a matrix $R \subseteq A \times A$, $R = (r_{ij})$, r_{ij} is the preference ration of alternative a_i to a_j. Saaty suggests measuring r_{ij} using a ratio scale, and defined 1–9 scale. Herein, $r_{ij} = 1$ represents the absence of a difference between a_i and a_j; $r_{ij} = 9$ denotes that a_i is maximally better than a_j. In this case, the preference relation R is typically assumed to be a multiplicative reciprocal, $a_{ij} \cdot a_{ji} = 1 \; \forall i, j \in \{1, 2, \ldots, n\}$.

(b) Fuzzy preference relations [6, 10, 8, 32]: A fuzzy preference relation P on a set of alternatives A is a fuzzy set on the product set $A \times A$ with membership function $u_P : A \times A \to [0, 1]$. The preference relation is represented by the $n \times n$ matrix $P = (p_{ij})$, where $p_{ij} = u_P(a_i, a_j) \; \forall i, j \in \{1, 2, \ldots, n\}$. Herein, p_{ij} is the preference ratio of alternative a_i to a_j: $p_{ij} = 1/2$ means that no difference exits between a_i and a_j, $p_{ij} = 1$ indicates that a_i is absolutely better than a_j, and $p_{ij} > 1/2$ indicates that a_i is better than a_j. In this case, the preference matrix P is generally assumed to be an additive reciprocal, $p_{ij} + p_{ji} = 1 \; \forall i, j \in \{1, 2, \ldots, n\}$.

Herrera-Viedma et al. [16] propose consistent fuzzy preference relation to construct the decision matrices of pairwise comparisons based on additive transitivity. They develop some important proposition given below.

Proposition 2.1. *Suppose there is a set of alternatives $X = \{x_1, x_2, \ldots, x_n\}$, which is associated with a reciprocal multiplicative fuzzy preference relation $A = (a_{ij})$ with $a_{ij} \in [1/9, 9]$. Then the corresponding reciprocal additive fuzzy preference relation $P = (p_{ij})$ with $p_{ij} \in [0, 1]$ to $A = (a_{ij})$ is defined as follows:*

$$p_{ij} = g(a_{ij}) = \frac{1}{2} \cdot (1 + \log_9 a_{ij}).$$

$\log_9 a_{ij}$ *is considered because* a_{ij} *is between 1/9 and 9. If* a_{ij} *is between 1/7 and 7, then* $\log_7 a_{ij}$. *With the transformation function g, a reciprocal multiplicative preference relation matrix can be transformed into kinds of preference relation.*

Proposition 2.2. *For a reciprocal fuzzy preference relation* $P = (p_{ij})$, *the following statements are equivalent:*

(a) $p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \qquad \forall i, j, k.$
(b) $p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \qquad \forall i < j < k.$

Proposition 2.3. *For a reciprocal fuzzy preference relation* $P = (p_{ij})$, *the following statements are equivalent:*

(a) $p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \qquad \forall i < j < k.$
(b) $p_{i(i+1)} + p_{(i+1)(i+2)} + \ldots + p_{(i+k-1)(i+k)} + p_{(i+k)i} = \frac{k+1}{2} \qquad \forall i < j.$

Proposition 2.3 is very important because it can be used to construct a consistent fuzzy preference relation from the set of $(n-1)$ values $\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\}$. Accordingly, decision makers are able to express consistent preferences in decision processes. A decision matrix with entries in the interval $[-k, 1+k], k > 0$ besides the interval [0, 1], can be constructed by transforming the obtained values using a transformation function that preserves reciprocity and additive consistency. The transforming function is f:

$$f : [-k, 1+k] \to [0, 1], \qquad f(x) = \frac{x+k}{1+2k}$$

The drawback of consistent fuzzy preference relation is that the values in consistent fuzzy preference relation matrix are crisp, which cannot reflect respondents' opinions when modeling imprecise judgment.

3. Construction of Fuzzy Linguistic Preference Relation (FLPR)

To solve the problems regarding the imprecise judgment in perceptual measure process, this paper constructs the framework of fuzzy linguistic preference relation (FLPR) to enhance the consistency of fuzzy AHP method. The fuzzy set theory is designed to deal with the extraction of the primary possible outcome from a multiplicity of information vaguely and imprecisely. Fuzzy set theory treats vague data as possibility distributions in terms of set memberships. Once determined and defined, the sets of memberships in possibility distributions can be effectively used in logical reasoning. Triangular fuzzy numbers are one of the major components. According to the definition of Laarhoven and Pedrycz [22], a triangular fuzzy number (TFN) should possess the basic features (see Appendix A).

This study adopts linguistic preference analysis [38, 39] and the proposed method establishes fuzzy preference relation matrices $\tilde{P} = (\tilde{p}_{ij}) = (p_{ij}^L, p_{ij}^M, p_{ij}^R)$ based on consistent fuzzy preference relation and fuzzy linguistic assessment variables. The matrices thus were termed the "Fuzzy linguistic preference relation". Table 1 lists the fuzzy linguistic assessment variables.

Linguistic variables	**Fuzzy numbers**
Very poor (VP)	$(p^L_{VP}, p^M_{VP}, p^R_{VP})$
More poor (MP)	$(p^L_{MP}, p^M_{MP}, p^R_{MP})$
Poor (P)	(p^L_P, p^M_P, p^R_P)
Some poor (SP)	$(p^L_{SP}, p^M_{SP}, p^R_{SP})$
Medium (M)	(p^L_M, p^M_M, p^R_M)
Some good (SG)	$(p^L_{SG}, p^M_{SG}, p^R_{SG})$
Good (G)	(p^L_G, p^M_G, p^R_G)
More good (MG)	$(p^L_{MG}, p^M_{MG}, p^R_{MG})$
Very good (VG)	$(p^L_{VG}, p^M_{VG}, p^R_{VG})$

TABLE 1. Fuzzy Linguistic Assessment Variables

The consistency of a fuzzy positive reciprocal matrix is defined below.

Definition 3.1. A fuzzy positive matrix $\tilde{A} = (\tilde{a}_{ij})$ is reciprocal if and only if $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$

Definition 3.2. A fuzzy positive matrix $\tilde{A} = (\tilde{a}_{ij})$ is consistent if and only if $\tilde{a}_{ij} \otimes \tilde{a}_{jk} \approx \tilde{a}_{ik}$

Proposition 3.3. *Given that a set of alternatives, $X = \{x_1, x_2, \ldots, x_n\}$ associated with a fuzzy reciprocal multiplicative preference matrix $\tilde{A} = (\tilde{a}_{ij})$ with $\tilde{a}_{ij} \in [1/9, 9]$, and the corresponding fuzzy reciprocal linguistic preference relation, $\tilde{P} = g(\tilde{p}_{ij}) = \frac{1}{2}(1 + \log_9 \tilde{a}_{ij})$ with $\tilde{p}_{ij} \in [0, 1]$, verifies the additive reciprocal, then, the following statements are equivalent.*

(a) $p^L_{ij} + p^R_{ji} = 1 \qquad \forall i, j \in \{1, 2, \ldots, n\}$.
(b) $p^M_{ij} + p^M_{ji} = 1 \qquad \forall i, j \in \{1, 2, \ldots, n\}$.
(c) $p^R_{ij} + p^L_{ji} = 1 \qquad \forall i, j \in \{1, 2, \ldots, n\}$.

Proposition 3.4. *According to Proposition 2.2 and 2.3, for a reciprocal fuzzy linguistic preference relation $\tilde{P} = (\tilde{p}_{ij}) = (p^L_{ij}, p^M_{ij}, p^R_{ij})$ to be consistent, verifies the additive consistency, then, the following statements must be equivalent:*

(a) $p^L_{ij} + p^L_{jk} + p^R_{ki} = \frac{3}{2} \quad \forall i < j < k$.
(b) $p^M_{ij} + p^M_{jk} + p^M_{ki} = \frac{3}{2} \quad \forall i < j < k$.
(c) $p^R_{ij} + p^R_{jk} + p^L_{ki} = \frac{3}{2} \quad \forall i < j < k$.
(d) $p^L_{i(i+1)} + p^L_{(i+1)(i+2)} + \ldots + p^L_{(j-1)j} + p^R_{ji} = \frac{k+1}{2} \quad \forall i < j$.
(e) $p^M_{i(i+1)} + p^M_{(i+1)(i+2)} + \ldots + p^M_{(j-1)j} + p^M_{ji} = \frac{k+1}{2} \quad \forall i < j$.
(f) $p^R_{i(i+1)} + p^R_{(i+1)(i+2)} + \ldots + p^R_{(j-1)j} + p^L_{ji} = \frac{k+1}{2} \quad \forall i < j$.

Notably, if the values of the obtained matrix $\tilde{P}$ with elements $\tilde{p}_{ij}$ in the interval $[-c, 1 + c](c > 0)$ are not in the interval [0, 1], the obtained fuzzy numbers would need to be transformed via a transformation function to preserve the reciprocity and additive consistency, namely $f : [-c, 1 + c] \to [0, 1]$, verifying

(a) $f(-c) = 0$.

(b) $f(1+c)=1$.
(c) $f(x^L)+f(x^R)=1 \quad \forall x \in [-c, 1+c]$.
(d) $f(x^M)+f(x^M)=1 \quad \forall x \in [-c, 1+c]$.
(e) $f(x^R)+f(x^L)=1 \quad \forall x \in [-c, 1+c]$.
(f) $f(x^L)+f(y^L)+f(z^R)=\frac{3}{2} \quad \forall x^L, y^L, z^R \in [-c, 1+c]$ such that $x^L+y^L+z^R=\frac{3}{2}$.
(g) $f(x^M)+f(y^M)+f(z^M)=\frac{3}{2} \quad \forall x^M, y^M, z^M \in [-c, 1+c]$ such that $x^M+y^M+z^M=\frac{3}{2}$.
(h) $f(x^R)+f(y^R)+f(z^L)=\frac{3}{2} \quad \forall x^R, y^R, z^L \in [-c, 1+c]$ such that $x^R+y^R+z^L=\frac{3}{2}$.

The linear solution verifying (a) and (b) has the form
$f(x^L)=a\cdot x^L+b$, being $a, b \in \Re$.
$f(x^M)=a\cdot x^M+b$ being $a, b \in \Re$.
$f(x^R)=a\cdot x^R+b$ being $a, b \in \Re$. These functions are

$$f(x^L)=\frac{1}{1+2c}\cdot x^L+\frac{c}{1+2c}=\frac{x^L+c}{1+2c}$$
$$f(x^M)=\frac{1}{1+2c}\cdot x^M+\frac{c}{1+2c}=\frac{x^M+c}{1+2c}$$
$$f(x^R)=\frac{1}{1+2c}\cdot x^R+\frac{c}{1+2c}=\frac{x^R+c}{1+2c}$$

Which verify (c), (d) and (e)

$$f(x^L)+f(x^R)=\frac{x^L+c}{1+2c}+\frac{x^R+c}{1+2c}=\frac{(x^L+x^R)+2c}{1+2c}=\frac{1+2c}{1+2c}=1,$$
$$f(x^M)+f(x^M)=\frac{x^M+c}{1+2c}+\frac{x^M+c}{1+2c}=\frac{(x^M+x^M)+2c}{1+2c}=\frac{1+2c}{1+2c}=1,$$
$$f(x^R)+f(x^L)=\frac{x^R+c}{1+2c}+\frac{x^L+c}{1+2c}=\frac{(x^L+x^R)+2c}{1+2c}=\frac{1+2c}{1+2c}=1,$$

and when, $x^L+y^L+z^R=\frac{3}{2}$, $x^M+y^M+z^M=\frac{3}{2}$, $x^R+y^R+z^L=\frac{3}{2}$

$$\begin{aligned} f(x^L)+f(y^L)+f(z^R)&=\frac{x^L+c}{1+2c}+\frac{y^L+c}{1+2c}+\frac{z^R+c}{1+2c}\\ &=\frac{(x^L+y^L+z^R)+3c}{1+2c}=\frac{3/2+2c}{1+2c}=\frac{3}{2},\\ f(x^M)+f(y^M)+f(z^M)&=\frac{x^M+c}{1+2c}+\frac{y^M+c}{1+2c}+\frac{z^M+c}{1+2c}\\ &=\frac{(x^M+y^M+z^M)+3c}{1+2c}=\frac{3/2+2c}{1+2c}=\frac{3}{2},\\ f(x^R)+f(y^R)+f(z^L)&=\frac{x^R+c}{1+2c}+\frac{y^R+c}{1+2c}+\frac{z^L+c}{1+2c}\\ &=\frac{(x^R+y^R+z^L)+3c}{1+2c}=\frac{3/2+2c}{1+2c}=\frac{3}{2}, \end{aligned}$$

then (f), (g) and (h) are verified.

4. Empirical Study

4.1. **Survey Instrument.** A survey instrument was developed based on the study to consumer perceptions of mobile advertising. In order to have the same sample sizes, quota sampling was employed with the questionnaires and sent to approximately 400 respondents. As a result, 308 questionnaires were completed in all respects. The response rate was 77 percent. The areas of our sampling were performed at various cities like Taipei, Taichung, Tainan and Kaoshiung in Taiwan. The time frame of the study was from June 2009 to October 2009. Primary-stage sampling units were the mobile phone users while the secondary stage sampling units were markets, shopping malls, institutions, and residential localities of the above-mentioned cities. In order to make the samples hold representative, sampling was performed in various marketplaces (78 questionnaires), shopping malls (82 questionnaires), office complexes (75 questionnaires), and some residential localities (73 questionnaires), considering the desired quotas.

The questionnaire and survey instruments were developed and designed on the basis of relevant studies from past researchers [33, 41, 45]. The first section of the questionnaire contained consumer perception towards mobile advertising. Respondents were asked to express their perceptions on the degree of importance of the factors in affecting mobile advertising by a 5-point Likert scale ranging from 1 (extremely unimportant) to 5 (extremely important). The second section comprised statements that aimed at recognizing the extent of ideas, feelings, and emotions among consumers and their attitudes and behavior in relation to mobile advertising. Respondents were asked to express their level of weighted preferences on fuzzy linguistic assessment variables ranging from "Very Poor" to "Very Good" (see Table 1). The final section measured various sociodemographic variables.

An attempt has been made to keep the sample fairly representative across the demographic variables by constructing quotas according to these factors, e.g., age, gender, occupation, and level and purpose of mobile usage. Almost 54 percent of the respondents belonged to the age group of 20 to 30 years and approximately 30 percent of the respondents belonged to the age group of more than 30 years; 30 percent of the respondents were students, 27 percent were in service, 14 percent were housewives, and 29 percent were in business; 59.7 percent were males and 40.3 percent were females; 75 percent of the respondents used their mobiles primarily for personal communication.

4.2. **Consumer Perception about Mobile Advertising.** In order to gain an insight into consumer perception towards mobile advertising, we first ran factor analysis. These factors were based on the selection of the most indicative attributes interpreted from focus group discussions and in-depth interviews with mobile users. In addition, secondary information material (prior consumer researches related to mobile advertising) was studied. This secondary material was crossed with the results of the qualitative research, namely, the results of the in-depth interviews. Finally, a list of 13 factors, adequately explaining perception of mobile users towards mobile advertising was finalized. The factor analyses results are shown in Tables 2, 3 and 4. The variance explained by the initial solution, extracted components, and

the rotated components are displayed in Table 2. The total variance shown in this Table accounted for by all of the three components explains nearly 71 percent of the variability in the original 13 variables. So, we can reduce the original dataset by using these three components, including "lack of contextualization", "perceived usefulness" and "disruptive nature" (Eigen values greater than 1 as shown in Table 2) with only 26 percent loss of information.

Component	Rotation sum of squared loadings		
	Total	% of variance	Cumulative %
1	3.763	30.704	30.704
2	2.534	24.896	55.600
3	2.098	18.634	74.234

Table 2. Total Variance Explained

Kaiser-Meyer-Olkin measure of sampling adequacy		0.830
Bartlett's test of sphericity	Approx. Chi-Square	1635.042
	Df	78
	Sig.	0.0000

Table 3. KMO and Bartlett's Test

	Component		
	1	2	3
Less informative	0.678	−0.137	0.136
Does not suit personal needs	0.812	−0.126	0.049
Relayed at the wrong time	0.734	−0.051	0.183
Clutter as a result of too many ads	0.618	0.032	0.284
Recall of brands advertised	−0.243	0.677	−0.161
Recall of sale/special promotions	−0.132	0.694	−0.067
Recall of products/services advertised	−0.086	0.776	−0.056
Ad positioning	−0.007	0.635	0.092
Positive impact of mobile ads	0.046	0.683	−0.107
Cause disturbance at work	0.431	−0.089	0.653
Junk ads without going through it	0.387	−0.168	0.690
Time-consuming to go through ads	0.213	−0.105	0.704
Loss of privacy	0.033	0.034	0.779

Table 4. Rotated Component Matrix

The Rotated Component Matrix reveals three factors (which represent the three broad perceptual dimensions about mobile advertising) derived from 13 variables (which represent the perception of mobile users towards mobile advertising). The components of each factor have been highlighted in Table 4.

(1) Factor 1 incorporates the variables: mobile ads are less informative, do not satisfy personal needs, inappropriate timing, and clutter. Since all these variables are related to lack of contextualization and personalization, this factor can labeled as "lack of contextualization".

(2) Factor 2 incorporates the variables: brand recall, recall of sales/promotion information, recall of product/services, ad positioning and repetitive nature of mobile ads, and positive impact of mobile ads. Since all these components are related to perceived usefulness of mobile advertising, this factor can be labeled as "perceived usefulness" of mobile ads.
(3) Factor 3 incorporates the variables: causing disturbance at work, busy work schedule, wastage of time, and loss of privacy. Since all these components are related to disturbance caused due to mobile advertising, this factor can be labeled as "disruptive nature" of mobile ads.

Thereafter, to gain further insight into the perception of mobile users (towards mobile advertising), we used the proposed FLPR, designed for situations in which ideas, feelings, and emotions are to be quantified and decision alternatives based on them are prioritized. A FLPR is a multi-criteria decision-making procedure. Here the respondents provide weighted preferences for the criteria, which are used to determine the preferences for the decision alternatives. FLPR is used due to its suitability for undertaking quantitative as well as qualitative analysis. This proposed approach differs from other multi-criteria methods as subjective judgments are readily included and inconsistencies are dealt with appropriately.

4.3. **Relative Importance Ratings of Mobile Advertising.** The proposed FLPR is demonstrated using the mobile advertising. A media/software agent is considering the impact of mobile advertising on purchase decisions of mobile users. The criteria considered in this decision are lack of contextualization (C1), perceived usefulness (C2), disruptive nature (C3). The sub-criteria of "the lack of contextualization" are less informative (C11), do not satisfy personal needs (C12), inappropriate timing (C13), and clutter (C14). The sub-criteria of "perceived usefulness" are brand recall (C21), recall of sales/promotion information (C22), recall of product/services (C23), ad positioning and repetitive nature of mobile ads (C24), and positive impact of mobile ads (C25). The sub-criteria of "disruptive nature" are causing disturbance at work (C31), busy work schedule (C32), wastage of time (C33), and loss of privacy (C34). Finally, the mobile advertising alternatives are generalized advertisement (P1), permission advertising (P2), and personalization/customization advertisement (P3). Figure 1 shows the hierarchy structure.

Part 1: *Interval of each triangular fuzzy number*

Figure 2 illustrates the interval of each triangular fuzzy number for degree of importance. The meaning of each triangular fuzzy number is expressed as follows: Very poor (VP) = (0.1, 0.1, 0.2), More poor (MP) = (0.1, 0.2, 0.3), Poor (P) = (0.2, 0.3, 0.4), Some poor (SP) = (0.3, 0.4, 0.5), Medium (M) = (0.4, 0.5, 0.6), Some good (SG) = (0.5, 0.6, 0.7), Good (G) = (0.6, 0.7, 0.8), More good (MG) = (0.7, 0.8, 0.9), Very good (VG) = (0.8, 0.8, 0.9). A triangular fuzzy number is demoted simply as (p^L, p^M, p^R). The parameters P^L, P^M and P^R indicate the smallest possible value, the most promising value, and the largest possible value, respectively.

The mobile users express according to one of the opinions contained in Figure 1. The mobile users can also add or remove linguistic terms according to a specific

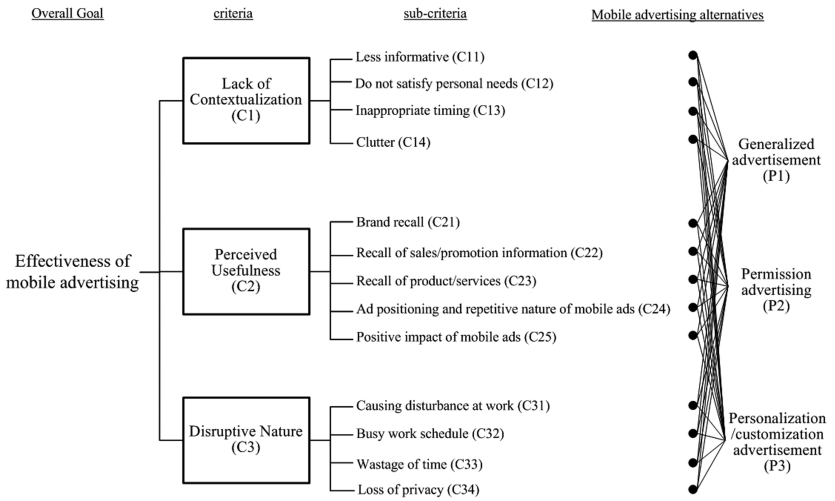


FIGURE 1. The Hierarchy Framework of the Mobile Advertising

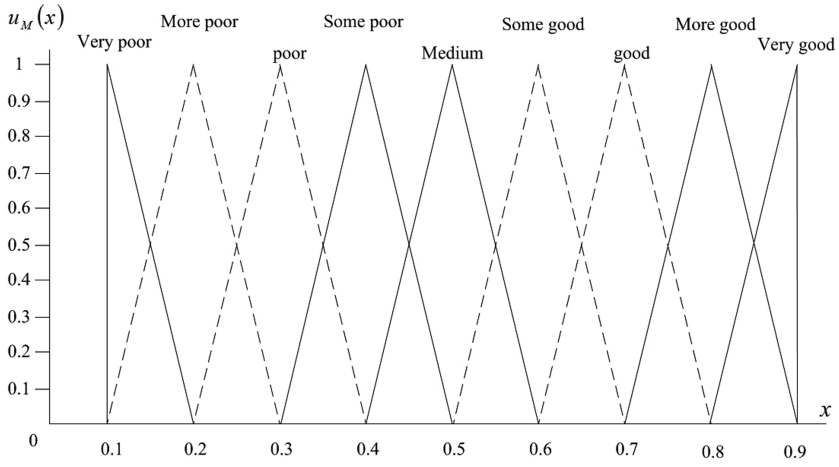


FIGURE 2. Interval of Each Triangular Fuzzy Number for Degree of Importance

situation. For example, the accuracy and the number of terms are increased as more detailed information becomes available.

Part 2: *Relative importance degree of mobile advertising*

Please place a check "VP" "MP" "P" "SP" etc. on the pairwise comparison matrix for the degree of importance of the criteria. Table 5 lists the pairwise comparison matrix for the goal and all criteria of mobile advertising. The sign

"×" indicates the remaining $\tilde{a}_{ij}^k$ which can be done by Propositions 3.3 and 3.4. Tables 6∼8 displays the pairwise comparison matrix for all criteria and sub-criteria of mobile advertising. Tables 9∼11 lists the pairwise comparison matrix for all sub-criteria and mobile advertising alternatives.

Goal	Lack of contextualization (C1)	Perceived usefulness (C2)	Disruptive nature (C3)
Lack of contextualization (C1)	(1,1,1)	P	×
Perceived usefulness (C2)	×	(1,1,1)	G
Disruptive nature (C3)	×	×	(1,1,1)

The sign "×" indicates the remaining $\tilde{a}_{ij}^k$ which can be done by Proposition 3.3 and 3.4.

TABLE 5. Pairwise Comparison of Three Criteria with Respect to the Goal

C1	Less informative	Do not satisfy personal needs	Inappropriate timing	Clutter
Less informative	(1,1,1)	MG	×	×
Do not satisfy personal needs	×	(1,1,1)	P	×
Inappropriate timing	×	×	(1,1,1)	G
Clutter	×	×	×	(1,1,1)

TABLE 6. Pairwise Comparison of "Lack of Contextualization (C1)" with Respect to the Sub-criteria

C2	Brand recall	Recall of sales/promotion information	Recall of product/services	Ad positioning	Positive impact
Brand recall	(1,1,1)	G	×	×	×
Recall of sales/promotion information	×	(1,1,1)	P	×	×
Recall of product/services	×	×	(1,1,1)	VG	×
Ad positioning	×	×	×	(1,1,1)	MP
Positive impact	×	×	×	×	(1,1,1)

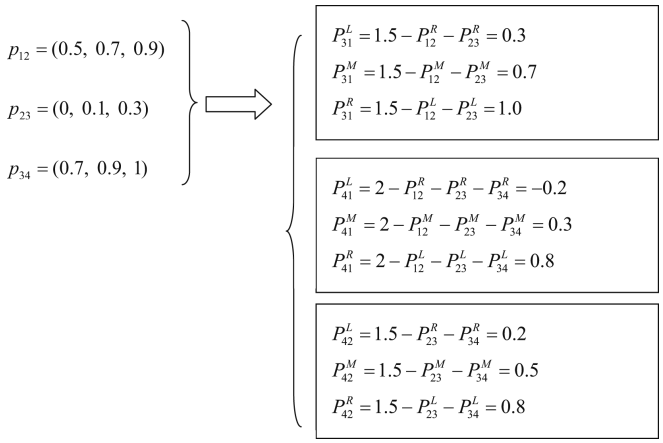
TABLE 7. Pairwise Comparison of "Perceived Usefulness (C2)" with Respect to the Sub-criteria

C3	Causing disturbance at work	Busy work schedule	Wastage of time	Loss of privacy
Causing disturbance at work	(1,1,1)	MP	×	×
Busy work schedule	×	(1,1,1)	P	×
Wastage of time	×	×	(1,1,1)	MP
Loss of privacy	×	×	×	(1,1,1)

TABLE 8. Pairwise Comparison of "Perceived Usefulness (C3)" with Respect to the Sub-criteria

For example, "Less of contextualization" of mobile advertising has four sub-criteria in Table 6, and only $n-1=4-1=3$ comparison judgments (p_{12}, p_{23}, p_{34})

are required to construct the decision matrix of fuzzy linguistic preference relation. According to Propositions 3.3 and 3.4, the entire calculation is as follows:



	Generalized advertisement (P1)	Permission advertising (P2)	Personalization/customization advertisement (P3)
Less informative (C11)			
P1	(1,1,1)	M	×
P2	×	(1,1,1)	P
P3	×	×	(1,1,1)
Do not satisfy personal needs (C12)			
P1	(1,1,1)	MP	×
P2	×	(1,1,1)	M
P3	×	×	(1,1,1)
Inappropriate timing (C13)			
P1	(1,1,1)	G	×
P2	×	(1,1,1)	MG
P3	×	×	(1,1,1)
Clutter (C14)			
P1	(1,1,1)	P	×
P2	×	(1,1,1)	MP
P3	×	×	(1,1,1)

TABLE 9. Pairwise Comparison of Three Alternatives with Respect to the Sub-criteria (C11∼C14)

Table 12 lists the FLPR decision matrix for four sub-criteria of "Lack of contextualization (C1)". The matrix has entries that are not included in the interval [0,1], thus the following transforming are applied: $f(x^L) = \frac{x^L+c}{1+2c}$, $f(x^M) = \frac{x^M+c}{1+2c}$, $f(x^R) = \frac{x^R+c}{1+2c}$. The average (A_i) in Table 13 is calculated as $A_i = \frac{1}{n}(\sum_{j=1}^{n} p_{ij})$, and the weight (W_i) is calculated as $W_i = A_i / \sum_{i=1}^{n} A_i$.

	Generalized advertisement (P1)	Permission advertising (P2)	Personalization/customization advertisement (P3)
C21			
P1	(1,1,1)	P	×
P2	×	(1,1,1)	M
P3	×	×	(1,1,1)
C22			
P1	(1,1,1)	MP	×
P2	×	(1,1,1)	P
P3	×	×	(1,1,1)
C23			
P1	(1,1,1)	M	×
P2	×	(1,1,1)	P
P3	×	×	(1,1,1)
C24			
P1	(1,1,1)	MG	×
P2	×	(1,1,1)	P
P3	×	×	(1,1,1)
C25			
P1	(1,1,1)	P	×
P2	×	(1,1,1)	MG
P3	×	×	(1,1,1)

TABLE 10. Pairwise Comparison of Three Alternatives with Respect to the Sub-criteria (C21∼C25)

	Generalized advertisement (P1)	Permission advertising (P2)	Personalization/customization advertisement (P3)
C31			
P1	(1,1,1)	G	×
P2	×	(1,1,1)	G
P3	×	×	(1,1,1)
C32			
P1	(1,1,1)	M	×
P2	×	(1,1,1)	P
P3	×	×	(1,1,1)
C33			
P1	(1,1,1)	G	×
P2	×	(1,1,1)	M
P3	×	×	(1,1,1)
C34			
P1	(1,1,1)	MP	×
P2	×	(1,1,1)	MP
P3	×	×	(1,1,1)

TABLE 11. Pairwise Comparison of Three Alternatives with Respect to the Sub-criteria (C31∼C34)

Part 3: *Establishing a synthetic mobile advertising alternative score*

C1	Less informative	Do not satisfy personal needs	Inappropriate timing	Clutter
Less informative	(0.5, 0.5, 0.5)	**(0.5, 0.7, 0.9)**	(0.0, 0.3, 0.7)	(0.2, 0.7, 1.2)
Do not satisfy personal needs	(0.1, 0.3, 0.7)	(0.5, 0.5, 0.5)	**(0.0, 0.1, 0.3)**	(0.2, 0.5, 0.8)
Inappropriate timing	(0.3, 0.7, 1.0)	(0.7, 0.9, 1.0)	(0.5, 0.5, 0.5)	**(0.7, 0.9, 1.0)**
Clutter	(−0.2, 0.3, 0.8)	(0.2, 0.5, 0.8)	(0.0, 0.1, 0.3)	(0.5, 0.5, 0.5)

TABLE 12. Fuzzy Linguistic Preference Relation Decision Matrix of "Lack of Contextualization (C1)" with Respect to the Sub-criteria

	Less informative	Do not satisfy personal needs	Inappropriate timing	Clutter	Average (A_i)	Weight (W_i)
Less informative	(0.50,0.50,0.50)	(0.50,0.64,0.79)	(0.14,0.36,0.64)	(0.29,0.64,1.00)	(0.36,0.54,0.73)	(0.14,0.27,0.52)
Do not satisfy personal needs	(0.21,0.36,0.50)	(0.50,0.50,0.50)	(0.14,0.21,0.36)	(0.29,0.50,0.71)	(0.29,0.39,0.52)	(0.11,0.20,0.37)
Inappropriate timing	(0.36,0.64,0.86)	(0.64,0.79,0.86)	(0.50,0.50,0.50)	(0.64,0.79,0.86)	(0.54,0.68,0.77)	(0.21,0.34,0.54)
Clutter	(0.00,0.36,0.71)	(0.29,0.50,0.71)	(0.14,0.21,0.36)	(0.50,0.50,0.50)	(0.23,0.39,0.57)	(0.09,0.20,0.41)

TABLE 13. Transforming Results of the Four Criteria Matrix from Table 12

Finally, the simple additive weighted method is used to aggregate the final synthetic score with respect to each mobile advertising alternative. We can then obtain the consumer perception towards mobile advertising based on the final score.

Apart from the proposed FLPR, the defuzzification procedure has been found to derive the best non-fuzzy performance (BNP) value as fuzziness in the data. Since utilizing the Centroid method (COA, center of area) to determine the BNP is a practical measure and introducing the preferences of evaluators is unnecessary [42, 35, 31]. The BNP value of the triangular fuzzy number (p^L, p^M, p^R) can be obtained by $BNP_i = [(P^R - P^L) + (P^M - P^L)]/3 + P^L$. Each alternative of mobile advertising can then be evaluated. The order of importance of each sub-criterion can also be ranked according to the value of the derived BNP. Finally, Table 14 shows the results of the sub-criteria weights for consumer responsiveness towards mobile advertising. And Table 15 shows BNP values of the fuzzy performance scores with respect to the sub-criteria.

4.4. **Results and Discussions.** From Table 14, the five most important sub-criteria in determining the prioritizations of reactions towards mobile advertisements are wastage of time (C33), busy work schedule (C32), less informative (C11), do not satisfy personal needs (C12) and loss of privacy (C34). Hence, we can safely assume that respondents reacted with irritation and indifference towards mobile advertising. Also, the responds apparently got confused, on being bombarded with a plethora of advertisements from various sources. It can thus be inferred that mobile advertising in its current format is unacceptable to customers and requires inclusion of certain attributes so that the relevance and utility value of such marketing messages, increases their overall acceptance by consumers.

Criteria and sub-criteria	Local weights	Overall weights	BNP	Ranking
Lack of contextualization	(0.18, 0.28, 0.89)			
C11	(0.14, 0.27, 0.52)	(0.038, 0.109, 0.740)	0.295	3
C12	(0.11, 0.20, 0.37)	(0.039, 0.098, 0.710)	0.282	4
C13	(0.21, 0.34, 0.54)	(0.034, 0.083, 0.456)	0.191	8
C14	(0.09, 0.20, 0.41)	(0.039, 0.096, 0.543)	0.225	6
Perceived usefulness	(0.16, 0.27, 0.78)			
C21	(0.12, 0.13, 0.63)	(0.022, 0.035, 0.493)	0.183	9
C22	(0.12, 0.12, 0.52)	(0.021, 0.034, 0.410)	0.154	12
C23	(0.12, 0.12, 0.53)	(0.022, 0.035, 0.413)	0.156	10
C24	(0.12, 0.12, 0.52)	(0.021, 0.034, 0.411)	0.155	11
C25	(0.11, 0.11, 0.51)	(0.019, 0.031, 0.405)	0.152	13
Disruptive nature	(0.17, 0.27, 0.87)			
C31	(0.27, 0.28, 0.58)	(0.048, 0.077, 0.516)	0.214	7
C32	(0.25, 0.35, 0.85)	(0.043, 0.096, 0.746)	0.296	2
C33	(0.25, 0.37, 0.85)	(0.043, 0.102, 0.746)	0.297	1
C34	(0.20, 0.31, 0.72)	(0.036, 0.087, 0.633)	0.252	5

TABLE 14. The Sub-criteria Weights for Evaluating Mobile Advertising

Alternatives	BNP values of sub-criteria								
	C11	C12	C13	C14	C21	C22	C23	C24	C25
Generalized advertisement	72.70	53.66	73.46	59.90	71.43	73.20	66.22	64.29	57.02
Permission advertising	68.69	52.65	67.25	60.65	64.11	67.73	62.78	59.93	55.33
Personalization/customization advertisement	65.34	56.49	69.09	54.48	70.06	70.03	62.37	64.38	57.85
	C31	C32	C33	C34					
Generalized advertisement	58.62	57.59	56.83	52.13					
Permission advertising	60.15	58.83	62.24	57.51					
Personalization/customization advertisement	51.81	49.55	44.46	43.05					

TABLE 15. The BNP Values of the Fuzzy Performance Scores with Respect to the Sub-criteria

Based on the procedure of the FLPR method mentioned above, the final synthetic score (Table 14 and Table 15) with respect to each alternative of mobile advertisement are summarized in Table 16. The synthetic scores for mobile advertisement alternatives are also ranked as follows: Personalization/customization advertisement $\succ$ Permission advertising $\succ$ Generalized advertisement, in which Personalization/customization advertisement $\succ$ Permission advertising indicating that Personalization/customization is preferred Permission advertising. However, the ranking order is Permission advertising $\succ$ Generalized advertisement $\succ$ Personalization/customization advertisement as the fuzzy preference relation method is further employed. Notably, ranking order differed when the two methods are used to obtain overall scores. The ranking derived by using the FLPR appears reasonable since the ranking correlated with the statistical analysis of our questionnaire for current major mobile ads strategy in Taiwan. The main reasons for these statistical results may be that the fuzzy preference relation method adopts the values in consistent relation matrix are crisp while the values in FLPR method are linguistics with fuzzy number.

Alternatives	The FLPR		Fuzzy preference relations		Current ads strategy[a]
	Synthetic scores	Ranking	Synthetic scores	Ranking	Ranking
Generalized advertisement	59.71	3	60.95	2	3
Permission advertising	61.68	2	62.88	1	2
Personalization/customization advertisement	63.74	1	56.54	3	1

a: Current ads strategy represents the statistical analysis of our questionnaire for current major mobile ads strategy in Taiwan.

TABLE 16. Compare the Results of the FLPR and Fuzzy Preference Relations

After verifying the FLPR method, the ranking effects of the demographic variables are further investigated. Table 17 and Figure 3 indicate that the occupation rankings of students, service and business are equivalent to the whole samples. Nevertheless, the occupation ranking of housewives clearly differed from the others. Moreover, Spearman' test [46] is conducted to analyze the ranking results of both students and housewives. According to results of Spearman's test, low correlation could be found between students and housewives ($P > 0.05$). Restated, the rankings of the students differ with respect to service and business. To explain this finding, housewives of Taiwan living in Taipei are interviewed. Most interviewed housewives agree that advertisers should have permission and convince consumers of the utility of the messages to "opt-in" before sending advertisements. They also think a simple registration ensures sending relevant messages to an interested audience. Unsolicited messages, commonly known as spam, stifle user acceptance – particularly as mobile phones cannot distinguish between spam and genuine communication automatically. Additionally, personalizing messages increases consumers' impact. Similar to traditional media, a personalized SMS campaign relies upon databases with enough active and potential clients to reach the target group profitably. Such databases regularly contain personal information such as leisure activities, holidays, music and media interests, type of internet access, occupation, marital status, car ownership, and income.

Alternatives	Students	Service	Housewives	Business
	Ranking	Ranking	Ranking	Ranking
Generalized advertisement	3	3	3	3
Permission advertising	2	2	1	2
Personalization/customization advertisement	1	1	2	1

TABLE 17. The Comparison of Occupation Variables for Mobile Advertising

The key findings of the extended analysis can be summarized as follows. First, the traditional fuzzy preference relation ignores the problem of preference variance and cannot perform rational decision-making in practice. To address this problem, the FLPR decision-making model is proposed to overcome the consistent and interval problem among criteria. Applying the proposed approach to an actual mobile advertising indicate that the method is both operational and rational. Second, the study reveals distinct preferences expressed by consumers regarding the desirable

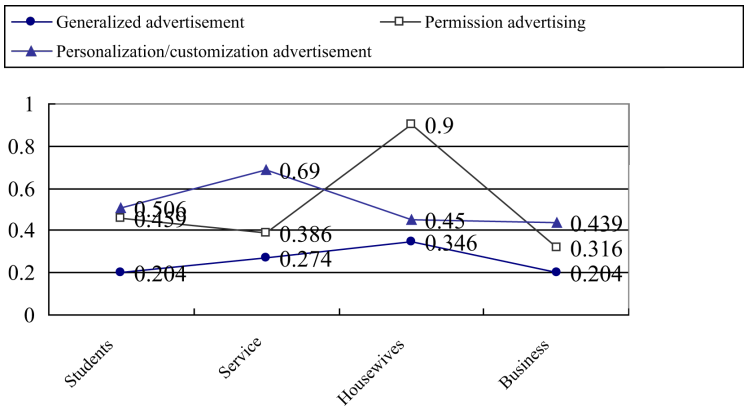


FIGURE 3. The Spread of Mobile Dvertising in Different Types of Occupations

content of such messages. Consumers are looking for customization of mobile marketing messages as per their individual requirements, tastes, and preferences. Hence the need of the hour appears to be personalization and customization. Finally, the challenge lies in customizing the marketing communication to suit individual needs (customization), i.e., reaching the right target market with the right message at the right time.

5. **Conclusion**

This study presents a FLPR model for mobile advertising, especially when the issue has multiple attribute characteristics and vast body of data that are often inaccurate or uncertain. The FLPR model involves several components: (1) fuzzy linguistic preference, (2) fuzzy positive reciprocal matrix, (3) transformation function. A study of a series of methods provides academics and managers a macro view of the strategies for implementing mobile advertising.

To demonstrate the applicability of the proposed methodology, this study designs and conducts a questionnaire survey as well as interviews to examine the effectiveness of mobile advertising. The results from the empirical study reveal some essential properties as follows. First, the mobile advertising in its current format does not have a significant impact on the purchase decision of consumers, and that there might be other significant factors (like consumers' socio-cultural environment) affect their purchase decision. Second, mobile marketing efforts don not have a substantial impact on the purchase decision of the consumer. The crux of the problem lies not in relaying mobile advertising messages to mobile users, but in the mass marketing approach being adopted by the companies. Finally, some features enhancing the practical benefits drawn or expected from mobile advertising are prioritized. Further, companies confer that these findings would be useful when selecting mobile advertising for marketing strategy mix. This survey is significant in practice due to combining consumers' user profile and the context situation. Advertising companies can provide the target consumers exactly the advertisement information they desire, not just "spam" them with irrelevant advertisements.

Our research differs from fuzzy AHP and fuzzy preference relation method in several respects. First, the FLPR method solves the uncertainty using linguistic and fuzzy numbers instead of 1–9 scale. Besides, the method constructs the decision matrices of pair-wise comparisons using an additive transitivity. Only $n-1$ comparisons are required to ensure consistency for a level with n criteria. Finally, the presented FLPR method is an easy and practical way to provide a mechanism for improving consistency in fuzzy AHP method. This research has attempted to propose a perceptual measure model in the mobile marketing messaging service, with the objective of increasing its overall acceptance, utility value, and impact (in terms of positively affecting purchase decisions) on the perception of mobile users or target consumers. In addition, the limitations of this research in regard to data acquisition prevent us from analyzing more the issue of independence or dependence. A future study can be expanded to cover interaction/inter-dependencies with the fuzzy analytical network process (FANP) to validate the findings of the present study.

6. **Appendix**

A fuzzy number $\tilde{A}$ on $\Re$ in side to be a TFN if its membership function $u_{\tilde{A}}(x) : \Re \to [0,1]$ is equal to

$$u_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l) & l \leqslant x \leqslant m, \\ (u-x)/(u-m) & m \leqslant x \leqslant u, \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

where l and u represent the lower and upper bounds of the fuzzy number $\tilde{A}$, respectively, and m is the median value. The TFN is denoted as $\tilde{A} = (l, m, u)$ and the following is the operational laws of two TFNs $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$, as shown [18]:
Fuzzy number addition $\oplus$:

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2). \tag{2}$$

Fuzzy number subtraction Θ:

$$\tilde{A}_1 \Theta \tilde{A}_2 = (l_1, m_1, u_1) \Theta (l_2, m_2, u_2) = (l_1 - u_2, m_1 - m_2, u_1 - l_2). \tag{3}$$

Fuzzy number multiplication $\otimes$:

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) \cong (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \text{ for } l_1 \geqslant 0, l_2 \geqslant 0. \tag{4}$$

Fuzzy number reciprocal:

$$(\tilde{A})^{-1} = (l, m, u)^{-1} \cong (1/u, 1/m, 1/l) \text{ for } l > 0. \tag{5}$$

Fuzzy number logarithm:

$$\log_n(\tilde{A}) \cong (\log_n l, \log_n m, \log_n u) \quad n \text{ is base } l > 0. \tag{6}$$

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