Identifying Factors of Customer Satisfaction from Smartphones: A Fuzzy Cognitive Map Approach

***Gerogiannis,V. C.,**
Department of Project Management, Technological Education Institute of Larissa, Larissa, GR-4110, Greece
Papadopoulou, S.
Department of Project Management, Technological Education Institute of Larissa, Larissa, Greece
Staffordshire University, Business School, UK
Papageorgiou, E. I.
Department of Informatics & Computer Technology, Technological Education
Institute of Lamia, Greece

*Correspondin author E-mail: gerogian@teilar.gr

Abstract: *Smartphones have gained growing popularity as communication tools that provide "smart" functionalities of cellular phones and Personal Digital Assistant devices. Smartphones are becoming an integral part of users' everyday life, since they are not just simple and friendly communication devices but also means for connecting the Internet, using various software applications as well as they provide ways for expressing the user lifestyle through a variety of modes. The purpose of this study is to investigate the factors affecting customer satisfaction from a smartphone and identify how these factors relate to each other. To achieve this objective we have applied a Fuzzy Cognitive Map approach that provided an informative qualitative model showing both positive and negative causal relationships between the factors which influence the smartphone user's overall satisfaction.*
Keywords: *Fuzzy Cognitive Maps, Consumer satisfaction from technology*

1. INTRODUCTION

Research results show that the context of customer satisfaction and consumer behaviour perception towards contemporary cellular phones (smartphones) includes a number of different factors (Ling et al., 2006). The most representative of these are the cost of purchase, familiarity with technology, ease of use, fast communication, connection with social networks and ease of internet access, at any time and place (Park and Chen, 2007). Recently, Park and Lee (2011) in a pilot study investigated the factors that affect smartphone usage with respect to customer satisfaction. Trough statistical analysis techniques (regression analysis) they reported that instant connectivity, perceived enjoyment and simplified user-device interface influence more the customer satisfaction. Regarding the perceived device-related stress, they concluded that smartphone users are often tech-savvy persons and find less difficult to use new devices than novice users or users with low familiarity with new technologies.

This paper presents the adoption of a Fuzzy Cognitive Map (FCM) approach (Kosko, 1986; Papageorgiou, 2011) for approaching a similar research objective. However, the approach presented in the current paper aims to identify not only the impact of factors on smartphone customers' satisfaction but also to reveal positive or negative causal relationships between these factors. A FCM is a fuzzy-based cognitive model and its visual representation is in the form of a directed graph consisting of nodes, which represent the most relevant concepts of a problem domain, and directed edges between nodes, which denote cause-effect relationships between the concepts (Kosko, 1986). The reason to follow a FCM-based approach to identify the causal relationships between factors affecting smartphone customers' satisfaction and not a statistical technique (e.g., regression analysis or the Structural Equation Modeling approach (Joreskog, 1977)) is that a FCM is more concerned with giving qualitative information for each cause-effect relationship and any relationship valuation can be easily changed and tested through applying activating/simulating the model. A FCM model may become dynamic by activating effects of changes in factors (nodes), which in turn can trigger (through edges) changes in other factors, until an equilibrium state is reached (Bueno and Salmeron, 2008). FCMs have been applied in various application areas (including marketing) where perceptions/preferences of relevant stakeholders cannot be easily and precisely quantified. Representative application fields of FCMs include customer relationship management in service business, business strategy formulation, medical diagnosis, decision analysis in management problems, software requirements analysis, knowledge base modeling, project risk analysis and project success factors evaluation. The reader is referred to (Papageorgiou, 2011) for a recent survey on various FCM application areas.

The paper considers that FCM can be a suitable representation model for customers' perceptions of satisfaction from highly technological products, such as smartphones. We demonstrate that a FCM can be used to represent the factors influencing the product acceptance from current/potential customers. For constructing the final map, we have followed a method originally proposed by Schneider et al. (1998). The method was also applied by Rodriguez-Repiso et al. (2007a) for modeling success factors of Information Technology (IT) projects as well as by Fekri et al. (2009) for analyzing critical success factors in new product development projects. To apply the method in our pilot study in the context of smartphone users' satisfaction, an extended set of satisfaction factors and smartphone characteristics was first derived from the literature. Then, a questionnaire was composed and disseminated to randomly selected smartphone current/potential users. The users' preferences were converted into corresponding fuzzy numbers to represent the degree of satisfaction, as it was expressed by each individual, from each corresponding factor. Strengths of causal relationships between any pair of factors were derived, by calculating average distances and similarities/dissimilarities between these vectors of fuzzy numbers. The final FCM indicates what are the factors influencing more the perceived customer satisfaction and what are the relationships/trade-offs between these factors. This model can be used to identify and evaluate relations between customer satisfaction perceptions and, potentially, as a decision analysis tool for smartphones evaluation and selection.

2. FACTORS INFLUENCING THE ACCEPTANCE OF SMARTPHONES

Smartphones have recently dominated the mobile phone market. Cellular phones have been transformed from conventional make/receive call devices to highly interactive multimedia systems, providing Wi-Fi (Wireless Fidelity) internet connection/access. Smartphones are intended to satisfy users through a variety of advanced technological characteristics and functionalities (Ling et al. 2006; Chen et al., 2010). By taking into account that smartphones present some common features with conventional mobile phones, characteristics such as the phone style, physical design, colour and size can contribute positively to the customer satisfaction (Chang et al., 2009). Additional embedded features, such as power-efficient microprocessors, modern operating systems and extra available memory, increase more the smartphones' capabilities and support more their popularity. By considering the provided functionalities, smartphones offer 3G (third-generation) and broadband access to Internet services, web browsing services, e-mail access, connection to social networks and video-streaming. Users may have access not only to MP3 player and gaming but also to additional helpful/enjoyable functions, such as watching TV, access in maps (through a Global Positioning System-GPS) and internet banking. Contemporary mobile phones also include Personal Information Management (PIM) applications, such as phonebooks, appointment books, notepads and calculators (Park and Lee, 2011; Heo et al., 2009).

Generally, this diversity of characteristics/functionalities positively impacts the user satisfaction that can be attributed to issues like perceived convenience, usability, efficiency and security (Kim et al., 2004; Park and Chen 2007). Factors such as the ability to perform remote control of everyday things, independence of time and place and fast communication, influence the user preferences (Rodriguez-Repiso et al., 2007a). Effective service support and help-desk services have also positive impact on customer satisfaction (Kim et al., 2004). However, offered functionalities are often in conflict with cost and difficulty/complexity issues concerning the device usage. On one hand, smartphones, by offering functionalities similar to a personal computer, become complex and "learning consuming" devices and, consequently, novice technology users may be discouraged from using these devices (Chang et al., 2009). In many cases, smartphone users are stressed as they confront usability problems and difficulties to learn how to use the phone features and applications. On the other hand, smartphone devices are more expensive compared to conventional mobile phones. A potential buyer should balance the cost of purchasing the device with the level of offered characteristics/functionalities. Consequently, smartphone providers should decide and offer a proper pricing scheme that has to be reasonable, according to the provided functionality and services (Kim et al., 2004). Furthermore, smartphones are energy "hungry" devices and users tend to prefer models characterized by efficient battery functionality (Chang et al., 2009). Contemporary mobile phones are thus powerful software intensive technological products which present a significant market potential. However, to meet high expectations of current or potential customers, many issues have to be considered as well as possible trade-offs between them (Kim et al., 2004). Research studies on cellular phones including smartphones can be classified according to their target purpose into three broad categories (Park and Lee, 2011): i) research on identifying the success factors and explaining the adoption of mobile phones (Ling et al. 2006), mainly though the use of the Technology Acceptance Model (Kwon and Chidambaram, 2000; Kim, 2011;), ii) research on investigating dependencies and "addiction" of users to mobile phone usage (Kawasaki, 2006) and iii) research on identifying the factors which make the phone applications (and, in particular, mobile gaming) more appealing to users (Licoppe and Inada, 2006). In the next section, we will complete the literature review by briefly discussing available methods for supporting analysis of the success factors/adoption of advanced software intensive technological products, such as smartphones in our case problem.

3. IDENTIFYING SUCCESS FACTORS OF SOFTWARE INTENSIVE PRODUCTS

The problem of evaluating the success factors which influence the adoption of a software intensive technological product has been supported by various methods and techniques. Representative methods are: i) the Technology Acceptance Model (TAM), ii) the DeLone and McLean Model of Information System (IS) Success, iii) the model of Critical Success Chains (CSC), iv) the decision making technique of Analytic Hierarchy Process (AHP) and v) the model of Fuzzy Cognitive Maps (FCM). For a comparative study of these methods the reader is referred to (Rodriguez-Repiso et al., 2007b).

TAM (Davis, 1989) can be applied to predict people intentions to use technology based on their perception of its ease of use and usefulness. Perceived usefulness and ease of use represent the beliefs that lead to the acceptance of a new technology. Perceived usefulness is the degree to which a particular system would "enhance people lives", while perceived ease of use is the degree to which system usage would be "free of effort" (Versakalo et al., 2010). DeLone and McLean (1992) proposed a model of interrelationships between the following six success variables: i) system quality, ii) information quality, iii) system use, iv) user satisfaction, v) individual impact, and vi) organisation impact. Their model has gained a wide popularity among researchers and it has been applied in several studies with the aim to analyze the success of information systems in various domains (Seddon, 1997). CSC is another approach for identifying and mapping the success indicators of an IT project (Peffers et al., 2003). A CSC highlights the relationships among system attributes, critical success factors and organization goals. AHP is a multi criteria decision making technique that can be used for ranking the success factors of a technological product by collecting individuals' pair-wise preferences about the importance of the factors and deriving ratio scale weights (Saaty, 1980). Although AHP is a very powerful technique with very wide popularity among researchers, it has been criticised since the number of required pair-wise comparisons is growing exponentially with respect to the number of items compared (Gerogiannis et al., 2010).

FCMs can be also adopted as a tool for modeling the beliefs that a group of stakeholders share with respect to the success factors of a software intensive technological product (Rodriguez-Repiso et al., 2007a). FCM is an attractive modeling method based on fuzzy logic and supervised neural networks that that has been successfully used to represent complex systems and support decision making by accumulating knowledge on the causal relationships between factors of a decision problem in the form of a fuzzy weighted cognitive map. In general, there are two categories of methods for constructing a FCM: i) Domain experts/stakeholders can individually construct separate FCMs to express their ratings on the relationships between the factors of interest. Then, an augmented FCM is composed that shows the consensus of stakeholders upon the strengths of the relationships (Ozesmi and Ozesmi, 2004). ii) A FCM can be automatically constructed by data gathered from a rather large number of stakeholders which individually rate their preferences about the perceived importance of each factor. These ratings are accordingly converted into fuzzy values within the interval [0, 1] and four matrices are constructed by applying distance-based calculations of similarities/dissimilarities between stakeholders' preferences. These matrices are: i) the initial matrix of success (IMS), ii) the fuzzified matrix of success (FZMS), iii) the strength of relationship matrix of success (SRMS), and iv) the final matrix of success (FMS) (Schneider et al., 1998; Rodriguez-Repiso et al., 2007a).

In (Rodriguez-Repiso et al., 2007b) the authors argue that FCMs have advantages if there is a high probability of considering new product features which may require further exploration upon their impact on the product success. Given that the technology of cellular phones presents rapidly changing characteristics, a FCM can be a suitable modeling/analysis tool for analyzing factors which affect smartphone marketing success and, consequently, satisfaction of smartphone users. In our approach, we have selected the second method mentioned before to construct the FCM since our interest was to reveal the strength of each relationship between the perceived satisfaction factors from a smartphone. To achieve this, there is no need for an individual to rate the strength of each relationship, not even to identify each relationship. Current/potential users of smartphones can be asked to express only their ratings on the characteristics/factors which they believe that affect their satisfaction.

4. USING FCM FOR MODELING SATISFACTION FACTORS FOR SMARTPHONES USERS

The set of survey items in the pilot research consisted of 24 characteristics/factors which affect satisfaction of smartphone users. The survey items were adapted from various sources in the literature (Salmeron and Herrero, 2005) and stand for smartphone features and customer satisfaction factors, such as fast communication, complexity, perceived enjoyment, efficiency and convenience. An online questionnaire was distributed to 48 individuals. After assessing the responses quality, 40 respondents (male: 26, female: 14) were selected. Regarding these 40 individuals, 28 of them were currently users of smartphones and 12 were potential users, willing to buy and use a smartphone device in the near future. All users were in their twenties-thirties. Before disseminating the questionnaire, two smartphone marketing experts were asked to carry out a pre-test to ensure the construct and internal validity of the survey results.

In the first step of the method, we composed the IMS. It is a 24x40 matrix, where 24 is the number of smartphone satisfaction factors and 40 is the number of respondents. Each element O_{ij} in the IMS represents the importance value that the user *j* gave to a factor *i* (with respect to the impact of factor *i* the user satisfaction), within a scale from 0 to 100. Table 1 depicts an excerpt of the final IMS that presents the ratings/preferences of 12 (out of 40) smartphone users on four factors, namely i) service quality, ii) 3G services, iii) perceived enjoyment, and iv) available memory in the device. Users evaluated 3G services as a key factor for their satisfaction, since the majority of them gave to that concept values from 50 up to 100.

Service quality is also vital for users' satisfaction and it was rated with ranging values from 40 up to 90. The factors of perceived enjoyment and memory seem to be less important for the satisfaction of the respondents.
In the second step of the method, the fuzzification of the IMS resulted to the FZMS. This matrix includes corresponding fuzzy values, within the range of [0, 1], which represent respectively grades of membership of each individual preference with respect to each satisfaction factor. Lower and upper thresholds were introduced to fuzzify the IMS values so as to maintain the logical integrity of data/users preferences. Very low ratings (i.e., IMS values less than or equal to 20) were converted into 0's and very high ratings (i.e., IMS values greater than or equal to 80) were converted into 1's. Consequently, it was understood that ratings from 0 to 20 mean that the respondents consider the contribution of the corresponding factor very low for their satisfaction, whereas ratings between 80 and 100 mean that the respondents consider the contribution of the corresponding factor very high for their satisfaction The rest of IMS values were fuzzified by the following steps: i) Find the maximum value $\mathrm{MAX}(O_{iq})$ $(1 \le q \le 40)$ in each row i $(1 \le i \le 24)$ of the IMS assign 1 to it. ii) Find the minimum value $\mathrm{MIN}(O_{iq})$ in each row i of the IMS assign 0 to it. iii) Project proportionally each value into a weight within [0, 1] that is equal to $(O_{ij} - MIN(O_{iq}))/((MAX(O_{iq}) - MIN(O_{iq}))$. Table 2 depicts an excerpt of the FZMS which presents the corresponding fuzzy values of all ratings presented in the excerpt of the IMS, shown in Table 1. For example, in the IMS row that presents the ratings of smartphone available memory with respect to the user satisfaction, the value of 70, given by the 5th user, was converted into a fuzzy value equal to (70-20)/(80-40) = 0.83.

Table 1: The IMS matrix (excerpt)

Success Factors	1	2	3	4	5	6	7	8	9	10	11	12
Service quality	80	80	80	60	65	75	70	60	80	70	80	50
3G (third generation) services	90	90	95	70	75	85	80	80	90	80	90	60
Perceived enjoyment	70	10	40	60	50	40	30	30	50	50	60	40
Smartphone memory	30	40	30	50	70	65	60	70	50	30	70	70

Table 2: The FZMS matrix (excerpt)

Success Factors	1	2	3	4	5	6	7	8	9	10	11	12
Service quality	1.00	1.00	1.00	0.50	0.63	0.88	0.75	0.50	1.00	0.75	1.00	0.25
3G (third generation) services	1.00	1.00	1.00	0.67	0.83	1.00	1.00	1.00	1.00	1.00	1.00	0.33
Perceived enjoyment	0.83	0.00	0.33	0.67	0.50	0.33	0.17	0.17	0.50	0.50	0.67	0.33
Smartphone memory	0.17	0.33	0.17	0.50	0.83	0.75	0.67	0.83	0.50	0.17	0.83	0.83

The third step was to calculate the degree of similarity/dissimilarity between any two vectors of corresponding satisfaction factors' ratings, i.e. any two rows i and j of fuzzy values in FZMS. We have calculated the similarity/dissimilarity measures suggested in (Rodriguez-Repiso et al., 2007a). The result of this step was the 24x24 SRMS matrix. Each element S_{ij} in this matrix is a quantified value (a fuzzy weight) in the interval [-1, 1] that represents the strength for (possible) relationship between factor i and factor j, provided by a positive or negative sign. There are three possible cases: (i) $S_{ij} > 0$ indicates a direct (positive) relationship between factor i and factor j (i.e., increasing factor i results factor j to be increased), (ii) $S_{ij} < 0$ indicates an inverse (negative) relationship between factor i and factor j (i.e., increasing the value of factor i leads to a decrease in the value of factor j), (iii) $S_{ij} = 0$ indicates that there is no relationship between factors i and j. The SRMS presented the strength of the relationship between any pair of the 24 satisfaction factors (due to paper length limitations the table is not presented here).

In the fourth step, we had to consider that not all relationships in the SRMS are valid from a causality point of view, since it may happen two rows in the SRMS matrix to be related by coincidence. To clean up the SRMS and keep only valid (in terms of causality) relationships, two smartphone marketing experts were jointly interviewed and validated any causality existence. The results of experts' judgments were depicted in the FMS (i.e. a sparse SRMS) that contains only those fuzzy weights in the SRMS matrix which represent relationships of causality between factors affecting the user satisfaction. The graphical representation of the FMS was given in the form of a FCM (Figure 1), that shows an informative, comprehensive picture of satisfaction factors, how they are related and the degree (strength) of each relationship. For example, in the FCM of Figure1 it can be seen that 3G services have a positive impact on service quality (with a degree of +0.88), broadband internet access (+0.72), access in maps and GPS (+0.70). Inverse relationships can be also identified in the map. For example, factors such as service quality, available phone memory and power-efficient embedded processor cause a negative impact on the product price with a degree equal to -0.27, -0.40, and -0.75, respectively. The FCM reveals that a user perceived convenience when utilizing a smartphone device was the satisfaction factor with the highest degree centrality in the map (Ozesmi and Ozesmi, 2004). Convenience is therefore a very important factor, influenced positively by factors such as faster communication (+0.82), independence of time and place (+0.80), remote control of everyday things (+0.76) and service quality (0.65), while it is negatively influenced by the complexity of the device use (-0.60). In addition, smartphone characteristics/functionalities which influence more the user convenience are personal information management functionalities (+0.83), broadband and internet access (+0.78) and battery functionality (+0.65).

5. CONCUSIONS

We have applied a pilot research study to investigate the factors which influence positively/negatively the satisfaction of smartphone users. We have quantified the strength of causal relationships between any pair of satisfaction factors through a Fuzzy Cognitive Map (FCM). To construct the final FCM model, we identified in the literature an extended set of customer satisfaction factors which served as the survey items. Then, we followed a systematic approach (Salmeron and Herrero, 2005) to generate the FCM. This approach considered preferences gathered from the survey respondents (i.e., users currently owning a smartphone and users which are willing to have a smartphone in the future). To reveal the causal relationships between the satisfaction factors we have taken into account expert judgment by interviewing smartphone marketing experts, while the positive/negative strength of each causal relationship was calculated automatically. Although, the sample of the pilot study is rather limited, the final FCM can be very informative to present factors influencing more smartphones acceptance and satisfaction from current/potential customers. For example, the FCM reveals that user convenience is one the most important satisfaction factors and it is influenced very positively by factors such as faster communication, independence of time and place and remote control of everyday things. Another interesting assertion is that complexity affects negatively both user convenience and efficiency. These negative relationships were identified in the final FCM which included both current and potential users' preferences. However, it should be noted that these specific negative relationships were not identified in another FCM that was also conducted by following the same method and included only the ratings of current smartphone users. This fact demonstrates that complexity of usage is a negative factor for satisfaction that can be attributed only to customers which do not have previous experience with using smartphones. From the analysis we have found that complexity is a factor influencing negatively the satisfaction of potential users who are willing to buy a smartphone device. This is rational since when a device is too complex in use then people are not willing to use it. Complexity of smartphone devices may discourage smartphone customers (Chang et al., 2009). This conclusion differentiates our findings from other research results in the literature (Park and Lee, 2011) which founded that device-related stress and new-learning stress are not important factors regarding smartphone users' satisfaction. We believe that the limitation of these studies is that their target is only existing smartphone users which may are often tech-savvy and find less difficult to use new devices, as learn more their application and usage. Our current research effort is to further validate the presented approach by contacting a larger sample of users. We have also plans to compare the final FCM with an augmented FCM that will result from composing individual FCMs designed by domain experts (smartphone marketing experts). Finally, we have the intention to use the full capabilities of FCMs (i.e., simulation by activating the FCM) as a proper decision analysis tool for supporting the selection of a suitable smartphone device model which confronts with each individual customer's needs/preferences.

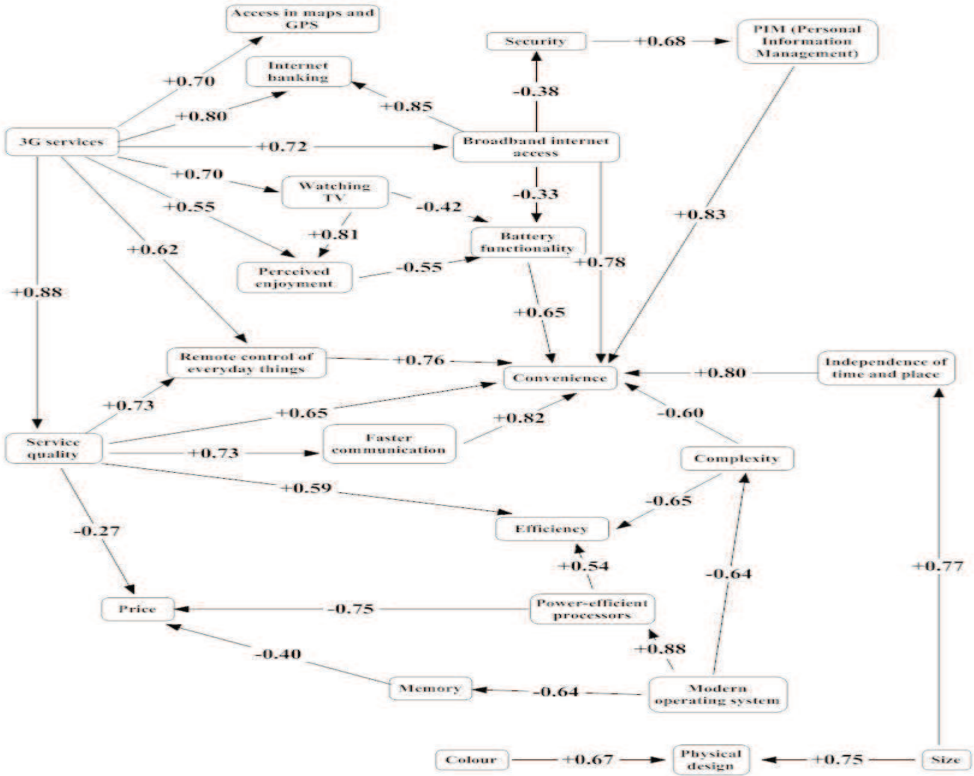

Figure 1: FCM for factors affecting the satisfaction of smartphone users

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