Utilizing Analytic Hierarchy Process to Analyze Consumers’ Purchase Evaluation Factors of Smartphones

Yi-Chung Hu and Yu-Lin Liao

Abstract—Due to the fast development of technology, the competition of technological products is turbulent; therefore, it is important to understand the market trend, consumers’ demand and preferences. As the smartphones are prevalent, the main purpose of this paper is to utilize Analytic Hierarchy Process (AHP) to analyze consumer’s purchase evaluation factors of smartphones. Through the AHP expert questionnaire, the smartphones’ main functions are classified as “user interface”, “mobile commerce functions”, “hardware and software specifications”, “entertainment functions” and “appearance and design”, five aspects to analyze the weights. Then four evaluation criteria are evaluated under each aspect to rank the weights. Based on an analysis of data shows that consumers consider when purchase factors are “hardware and software specifications”, “user interface”, “appearance and design”, “mobile commerce functions” and “entertainment functions” in sequence. The “hardware and software specifications” aspect obtains the weight of 33.18%; it is the most important factor that consumers are taken into account. In addition, the most important evaluation criteria are central processing unit, operating system, touch screen, and battery function in sequence. The results of the study can be adopted as reference data for mobile phone manufacturers in the future on the design and marketing strategy to satisfy the voice of customer.

Keywords—Analytic Hierarchy Process (AHP), evaluation criteria, purchase evaluation factors, smartphone.

I. INTRODUCTION

THE mobile phone markets are a swift and turbulent market environment due to the fast development of technology and increased competition and change. According to the international marketing institution, IDC’s (International Data Corporation) analysis report shows that the world-wide smartphone shipments have grown 15% and reached 170 million in 2009 and furthermore the selling of smartphones will dramatically rise 55% by 2012. Therefore smartphones have shown the rapid growth and evolution.

Mobile phones have become a fundamental part of personal communication across the globe during the past ten years. After years of development and innovation, the mobile phone industry has evolved from voice phones to smartphones. Generally, a smartphone is the product of convergence of regular mobile phone and PDA (personal digital assistant); hence a smartphone not only comes with a telecommunication function but incorporates the functionalities of PDA, such as Personal Information Management (PIM), multi-media, program application, Internet, and e-mail service. As the mobile phone market is a typical technology push driven market where products are created ahead of the recognition of existing recognized consumer needs [1], in such a market environment, a smartphone selection becomes an important issue to a consumer. According to Woodruff [2], customers’ needs can be satisfied with product characters and functions. If the product or service can increase the utility/value, then customers will purchase these products. Since more and more consumers consider the smartphone is convenient and necessary in their daily lives, the producers had started to develop their sale strategies based on consumer preferences over time [3]. As the smartphone has become one of the most desirable electronic products for consumers, it is important for smartphone manufactures to comprehend the evaluation factors of consumers. Based on consumers’ needs, then the smartphone manufactures can plan the development strategy for satisfying the consumers’ voice of sound. In such circumstances, the smartphone evaluation can be considered as a multiple criteria decision problem. One of the most outstanding MCDM (multiple criteria decision making) approaches is the Analytic Hierarchy Process (AHP) which has its roots on obtaining the relative weights among the factors. Therefore, in this study, we use the AHP to propose an evaluation model with five aspects (user interface, mobile-commerce function, software and hardware specifications, entertainment function, and appearance and design) and twenty criteria to understand consumers’ choice and adoption behaviors.

The remainder of this paper is structured as follows. The related studies are reviewed in Section II. Then an evaluation framework of smartphones is proposed in Section III. The AHP method to evaluate criteria and compute the criteria weights in Section IV. Finally, results and conclusions are presented in Section V and VI.

II. BACKGROUND

Researchers have various perspectives towards smartphones, for instance, “There is a significant difference between
smartphones and traditional phones, and defined smartphones are progress and require integrating multiple requirements into one device”. TRI’s (2006) industry report: The product trend of a smartphone is not only business-oriented but also entertainment-oriented. Beside, slim and fashion modeling, high resolution touch screen, high battery efficiency etc.

The related literature studies are to investigate what is the importance of the smartphone feature preferences for consumer. Han et al. [4], Chuang et al. [5], Han and Hong [6] attempted to investigate the relationship between user preferences of mobile phones and their design elements. User satisfaction depends on the product design and they build relationship models based on experimental data to predict user satisfaction and to provide significant remedies for design change. Chuang, Chang, and Hsu [5] analyzed the preference impression of design trend and design elements for mobile phones by the morphological analysis method, then defined the soft critical design elements to evaluate the suitable design solution of mobile phone. Isiklar and Buyukozkan [7] developed a multi-criteria decision making (MCDM) approach to evaluate the mobile phone options in respect to the users’ preferences order.

Some researches concentrate on the mobile phone attributes and usage. It is well known that usability is a significant quality attribute of mobile phones and thus usability evaluation is becoming increasingly important in the mobile phone industry [8]. A research of product design for mobile phone considered product form features should include body (length, width, thickness, volume, and type), function button (type, style), number button (shape, arrangement) and panel (detail treatment). They analyzed the customer’ needs of product designs for different styles users (plain, sports, female, simplicity and business) [9]. Chang, Chen and Zhou [10] identified nineteen features for the ideal smartphone and suggested eleven “must-have” and eight “desirable-to-have” features. Tetard and Collan [11] argued that users are in principle lazy and they are reluctant to make extra effort in complex situation-like choosing service that fits their needs.

AHP is a Multiple Criteria Decision Making (MCDM) method and has been widely used in weighing user requirements and preferences in many studies [12], [13]. Isiklar and Buyukozkan [7] have also used AHP as their research approach to evaluate users’ preferences toward different mobile phone alternatives. Nikouand Mezei [14] evaluated the mobile services and substantial adoption factors with AHP.

III. AN EVALUATION FRAMEWORK FOR SMARTPHONE MARKET

It is evident that the mobile phones are deeply rooted in every person’s everyday life and enable undertaking of many tasks, therefore, the smartphone’s great market potential and its popularity in telecom world can’t be neglected.

AHP techniques enable to structure the problem explicitly and systematically. With the characteristics, decision makers can easily examine the problem and scale it in compliance with their requirements. Therefore, we utilize AHP approach to analyze consumers’ purchase evaluation factors of smartphones.

The evaluation procedure of this study consists of three main steps and summarized in Fig. 1.

Step 1. Identifying the smartphone evaluation aspects and criteria that are considered important for the users.

Step 2. Constructing the evaluation criterion hierarchy and calculating the criteria weights.

Step 3. Finding out the final ranking results.

![Fig. 1 The evaluation procedure](image-url)
TABLE I
EVALUATION ASPECTS AND CRITERIA

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criteria</th>
</tr>
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<tbody>
<tr>
<td>User interface</td>
<td>Touch screen</td>
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<tr>
<td></td>
<td>Easy to internet access</td>
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<tr>
<td></td>
<td>High quality screen</td>
</tr>
<tr>
<td></td>
<td>Operation platform</td>
</tr>
<tr>
<td>Mobile-commerce function</td>
<td>Word processing</td>
</tr>
<tr>
<td></td>
<td>E-mail service</td>
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<tr>
<td></td>
<td>Personal information manager (PIM)</td>
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<tr>
<td></td>
<td>Global positioning system (GPS)</td>
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<tr>
<td>Software and Hardware</td>
<td>Battery life</td>
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<tr>
<td>specifications</td>
<td>High-speed Internet access</td>
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<tr>
<td></td>
<td>Build-in memory</td>
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<tr>
<td></td>
<td>Central processing unit (CPU)</td>
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<tr>
<td>Entertainment function</td>
<td>Photograph function</td>
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<tr>
<td></td>
<td>Multimedia</td>
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<tr>
<td></td>
<td>Sound recording</td>
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<tr>
<td></td>
<td>Mobile TV</td>
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<tr>
<td>Appearance and design</td>
<td>Style design</td>
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<td></td>
<td>Cover material</td>
</tr>
<tr>
<td></td>
<td>Screen size</td>
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<tr>
<td></td>
<td>Weight</td>
</tr>
</tbody>
</table>

IV. AHP METHODOLOGY

The Analytic Hierarchy Process (AHP) is a multiple criteria decision making method proposed by Saaty [15]-[17]. AHP was applied to uncertain decision problems with multiple criteria, and has been widely used in solving problems of ranking, selection, evaluation, optimization, and prediction decisions. AHP is a comprehensive framework designed to deal with the intuitive, rational response when we make multi-objective, multi-criteria, and multi-factor decisions with and without certainty for any number of alternatives.

The AHP includes four steps as follows:

Step 1. Develop the hierarchy structure

Decompose the analytic hierarchy of the decision problem. In order to ensure the consistency test, the analytic hierarchy does not exceed 7 in one level.

Step 2. Construct the pair-wise comparison matrix

Pair-wise comparison of the relative importance of factors/criteria and obtain an \( n \times n \) pair-wise comparison matrix, \( n \) means the number of criteria.

Step 3. Test consistency

AHP calculates the judgment consistency using the consistency index (C.I.) and consistency ratio (C.R.). The C.I. value is defined as \( C.I. = \frac{(\lambda_{\text{max}} - n)}{(n - 1)} \), and the \( \lambda_{\text{max}} \) is the largest eigenvalue of the pair-wise comparison matrix. The C.R. value is defined as \( C.R. = C.I./R.I. \) (R.I.: random index). The R.I. value is decided by the value of \( n \). In general, the values of C.I. and C.R. should be less than 0.1.

Step 4. Synthesis of the results to obtain a final ranking

Use the normalized eigenvector of the largest eigenvalue \( (\lambda_{\text{max}}) \) as the factor weights and obtain a ranking, as shown in Table III and Table IV.

In the decomposition step, the components of the problem are organized in a hierarchical structure as shown in Fig. 2. The main goal of determining the most influential factors of purchasing a smartphone can be considered by evaluating the aspects of user interface, mobile-commerce function, software and hardware specifications, entertainment function and appearance and design. These aspects can be decomposed four criteria respectively.

After the hierarchical tree is constructed, pairwise comparisons are made in terms of importance for all combinations of elements. When comparing a pair of criteria, a ratio of relative importance expressed on a verbal scale is generally used as shown in Table II.

Consistency index (C.I.) and consistency ratio (C.R.) are used to evaluate the consistency of the pair-wise comparison matrix. The results of C.I. and C.R. are depicted in Table III.
The problem of evaluating factors consists of three levels: the high level is the objective, the evaluating aspects are listed in the second level and the last level is the criteria.

The AHP methodology constructs the pair-wise comparisons of the aspects and the criteria in order to determine their weights. According to the aspect weights, Table V shows the aspect of software and hardware specifications play a main role with an overall weight of 33%. The weight of the user interface is 32%.

Furthermore, the consensus degree of criteria is shown as Table IX. In the first aspect of user interface, the highest degree of consensus is the criterion of operation platform. In the second aspect of mobile-commerce function, the highest degree of consensus is the criterion of e-mail service. Among the criteria of the next aspect of software and hardware specifications, the criterion of photograph function has the highest degree of consensus. In the last aspect of appearance and design, the highest degree of consensus is the criterion of screen size.

The scree plot of criteria weights ranking (Fig. 3) indicates that all the criteria can be divided into three groups. As shown in Fig. 3, the horizontal axis is the evaluation criterion and the vertical axis is the criterion weight. It is illustrated that the major and the minor factors which consumers consider to purchase smartphones. The first group consists of the first four criteria in the priority ranking.

The analysis of consensus degree can demonstrate the consistency of respondents in evaluation aspects and criteria. The indicator of consensus degree is the coefficient of variance (CV). If the coefficient of variance (CV) is smaller, the consistency of respondents’ evaluations is higher. The consensus degree of aspects is shown as Table VIII. According to Table VIII, the highest coefficient of variance (CV) is the aspect of entertainment function which means the entertainment function has the lowest degree of consensus. The highest degree of consensus in aspects is the user interface as the aspect of user interface has the lowest coefficient of variance (CV).

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### V. RESULT

The priority rankings and weights in Table VI were obtained for the criteria. We sort the weights of all criteria in order and the result is shown in Table VIII. The respondents think the central processing unit (CPU) as the most important criterion. The operation platform ranked as the 2nd most important criterion. The touch screen and battery life criteria were ranked as the 3rd and 4th, while multimedia (0.019), weight (0.018), and sound recording (0.012) were ranked as the last 3 criteria respectively.

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TABLE VIII
DEGREE OF CONSENSUS IN ASPECTS

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Coefficient of variance (CV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>User interface</td>
<td>0.4940</td>
</tr>
<tr>
<td>Mobile-commerce function</td>
<td>0.6507</td>
</tr>
<tr>
<td>Software and Hardware</td>
<td>0.5634</td>
</tr>
<tr>
<td>Specifications</td>
<td>0.5634</td>
</tr>
<tr>
<td>Entertainment function</td>
<td>1.2438</td>
</tr>
<tr>
<td>Appearance and design</td>
<td>0.9846</td>
</tr>
</tbody>
</table>

The results indicate that the main choice factor of smartphones is software and hardware specifications. The first four most important criteria are central processing unit (CPU), operation platform, touch screen and battery life. Furthermore, it can use the coefficient of variance (CV) to judge the degree of consensus. The high consensus aspect and criterion are user interface and photograph function respectively.

We can learn consumers’ chief considerations through AHP evaluation model. To expand the market share, the enterprises must create the features and services that meet consumer needs. As the development condition of the smartphone market is presented, the analysis can assist operators to find their improvement strategies of products and services for the smartphone market.

The investigation demonstrates that consumers hold a high level of expectations with the usefulness of smartphones. Such results reflect why the functions of smartphones and other technology products must be continuously enhanced. Therefore, to meet the needs of consumers, the improvement of the smartphone’s functional dimension can facilitate conveniences of work and life. The research findings have also some practical implications, for example, designs of products and service, the development for application and the adoption of marketing strategies should take notice of consumers’ preferences.

The proposed framework in this study is illustrated with respect to the perspectives of Taiwanese smartphone users; it can extend to explore the users’ preferences of different countries and compare the results in the future research.

VI. CONCLUSION

The advances in technology directly influence consumers’ evaluation towards the smartphones. In this study, in order to realize the tendency of consumers’ choosing factors, we utilize the Analytic Hierarchy Process (AHP) method to construct the hierarchical structure of consumers’ evaluation. According to the aspects and criteria of the hierarchical structure, the model built to evaluate the main factors of purchasing smartphones.

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REFERENCES


