Deriving Factors Influencing the Acceptance of Pad Phones by Using the DNP Based UTAUT2 Framework

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Abstract--**The factors influencing acceptances of novel information technology (IT) devices can serve as the basis for product development strategy definitions. However, it is always not an easy job to predict consumer behaviors versus novel technology in general, and disruptive or radical innovation products in special. The Pad Phone, a disruptive innovative consumer electronic device integrating both a tablet personal computer (PC) as well as a smart phone, is a typical disruptive innovative device which consumer behaviors are difficult to predict based on mass customers' opinions. In order to derive key factors influencing users' acceptance of Pad Phones, the second generation Unified Theory of Acceptance and Use of Technology (UTAUT2) will be introduced as the theoretic framework. Based on opinions being derived from lead users, the Decision Making Trial and Evaluation Laboratory (DEMATEL) based Network Process (DNP) will be introduced for constructing the influence s between the factors in UTAUT2; and then, weights being associated with the factors can be derived accordingly. Based on the empirical study results, the social influence plays the dominant role in facilitating conditions. The habit and hedonic motivation are essential factors influencing customers' acceptances of Pad Phones. The empirical study results can serve as a basis for R&D and marketing strategy definitions for IT companies. Moreover, the UTAUT2 based analytic framework can be used for deriving factors influencing users' acceptances of disruptive innovations in the future.**

I. INTRODUCTION

During the past years, smart mobile devices such as smart phones and tablet personal computers (PCs) emerged due to their usefulness and ease of use being caused by disruptive innovations from novel electronic technologies like CMOS image sensor based camera, artificial intelligence based voice recognition techniques (e.g. Siri of iPhone), and massive applications (APPs) for fulfilling users' needs in communications (e.g. Skype), entertainments, learning, etc. Precision predictions of users' needs and thus, intentions for adopting disruptive innovations is one of the most significant jobs for information technology (IT) firms' information system research.

The Pad Phone, an integrated smart mobile device consisting of a Smartphone and a tablet PC, is one of the most popular smart mobile devices. Predictions of factors influencing customers' acceptances of Pad Phones or similar devices are always indispensable works for marketers of the IT firms such as ASUS Technology, HTC, and Samsung. However, precise predictions of customers' needs toward such disruptive innovative IT products are not easy though understanding the customers' real needs and enhancing their fulfillment will promote the competitive advantages of the IT firms [1].

In order to derive customers' perceived usability, how their purchase intentions are composed and what fundamental factors are satisfied toward such disruptive innovative IT devices like Pad Phones, the second generation Unified Theory of Acceptance and Use of Technology (UTAUT2) will be introduced for serving as the theoretical framework for exploring customers' needs and thus, acceptances of Pad Phones. The theoretic framework will be implemented by using the Decision Making Trial and Evaluation Laboratory (DEMATEL) based Network Process (or DNP) for constructing the decision problem based on the causal relationships between factors influencing customers' acceptances of Pad Phones and deriving weights being associated with the factors Pad Phone based on opinions of lead users, the customers who are ahead of market trends and industry experts.

An empirical study based on Taiwanese smart mobile device lead users' opinions will be used for verifying the feasibility and effectiveness of the proposed framework. Since mass customers usually do not have clear concepts regarding disruptive innovations, traditional market research approaches are not appropriate for such commercialization of technology by function expansions Therefore, the lead user method based on the opinions of innovators in the diffusion of innovation or those of experts' will be employed in this research for exploring factors influencing customers' acceptances of Pad Phones. The proposed framework and derived factors can be used for marketers' predictions of customers' needs for Pad Phones or similar integrated devices.

The remainder of this research is organized as follow. Related literatures of the UTAUT2 will be reviewed in Section 2. The analytic framework based on the DEMATEL based Network Process will be presented in Section 3. An empirical study for deriving factors influencing customers' acceptances of Pad Phones will be presented in Section 4. Managerial implications will be presented in Section 5. Section 6 will conclude the whole article.

II. LITERATURE REVIEW

In this Section, literature being related to factors which influence the technology acceptances of a novel IT device will be reviewed from social psychology models versus IT devices. These well-known models include the theories of reasoned action (TRA), planned behavior (TPB), technology

acceptance (TAM), UTAUT and UTAUT2 will be reviewed. Besides, the lead user method (LUM) will also be reviewed finally as a basis for the MCDM based expert systems to be constructed. The review results will serve as a basis for constructing the analytic framework.

a. TRA

Ajzen and Fishbein proposed the TRA [2] based on the social psychology. The model of TRA is one of the well-known analytic frameworks for predicting the human action across different fields [3]. The TRA posits that the variables of attitude and subjective norm are determinant factors influencing behavioral intention [2, 4]. The attitude is defined as an individual's positive or negative feelings regarding the human specific action [2]. On the other hand, in the TRA, external variables have an impact on attitudes only through the individual's belief. The definition of subjective norm is the perception of individuals that most people who are important to him think he should or should not perform the behavior in question [2]. The TRA has extensively been adopted in numerous studies on consumer behaviors and was verified as an effective model for predicting the customers' purchase behavior.

b. TPB

The TPB, an extension of the TRA, extend the limitations of the TRA by reconsidering possible control factors influencing human actions. The TRA assumes that a person is in full control of whether to adopt some kind of technology, and such adoption behavior will not be affected by a user's aptitude and external support [5]. The TPB being derived from the effort of TRA has been verified by explanation of users' usage behavior toward IT [6, 7]. Given that the influence of control behavior, the predictions of behavioral intentions must be involved with perceived behavioral control, which refers to the perception of how easy or difficult it would be perform the behavior. The TPB consists of four variables, i.e., attitude, subjective norm, intention and perceived behavioral control. Users' purchase intention in performing specific behavior is influenced directly by his or her intentions of actual behavior and in turn, jointly influenced by attitude toward the behavior, subjective norm and perceived behavior control toward performing the behavior. Variables of attitude, subjective norm and perceived behavioral have intertwined relationship. Since the TPB has better prediction capabilities in actual human behaviors than the TRA, the TPB has widely been adopted in marketing researches for predictions of consumer behaviors [8].

c. TAM

The TAM being proposed by Davis [9] has been used for explaining innovation usages [10] and novel technology acceptances. Hence, the TAM was often recognized as the most popular model to research consumer behavior. The TAM being derived from the TRA and TPB aims to derive the usage behavior of computers. The TAM was not only used in explaining the factors influencing users' adoption of computers but was also used in a investigating the adoptions of information technology adoption in various domains. Further, in order to extend the TRA and TPB for further understanding the adoption of technology, variables belonging to the attitude and perceived behavioral control aspects were removed from prior models.

d. UTAUT

For years, the factors influencing users' technology acceptances have been discussed by researchers. Since the introduction and emergence of the TAM, various concepts were added into the original TAM model. One of the most famous model is the UTAUT being proposed by Venkatesh [10] to better measure and predict the usage behavior and adoption of IT. The accuracy of the UTAUT is approximately 70% for explaining the variable variance in behavioral intention to adopt technology and approximately 50% for explaining the variable variance technology use [11].

The four determinants including constructs, performance expectancy, effort expectancy, social influence, facilitates conditions to be included in UTAUT [10]. Regarding to constructs, the performance expectancy is defined as "the degree to which an individual believes that using the system will help him or her attain gains in job performance" [10]. Performance expectancy refers to "the degree of ease associated with the use of the system" [10]. Social influence refers to "the degree to which a person perceives that important others believe he or she should use the new system" [10]. Facilitating conditions are defined as "the degree to which that a person believes that an organizational and technical infrastructure exists to support use of the system" [10].

e. UTAUT2

In order to enhance the prediction accuracy of the UTAUT model, Venkatesh reviewed numerous researches to expand the earlier UTAUT and propose the new UTAUT2 model [11]. The UTAUT2 consists of three constructs, hedonic motivation, price value and habit [11]. Due to the better prediction accuracy, this research will introduce the UTAUT2 as the theoretical framework to predict and understand the factors influencing users' acceptances of PAD phones.

f. The Lead User Method

The lead user method being proposed by von Hippel refers to researches of new product development and market trends based on opinions of users who have strong needs for specific novel technology or product or experts in related fields. [12]. Empirical studies also found that the innovative technology diffusion is mainly dependent on customers' opinions and experiences [13]. Thus, lead user theory can be applied in new product development and market research. Large firms such as 3M or P&G always focus on perspectives of lead users in early phase of product development; in other words, in order to enhance the success of new products,

companies should integrate lead user theory into their new product development processes [14].

The concept of the Lead User Method is often applied in product or process innovations for better understanding users' experiences in order to enhance products or technologies [15]. Since mass customers usually do not have clear concepts regarding disruptive innovations, traditional market research approaches are not appropriate for such commercialization of technology by function expansions Therefore, the lead user method based on the opinions of innovators in the diffusion of innovation or those of experts' will be employed in this research for exploring factors influencing customers' acceptances of Pad Phones.

III. THE DNP BASED UTAUTS ANALYTIC FRAMEWORK

To establish the influential model for exploring the consumer acceptance of Pad Phones, the DNP method will be introduced. After collecting the influential factors of consumer purchase intentions by literature reviewing, DEMATEL techniques will further derive the causal relationship based perspectives of Taiwan Pad Phones experts. Then, the associated factors' weights will be obtained by applying the DNP method. Finally, the empirical study results will demonstrate the consumer preference for predicting the users' acceptance of Pad Phones.

A. Decision Making Trial and Evaluation Laboratory (DEMATEL)

The DEMATEL method was developed by the Battelle Geneva Institute (1) to analyze complex 'world problems' dealing mainly with interactive man-model techniques; and (2) to evaluate qualitative and factor-linked aspects of societal problems. The applicability of the method is widespread, ranging from industrial planning and decision-making to urban planning and design, regional environmental assessment, analysis of world problems, and so forth. It has also been successfully applied in many situations, such as marketing strategies, control systems, safety problems, developing the competencies of global managers and group decision-making. Furthermore, a hybrid model using the DEMATEL methods has been widely used in various fields, for example, e-learning evaluation [16], airline safety measurement, and handset design for next generation handset. Therefore, in this paper we use DEMATEL not only to detect complex relationships and build a Network Relation Map (NRM) of the criteria, but also to obtain the influence levels of each element over others. To apply the DEMATEL method smoothly, the authors refined the definitions based on above authors, and produced the essential definitions indicated below. The DEMATEL method is based upon graph theory, enabling us to plan and solve problems visually, so that we may divide multiple criteria into a relationship of cause and effect group, in order to better understand causal relationships. Directed graphs (also called digraphs) are more useful than directionless graphs, because digraphs will demonstrate the directed relationships of sub-systems. A digraph typically represents a communication network, or a domination relationship between individuals, etc. Suppose a system contains a set of elements,.., and particular pair-wise relationships are determined for modeling, with respect to a mathematical relationship (MR). Next, portray the relationship MR as a direct-relation matrix that is indexed equally in both dimensions by elements from the set S. Then, extract the case for which the number 0 appears in the cell (i, j), if the entry is a positive integral that has the meaning of: the ordered pair (s_i, s_j) is in the relationship MR; it has the kind of relationship regarding that element such that s_i causes element s_j. The digraph portrays a contextual relationship between the elements of the system, in which a numeral represents the strength of influence (Fig. 1). The elements s_1, s_2, s_3 and s_4 represent the factors that have relationships in Fig. 1. The number between factors is influence or influenced degree. For example, an arrow from s_1 to s_2 represents the fact that s_1 influences s_2 and its influenced degree is two. The DEMATEL method can convert the relationship between the causes and effects of criteria into a structural model [17, 18].

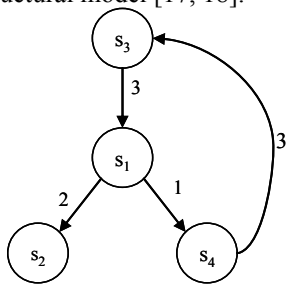

Fig. 1 An example of the directed graph

Definition 1: The pair-wise comparison scale may be designated as eleven levels, where the scores 0, 1, 2,…, 10 represent the range from 'no influence' to 'very high influence'.

Definition 2: The initial direct relation/influence matrix $\mathbf{A}$ is a $n \times n$ matrix obtained by pair-wise comparisons, in terms of influences and directions between the criteria, in which a_{ij} is denoted as the degree to which the i^{th} criteria affects the j^{th} criteria.

$$\mathrm{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Definition 3: The normalized direct relation/influence

matrix $\boldsymbol{N}$ can be obtained through Equations (1) and (2), in which all principal diagonal elements are equal to zero.

$$z = 1 \Big/ \max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij} \quad (1)$$

$$\boldsymbol{N} = z\mathrm{A}. \quad (2)$$

In this case, $\mathbf{N}$ is called the normalized matrix, since $\lim_{k \to \infty} \boldsymbol{N}^k = [0]$.

Definition 4: Then, the total relationship matrix $\mathbf{T}$ can be obtained using Equation (3), where $\mathbf{I}$ stands for the identity matrix.

$$\boldsymbol{T} = \boldsymbol{N} + \boldsymbol{N}^2 + \ldots + \boldsymbol{N}^k = \boldsymbol{N}(\boldsymbol{I} - \boldsymbol{N})^{-1} \quad (3)$$

where $k \to \infty$ and $\boldsymbol{T}$ is a total influence-related matrix; $\boldsymbol{N}$ is a direct influence matrix and $\boldsymbol{N} = [x_{ij}]_{n \times n}$; $\lim_{k \to \infty} \left(\boldsymbol{N}^2 + \cdots + \boldsymbol{N}^k \right)$ stands for a indirect influence matrix and $0 \le \sum_{j=1}^{n} x_{ij} < 1$ or $0 \le \sum_{i=1}^{n} x_{ij} < 1$, and only one $\sum_{j=1}^{n} x_{ij}$ or $\sum_{i=1}^{n} x_{ij}$ equal to 1 for $\forall i, j$. So $\lim_{k \to \infty} \boldsymbol{N}^k = [\boldsymbol{0}]_{n \times n}$. The (i, j) element t_{ij} of matrix $\mathbf{T}$ denotes the direct and indirect influences of factor i on factor j.

Definition 5: The row and column sums are separately denoted as $\boldsymbol{r}$ and .. within the total-relation matrix $\mathbf{T}$ through Equations (4), (5), and (6).

$$\boldsymbol{T} = [t_{ij}], \quad i, j \in \{1, 2, ..., n\} \quad (4)$$

$$\boldsymbol{r} = [r_i]_{n \times 1} = \left[\sum_{j=1}^{n} t_{ij} \right]_{n \times 1} \quad (5)$$

$$\boldsymbol{c} = [c_j]_{1 \times n} = \left[\sum_{i=1}^{n} t_{ij} \right]_{1 \times n} \quad (6)$$

where the $\boldsymbol{r}$ and $\boldsymbol{c}$ vectors denote the sums of the rows and columns, respectively.

Definition 6: Suppose r_i denotes the row sum of the i^{th} row of matrix $\boldsymbol{T}$. Then, r_i is the sum of the influences dispatching from factor i to the other factors, both directly and indirectly. Suppose that c_j denotes the column sum of the j^{th} column of matrix $\boldsymbol{T}$. Then, c_j is the sum of the influences that factor i is receiving from the other factors. Furthermore, when $i = j$ (i.e., the sum of the row sum and the column sum $(r_i + c_i)$ represents the index representing the strength of the influence, both dispatching and receiving), $(r_i + c_i)$ is the degree of the central role that factor i plays in the problem. If $(r_i - c_i)$ is positive, then factor i primarily is dispatching influence upon the strength of other factors; and if $(r_i - c_i)$ is negative, then factor i primarily is receiving influence from other factors [17, 18].

B. DEMATEL based Network Process (DNP) Technique

The DNP, an integrated MCDM analytic framework consisting of the DEMATEL and the ANP, was proposed by Tzeng [19, 20]. The DEMATEL technique was developed by the Battelle Geneva Institute: (1) to analyze complex "real world problems" dealing mainly with interactive map-model techniques [21]; and (2) to evaluate qualitative and factor-linked aspects of societal problems.

The DEMATEL technique was developed with the belief that the pioneering and proper use of scientific research methods could help to illuminate specific and intertwined phenomena and contribute to the recognition of practical solutions through a hierarchical structure. The DEMATEL has been successfully applied in many situations such as e-business model definitions [22, 23], policy definitions [17], global manufacturing system optimization [24], etc. The ANP is general form of the analytic hierarchy process (AHP) [25] which has been used in multi criteria decision making (MCDM) to can release the restriction of hierarchical structure.

Combing the DEMATEL and ANP method, which had been review in this chapter, the steps of this method can be summarized as follows:

Step 1: Calculate the direct-influence matrix by scores. Based on experts' opinions, evaluations are made of the relationships among elements (or variables/ attributes) of mutual influence using a scale ranging from 1 to 5, with scores representing "no influence" (1), "low influence" (2), "medium influence" (3), "high influence" (4), and "very high influence" (5). They are asked to indicate the direct effect they believe a factor will have on factor j, as indicated by d_{ij}. The matrix D of direct relations can be obtained.

Step 2: Normalize the direct-influence matrix based on the direct-influence matrix D, the normalized direct relation matrix N is acquired by using Eq. (7)

$$\mathbf{N} = v\mathbf{D}; v = \min\{1 / \max_i \sum_{j=1}^{n} d_{ij}, 1 / \max_j \sum_{i=1}^{n} d_{ij}\}, i, j \in \{1, 2, ..., n\} \quad (7)$$

Step 3: Attaining the total-influence matrix $\boldsymbol{T}$. Once the normalized direct-influence matrix $\boldsymbol{N}$ is obtained, the total-influence matrix $\boldsymbol{T}$ of the can be obtained.

$$\boldsymbol{T} = \boldsymbol{N} + \boldsymbol{N}^2 + \ldots + \boldsymbol{N}^k = \boldsymbol{N}(\boldsymbol{I} - \boldsymbol{N})^{-1} \quad (8)$$

where $k \to \infty$ and $\boldsymbol{T}$ is a total influence-related matrix; $\boldsymbol{N}$ is a direct influence matrix and $\boldsymbol{N} = [x_{ij}]_{n \times n}$; $\lim_{k \to \infty} \left(\boldsymbol{N}^2 + \cdots + \boldsymbol{N}^k \right)$ stands for a indirect influence matrix

and $0 \le \sum_{j=1}^{n} x_{ij} < 1$ or $0 \le \sum_{i=1}^{n} x_{ij} < 1$, and only one $\sum_{j=1}^{n} x_{ij}$ or $\sum_{i=1}^{n} x_{ij}$ equal to 1 for $\forall i, j$. So $\lim_{k\to\infty} \boldsymbol{N}^k = [\boldsymbol{0}]_{n\times n}$. The (i, j) element t_{ij} of matrix $\boldsymbol{T}$ denotes the direct and indirect influences of factor i on factor j.

Step 4: Analyze the result. In this stage, the row and column sums are separately denoted as $\boldsymbol{r}$ and $\boldsymbol{c}$ within the total-relation matrix $\boldsymbol{T}$ through Equations (9), (10), and (11).

$$\boldsymbol{T} = [t_{ij}],\ \ i, j \in \{1, 2, ..., n\} \tag{9}$$

$$\boldsymbol{r} = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{10}$$

$$\boldsymbol{c} = [c_j]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \tag{11}$$

where the $\boldsymbol{r}$ and $\boldsymbol{c}$ vectors denote the sums of the rows and columns, respectively.

Suppose r_i denotes the row sum of the i^{th} row of matrix $\boldsymbol{T}$. Then, r_i is the sum of the influences dispatching from factor i to the other factors, both directly and indirectly. Suppose that c_j denotes the column sum of the j^{th} column of matrix $\boldsymbol{T}$. Then, c_j is the sum of the influences that factor i is receiving from the other factors. Furthermore, when $i = j$ (i.e., the sum of the row sum and the column sum) $(r_i + c_i)$ represents the index representing the strength of the influence, both dispatching and receiving), $(r_i + c_i)$ is the degree of the central role that factor i plays in the problem. If $(r_i - c_i)$ is positive, then factor i primarily is dispatching influence upon the strength of other factors; and if $(r_i - c_i)$ is negative, then factor i primarily is receiving influence from other factors [17, 18]. Therefore, a causal graph can be achieved by mapping the dataset of $(r_i + s_i, r_i - s_i)$ providing a valuable approach for decision making (see Chiu et al. [20]).

Now we call the total-influence matrix $\mathbf{T_C} = \left[t_{ij}\right]_{nxn}$ obtained by criteria and $\mathbf{T_D} = \left[t_{ij}^{D}\right]_{nxn}$ obtained by dimensions (clusters) from $\boldsymbol{T_C}$. Then we normalize the ANP weights of dimensions (clusters) by using influence matrix $\mathbf{T_D}$.

$$\mathbf{T_D} = \begin{bmatrix} t_{11}^{D_{11}} & \cdots & t_{1j}^{D_{1j}} & \cdots & t_{1m}^{D_{1m}} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{D_{i1}} & \cdots & t_{ij}^{D_{ij}} & \cdots & t_{im}^{D_{im}} \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{D_{m1}} & \cdots & t_{mj}^{D_{mj}} & \cdots & t_{mm}^{D_{mm}} \end{bmatrix} \begin{matrix} \rightarrow d_1 = \sum_{j=1}^{m} t_{1j}^{D_{1j}} \\ \\ \rightarrow d_i = \sum_{j=1}^{m} t_{ij}^{D_{ij}},\ d_i = \sum_{j=1}^{m} t_{ij}^{D_{ij}}, i = 1, ..., m \\ \\ \rightarrow d_m = \sum_{j=1}^{m} t_{mj}^{D_{mj}} \end{matrix} \tag{12}$$

Step 5: The original supermatrix of eigenvectors is obtained from the total-influence matrix $\boldsymbol{T} = [t_{ij}]$. For example, *D* values of the clusters in matrix $\mathbf{T_D}$, as Eq.(30). Where if $t_{ij} < D$, then $t_{ij}^{D} = 0$ else $t_{ij}^{D} = t_{ij}$, and t_{ij} is in the total-influence matrix $\boldsymbol{T}$. The total-influence matrix $\mathbf{T_D}$ needs to be normalized by dividing by the following formula. There, we could normalize the total-influence matrix and represent it as $\mathbf{T_D}$.

$$\boldsymbol{T_D} = \begin{bmatrix} t_{11}^{D_{11}}/d_1 & \cdots & t_{1j}^{D_{1j}}/d_1 & \cdots & t_{1m}^{D_{1m}}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{D_{i1}}/d_i & \cdots & t_{ij}^{D_{ij}}/d_i & \cdots & t_{im}^{D_{im}}/d_i \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{D_{m1}}/d_m & \cdots & t_{mj}^{D_{mj}}/d_m & \cdots & t_{mm}^{D_{mm}}/d_m \end{bmatrix} = \begin{bmatrix} \alpha_{11}^{D_{11}} & \cdots & \alpha_{1j}^{D_{1j}} & \cdots & \alpha_{1m}^{D_{1m}} \\ \vdots & & \vdots & & \vdots \\ \alpha_{i1}^{D_{i1}} & \cdots & \alpha_{ij}^{D_{ij}} & \cdots & \alpha_{im}^{D_{im}} \\ \vdots & & \vdots & & \vdots \\ \alpha_{m1}^{D_{m1}} & \cdots & \alpha_{mj}^{D_{mj}} & \cdots & \alpha_{mm}^{D_{mm}} \end{bmatrix} \tag{13}$$

where $\alpha_{ij}^{D_{ij}} = t_{ij}^{D_{ij}} / d_i$. This research adopts the normalized total-influence matrix $\boldsymbol{T_D}$ (here after abbreviated to "the normalized matrix") and the unweighted supermatrix $\boldsymbol{W}$ using Eq. (13) shows theses influence level values as the basis of the normalization for determining the weighted supermatrix.

$$\boldsymbol{W}^* = \begin{bmatrix} \alpha_{11}^{D_{11}} \times \boldsymbol{W_{11}} & \alpha_{21}^{D_{21}} \times \boldsymbol{W_{12}} & \cdots & \cdots & \alpha_{m1}^{D_{m1}} \times \boldsymbol{W_{1m}} \\ \alpha_{12}^{D_{12}} \times \boldsymbol{W_{21}} & \alpha_{22}^{D_{22}} \times \boldsymbol{W_{22}} & \cdots & \cdots & \vdots \\ \vdots & \cdots & \alpha_{ji}^{D_{ji}} \times \boldsymbol{W_{ij}} & \cdots & \alpha_{mi}^{D_{mi}} \times \boldsymbol{W_{im}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \alpha_{1m}^{D_{1m}} \times \boldsymbol{W_{m1}} & \alpha_{2m}^{D_{2m}} \times \boldsymbol{W_{m2}} & \cdots & \cdots & \alpha_{mm}^{D_{mm}} \times \boldsymbol{W_{mm}} \end{bmatrix} \tag{14}$$

Step 6: Limit the weighted supermatrix by raising it to a sufficiently large power *k*, as Eq. (14), until the supermatrix has converged and become a long-term stable supermatrix to get the global priority vectors or called ANP weights .

$\lim_{k\to\infty} (\boldsymbol{W}^*)^k$

(15)

IV. EMPIRICAL STUDY

In this section, the criteria based on the UTAUT2 theory for predicting the customers' purchase intentions will be derived. The empirical study based on lead users' opinions will be leveraged for verifying the feasibility of the proposed analytic framework.

A. Possible Factor Derivations based on the UTAUT2

According to the UTAUT2 theory, nine criteria will be collected. Based on the experts' opinions on the causal relationships between the nine criteria, the causal relation can be constructed. Following, the requirements are defined and summarized in Table 4-1: (1) the performance expectancy (c_1); (2) the effort expectancy (c_2); (3) the social influence (c_3); (4) the facilitating conditions (c_4); (5) the hedonic motivation (c_5); (6) price value (c_6); (7) the habit (c_7); (8) the behavioral intention (c_8); (9) the use behavior (c_9) [11].

B. Deriving the Influential Factors based on the DNP

Based on the LUM, experts' opinions can be derived for deriving the influential factors by using the DNP method. At first, the initial direct influence matrix can be derived based Pad PhoneTaiwanese smart mobile device experts' opinions. Then, according to Eq. (1), a normalized direct influence matrix can be obtained based on the direct influence matrix. Finally, the total direct influence matrix T can be derived by using Eq. (2) as shown in Table 2.

After the derivation of the total influence matrix, the threshold value ($p = 0.502$) was adopted. The causal structure can be constructed and demonstrated in Fig. 2. In addition, the prominences and relations between factors are reflected by the sum of influences and provided in Table 3. Regarding to the causal structure, the criteria whose values of ($r_i - c_i$) were positive including c_1, c_2, c_3 and c_4, which have significant effect on others. The criteria whose values of ($r_i - c_i$) were negative including c_5, c_6, c_7, c_8 and c_9, which have intensively impact on others. In causal structure graph, c_2 has the highest ($r_i - c_i$) of 1,119, and is the factor with most direct effeteness to others. The relative criteria weights by using DNP method were verified in Table 4. The Table 4 below shows that the most important criteria of predicting the customers' purchase intentions in Pad Phones are: c_9, c_8 and c_7. The most important weights are respectively 0.146, 0.142 and 0.132. The criteria with the lowest level factors were c_7, with the associated weight of 0.083, and c_3, with the associated weight of 0.069, as well as c_4, with the associated weight of 0.067.

TABLE 1 THE CRITERIA OF EVALUATION

Criterion	Symbol
Performance expectancy	c_1
Effort expectancy	c_2
Social influence	c_3
Facilitating conditions	c_4
Hedonic motivation	c_5

Criterion	Symbol
Price value	c_6
Habit	c_7
Behavioral intention	c_8
Use behavior	c_9

TABLE 2 THE TOTAL INFLUENCE MATRIX

	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9
c_1	0.157	0.285	0.222	0.256	0.314	0.346	0.407	0.405	0.414
c_2	0.349	0.393	0.288	0.412	0.598	0.595	0.598	0.662	0.675
c_3	0.228	0.297	0.150	0.257	0.326	0.358	0.369	0.405	0.414
c_4	0.273	0.421	0.250	0.241	0.477	0.459	0.470	0.502	0.525
c_5	0.241	0.424	0.246	0.321	0.388	0.517	0.514	0.562	0.573
c_6	0.237	0.393	0.268	0.303	0.502	0.388	0.496	0.567	0.578
c_7	0.278	0.441	0.271	0.323	0.530	0.539	0.429	0.587	0.611
c_8	0.248	0.393	0.227	0.273	0.448	0.443	0.479	0.400	0.531
c_9	0.249	0.404	0.242	0.302	0.477	0.508	0.530	0.553	0.442

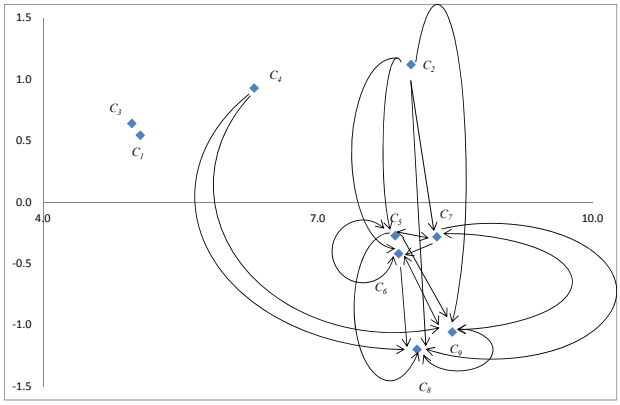

Figure 2 The causal structure of each criterion

TABLE 3 $r_i + c_i$ AND $r_i - c_i$ VERSUS EACH LATENT VARIABLE

Criteria	r	c	r+c	r−c
C_1	2.804	2.260	5.064	0.545
C_2	4.569	3.450	8.019	1.119
C_3	2.805	2.165	4.970	0.640
C_4	3.617	2.689	6.306	0.929
C_5	3.786	4.059	7.846	-0.273
C_6	3.732	4.153	7.885	-0.421
C_7	4.009	4.292	8.301	-0.282
C_8	3.443	4.642	8.085	-1.199
C_9	3.706	4.763	8.469	-1.058

TABLE 4 THE RELATIVE WEIGHTS OF EACH CRITERION

Criteria	Weights	Ranking
c_9	0.146	1
c_8	0.142	2
c_7	0.132	3
c_6	0.128	4
c_5	0.125	5

Criteria	Weights	Ranking
c_2	0.107	6
c_4	0.083	7
c_1	0.069	8
c_3	0.067	9

V. DISCUSSION

The possible factors of influencing customers' acceptance of novel IT products are the major concerns of IT firms' since the new product development always influence future competitiveness and profitability of that firm. In order to derive factors influencing customers' acceptance of disruptive innovative IT products like Pad Phone, this study introduced the DNP based UTAUT2 framework and derive factors influencing customers' acceptances.

According to the empirical study result, the use behavior and behavioral intention will play an important role in influencing PAD phone acceptances. Moreover, "habit" influence consumers' purchase intention significantly [26]. In other words, habit operates as a stored intention path to influence behavior [11]. The firms should investigate the consumer behavior and define marketing strategies versus market segmentations which customers are accustomed to carry the tablet PC as well as the smart phone simultaneously. Pad PhoneFurther, price value also plays a significant role in influencing users' purchase behavior. Therefore, the quality and price will be served as the major influential factor for customers' purchase of smart mobile devices.

Concerning the causal relationship, the effort expectancy aspect has the highest influences on other criteria. The "perceived usefulness" and the "ease of use" inside this aspect usually have critical influences on users' technology acceptance, which is consistent with the earlier research results by Davis [9].

Finally, the causal structure as well as the weights being associated with the criterion can be derived by using the DNP method. In Comparison to the the Structual Equation Model, the DNP method is significantly more appropriate for the lead user method based approach since lead users or experts cannot easily be surveyed for disruptive or even radical innovations.

VI. CONCLUSION

For IT firms, precision predictions of factors influencing users' acceptances of disruptive or even radical innovative products is very critical. In order to derive factors influencing customers' acceptance of Pad Phones, the DNP was introduced based on opinions of lead users'. According to the empirical study results, the use behavior, behavioral intention and habit are regarded as the most important factors influencing customers' Pad Phone acceptances. Besides, the effort expectancy also plays an important role. The research results not only can serve as the foundation for new product development strategy definitions for Pad Phones as well as novel smart mobile devices, the DNP based UTAUT2 analytic framework can also be used for exploring factors influencing acceptances of any other novel IT devices.

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