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Application of Fuzzy AHP method for ranking the effective factors on the Internet shopping (Case study: Customers of the Androidiha website)

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Abstract. Nowadays, by developing the electronic and Internet systems, businesses and industries owners have tried to develop and offer their services through this way. For this reason, many effective factors on the Internet shopping have been studied by researchers, but, in this paper, it is tried to select the most important factors among the effective factors on the Internet shopping. According to the research subject, ranking all effective factors on the Internet shopping is a very difficult and time consuming work, thus, by studying, and surveying several studies, seven criteria and thirty-two sub-criteria were selected among a large number of these factors after determining and verifying by experts and pairwise comparisons questionnaires were distributed in the statistical sample. Then, weight and rank of the main criterion and sub-criterion were obtained using Chang development analytical method and it was indicated that among the main factors influencing the Internet shopping in this study, website security factors, product quality, product price, users' good support, ease of use, speed of shopping and website design are respectively the first to seventh ranks of influencing the customers' Internet shopping.

Keywords: Ranking, Internet shopping, fuzzy hierarchy analysis, Chang developmental analysis, AHP Fuzzy

1. INTODUCTION

Effective and efficient management of a customer's relationship and creation and providing value to him are considered as the most important topic of interest and attention of researchers and managers in organizations. Studies have shown that successful organizations achieved positive results from customer relationship [7].

In the marketing concept, it is believed that achieving organizational goals depends on defining and determining needs and requirements of the target market and supplying the customer satisfaction more desirable and more effective than competitors. Evidences show that brands are successful in today's competitive market that creates a symbolic and emotional connection with their customers [8].

Popular values (such as felt values toward the paid price) create more desirability for more desirability for buying a product or service. This more favorable feeling increases the risk of customer loyalty [17]. Therefore, given the importance of Internet shopping and attention to the customer in the current era and the presence of some obstacles for this issue that makes people avoid using and working this technology despite the benefits and importance of the Internet shopping, evaluating obstacles and providing solutions in this area seems to be necessary.

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The main issue and the research objective

By increasing the number of Internet users, the users' usage of this interactive tool as an effective part in buying decisions and actions has attracted the attention of researchers and scholars [6] because, nearly 72 percent of Internet users search for different products online at least once a month [12]. On the other hand, internal factors such as attitudes, habits and perceptions influence the willingness of people to buy online. Thus, positive attitude of consumers to buy online can provide surviving and profitability for online retailers in the competitive market [15]. Given the numerous advantages of e-commerce, great advertisements for its application and considering the specific cultural, social, and infrastructure characteristics of the country; it should be observed that moving toward using it can change consumer's behavior or create satisfaction in customer and gain profit for the firm or not. Therefore, numerous advantages of information and communication technology, threat of misplacing the country from other countries in the electronic world, and the removal of development obstacles in the case of appropriate using the information technology are the primary reasons for e-readiness in different areas of the country [10]. Since, internet shopping in Iran is a new subject and a large amount of buying and selling around the world are done electronically; our country in the near future will be inevitable to accept and apply it. Identifying the factors affecting this phenomenon can help more to be accepted by customers and provide a proper context to move toward it. Therefore, providing a model that represents the characteristics of the effective factors on the Internet shopping is necessary. Thus, the main objective of this research is to explain the importance and ranking seven main criteria influencing the consumers' Internet shopping and the secondary objectives include weighting and ranking the sub-factors for each of the main criteria.

Research model

The presented model in this study involves three basic steps:

1. Problem definition: At this stage, the relevant criteria and sub-criteria are selected. Then, the hierarchical structure is formed on this basis; i.e. the objective are placed at the first level, criteria are placed at the second level, sub-criteria are placed at the third level and finally, options are placed at the last level.
2. Fuzzy calculations: At this stage, all the indicators that were set before the last stage are compared mutually and using the presented language and fuzzy scales in Table 2 [19]. In this way, pairwise comparison matrix is obtained. Consistency of the matrixes is investigated so that the results have the necessary validity. After confirming the consistency, the weight of each criterion, sub-criterion, and options are calculated using Chang development analytical method.
3. Ranking criteria and sub-criteria: In the third stage, the final ranking of criteria and sub-criteria affecting the Internet shopping are obtained. The overall research model is presented in Figure 1 to select the most important factor affecting the Internet shopping.

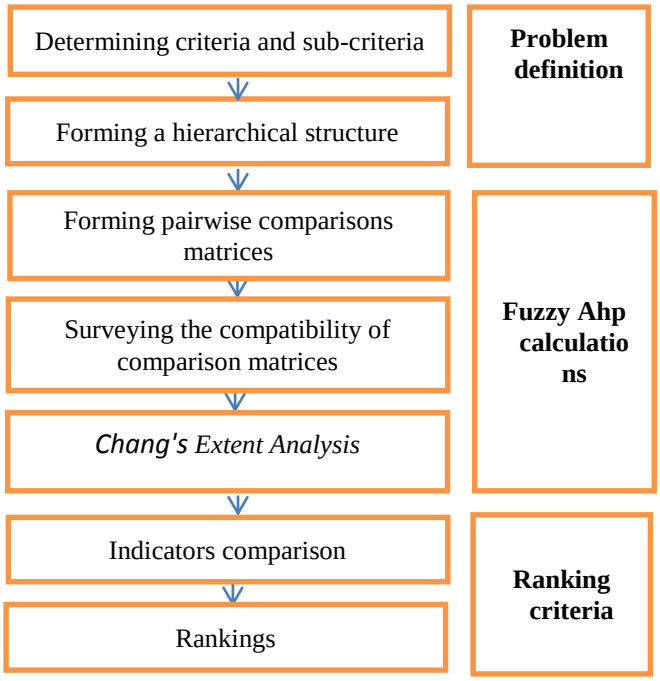

Figure 1. Research model.

Introduction of criteria and options

According to the research subject, investigating the effect of all the important factors affecting the Internet shopping are difficult and time consuming that on the one hand requires to determine many criteria and indicators which must be approved by experts and specialists and on the other hand, it will have a complex statistical analysis by answering the statistical population members to the questionnaire. By studying the literature and reviewing various papers, 40 indicators were selected among the many factors affecting the online shopping and the indicators' assessment questionnaire was prepared with Likert scale (five-point scale). The questionnaire was distributed among 67 experts (academics and professionals) that only 10 questionnaires were returned. Finally, 39 criteria (7 criteria and 32 sub-criteria) were selected above the average and they were considered as the basis for research. The final criteria are presented in Table 1.

Table 1. Research indicators.

Main criteria	Sub-criteria
Ease of use of the website	The availability of product information, ease of search, ease of using website , convenience of shopping, succinct information on the webSite
Product quality	Quantity and quality of product information, appearance quality (such as attractiveness, organization), variety of technology for showing products quality, comparing products with different quality
Product price	Reducing the research cost, search efficiency, eliminating shift costs, comparing prices and appropriate decision
Ease of Shopping	Service delivery speed, connection speed to the website, speed of transactions, speed of pages loading
Website design	Website aesthetics, providing product details, technical specifications of website design, detailed and accurate information, updated information
Appropriate support of users	Supporting the buying process and the ability to return or replace the goods, Responding to customer's information needs, internet answering and receiving system for users's complaints, pursuing the complaints and consequently proceedings it

Website security	Electronic signature for secure shopping, personalizing standards in the online environment, lack of detecting the online criterion, accuracy of transactions, lack of providing personal information to another website, minimizing operational and process errors

Research Methodology

This research is an applied research in term of objectives and descriptive-surveying in term of the method. Information was obtained through customers' surveys and the questionnaire. The statistical population is the customers of Idehpardaz Software firm (Androidiha website) which consists of 360 persons and the statistical sample was estimated 186 persons using Cochran formula.

In the first stage, 7 main criteria and 32 sub-criteria were identified and selected using various papers and questionnaires and also, interviews with experts in order to identify factors affecting the Internet shopping and finally, they were confirmed by the experts' questionnaire. Validity of the questionnaire were evaluated through evaluation by professors and experts and its reliability were confirmed through Cronbach's alpha with the amount of 0.812. In the second stage, the identified criteria were prepared for the statistical sample using the pairwise comparison questionnaire finally, the indicators were ranked with the help of fuzzy hierarchy analytic techniques (Chang method).

Analytical Hierarchy Process (AHP)

Analytical hierarchy process is based on decision-making with pairwise comparisons and can help to improve decision making and can be easily understood and used by operational managers [16]. This process which was invented by Thomas. El Saaty for the first time is basically a general thesis of measurement which is based on some of the principles of psychology and mathematics and has the ability to solve complex problems in a variety of qualitative and quantitative data.

In general, each problem deals with three overall levels that the first level is the overall objective of the problem, the second level is the evaluation criteria, and the third level is the possible options. Components in each hierarchy level are compared in pairs (Table 2) so that the relative preference of each one be determined in line of alternatives [13].

Table 2. Scale of relative preference based on Saaty [14**]**

Definition	**Numeric Value**
Equally preferred	1
Moderately preferred	3
Strongly preferred	5
Very strongly preferred	7
Extremely preferred	9
Intermediate preferred	8,6,4,2

Then these views should be converted to a unit view so that the optimal decision be achieved based on this. The best way to do this is using the geometric mean[4].

Consistency check

Gagvs and Boucher suggested that each fuzzy matrix should be derived to check the consistency of two matrixes (the middle number and the fuzzy number limit) and then, the consistency of each matrix is calculated based on Saaty's method. The stages of calculating the consistency rate pairwise comparisons fuzzy matrix are as follows:

First stage: In the first stage, divide the triangular fuzzy matrix into two matrix. The first matrix is formed of triangular judgments' middle numbers ($A^m = [a_{ijm}]$) and the second matrix is formed of the geometric mean of the high and low limits of triangular numbers ($A^g = \sqrt{a_{iju}.a_{ijl}}$).

Second stage: Calculate the weight vector of each matrix as follows.

$$w_i^m = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ijm}}{\sum_{i=1}^{n} a_{ijm}} \quad \text{Where } w^m = [w_i^m] \qquad (1)$$

$$w_i^g = \frac{1}{n}\sum_{j=1}^{n}\frac{\sqrt{a_{iju}.a_{ijl}}}{\sum_{i=1}^{n}\sqrt{a_{iju}.a_{ijl}}} \quad \text{Where } w_i^g = \frac{1}{n}\sum_{j=1}^{n}\frac{\sqrt{a_{iju}.a_{ijl}}}{\sum_{i=1}^{n}\sqrt{a_{iju}.a_{ijl}}} \qquad (2)$$

Third stage: Calculate the largest specific value for each matrix using the following formulas.

$$\lambda_{\max}^m = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ijm}\left(\frac{w_j^m}{w_i^m}\right) \qquad (3)$$

$$\lambda_{\max}^g = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \sqrt{a_{iju}.a_{ijl}}\left(\frac{w_j^g}{w_i^g}\right) \qquad (4)$$

The fourth stage: Calculate the consistency index using the following formulas:

$$CI^m = \frac{(\lambda_{\max}^m - n)}{(n-1)} \qquad (5)$$

$$CI^g = \frac{(\lambda_{\max}^g - n)}{(n-1)} \qquad (6)$$

The fifth stage: Divide the CI index on the random index (RI) to calculate the consistency index.

Table 3. Gagvs and Boucher random index (RI) [5].

Size	1	1	3	4	5	6	7	8	9	10	11	12
RI^m	0	0	0.4890	0.7937	1.0720	1.1996	1.2784	1.3410	1.3793	1.4095	1.4181	1.4462
RI^g	0	0	0.1796	0.2627	0.3597	0.3.818	0.4090	0.4164	0.4164	0.4455	0.4536	0.4776

After calculating the consistency index for the two matrixes, we compare them based on the following equations with the 0.1 threshold:

$$CR^g = \frac{CI^g}{RI^g} \qquad (7)$$

$$CR^m = \frac{CI^m}{RI^m} \quad (8)$$

If both of these indicators be less than 0.1, the fuzzy matrix is consistent. If both of them be more than 0.1, the decision maker will be asked to reconsider the proposed priorities and if only CR^m (CR^g) be more than 0.1, the decision maker reconsiders in the middle numbers (limits) of fuzzy judgments [5].

Fuzzy analytic hierarchy process (Fuzzy AHP)

Common analytical hierarchy process requires careful judgment. However, it is sometimes unrealistic or even impossible to do precise comparisons due to complexity and uncertainty involved in making real-world problems [3]. Thus, a good decision making should tolerance the ambiguity because being fuzzy and vague is the general characteristics of many of the decision making problems. Since, the decision makers often offer unreliable responses rather than providing exact procedures and numbers [2], it is recommended to use fuzzy linguistic data that their membership function is defined with triangular, trapezoidal, and etc. numbers for decision making and measuring desirability instead of classic methods and definitive data. Many researchers have used fuzzy analytical hierarchy process methods in their researches which have been experienced by Bozbura and his colleagues. These methods are able to provide a systematic and more realistic approach using concepts and theory of fuzzy sets and analysis of hierarchical structure [9].

In this research, fuzzy analytical hierarchy method under extent analysis or EA was used which was presented in 1996 by a Chinese researcher named Jung Chang that its fuzzy numbers are triangular type [1]. Pairwise comparisons of respondents are converted to triangular fuzzy numbers through Table 4.

Table 4. Conversion scale of triangular fuzzy numbers[11].

Linguistic variables	Positive triangular fuzzy numbers	Reverse triangular fuzzy numbers
Extremely important	(9,9,9)	(1/9,1/9,1/9)
Very important to extremely important	(7,8,9)	(1/9,1/8,1/7)
Very important	(6,7,8)	(1/8,1/7,1/6)
Important to very important	(5,6,7)	(1/7,1/6,1/5)
Important	(4,5,6)	(1/6,1/5,1/4)
Relatively important to very important	(3,4,5)	(1/5,1/4,1/3)
Relatively important	(2,3,4)	(1/4, 1/3, 1/2)
Equal important to relatively important	(1,2,3)	(1/3, 1/2, 1)
Equal important	(1,1,1)	(1,1,1)

Chang analytical method steps are as follows:

M^j_{gi} (j = 1,2, ..., m) are triangular fuzzy numbers whose parameters are l, m, and u which respectively are the least possible value, the most probable value, and the possible highest value. A triangular fuzzy number is shown in the form of (l, m, u) [18].

First step: Calculating the value of fuzzy synthetic extent (S_i) with respect to the *i*th criteria.
The value of fuzzy synthetic extent according to ith case is defined as the equation 9:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \qquad i = 1,2,\dots,n \qquad (9)$$

$\sum_{j=1}^{m} M_{gi}^{j}$ (the sum of m data values for a particular matrix) is calculated from the following calculation.

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j \ , \sum_{j=1}^{m} m_j \ , \sum_{j=1}^{m} u_j\right) \qquad i = 1,2,\dots,n \qquad (10)$$

To obtain the $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$ (the fuzzy sum of M^{j}_{gi} values) (j = 1,2,...,m) is calculated in accordance with the following equation

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i \ , \sum_{i=1}^{n} m_i \ , \sum_{i=1}^{n} u_i\right) \qquad (11)$$

And then, the reverse of the above vector is calculated using the following equation:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i} \ , \frac{1}{\sum_{i=1}^{n} m_i} \ , \frac{1}{\sum_{i=1}^{n} l_i}\right) \qquad (12)$$

Where $u_i, l_i, m_i > 0$

Finally, the multiply operation is performed in accordance with the following equation to obtain S_i:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \qquad (13)$$
$$= \left(\sum_{j=1}^{m} l_{ij} * \frac{1}{\sum_{i=1}^{n} u_i} \ , \sum_{j=1}^{m} m_{ij} * \frac{1}{\sum_{i=1}^{n} m_i}, \sum_{j=1}^{m} u_{ij} * \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

Second step: calculating the degree of possibility of each element toward other elements of the same level

If $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ be two triangular fuzzy number, the degree of possibility is defined in equation [14].

$V(M_2 \geq M_1) = \mathrm{hgt}(M_1 \cap M_2) = \mu_{M_2}(d)$

$$= \begin{cases} 1 & m_2 \geq m_1 \\ 0 & l_1 \geq u_2 \\ l_1 - u_2 \Big/ (m_2 - u_2) - (m_1 - l_1) & \text{otherwise} \end{cases} \qquad (14)$$

Figure 2 shows the relationship in which d is the width of D intersection in the horizon section between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, both $V(M_2 \geq M_1)$، $V(M_1 \geq M_2)$ values are required.

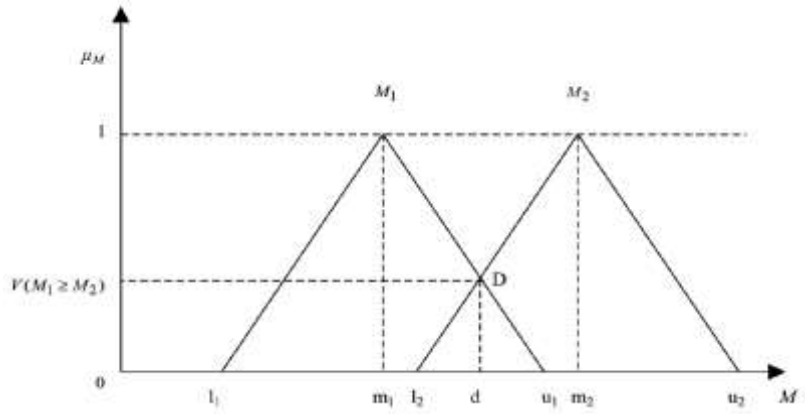

Figure 2. Degree of possibility $V(M_1 \geq M_2)$ [1].

The third step: Calculating the degree of possibility of each element toward other elements.
The degree of possibility that a fuzzy number be larger than k fuzzy numbers M_i (i = 1,2, ..., k) can be defined in the form of equation (15):

$$V(M \geq V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1), (M \geq M_2), \dots, (M \geq M_k)] = \min V(M \geq M_i) \qquad i = 1,2, \dots, k \quad (15)$$

Therefore, abnormal weight of criteria obtains from below

$$w'(x_i) = \min\{vS_i \geq S_k\} \qquad k = 1,2,...,n, k \neq i \quad (16)$$

And abnormal weight matrix of the criteria becomes as follows:

$$w' = [w'(c_1), w'(c_2),..., w'(c_n)]^t \quad (17)$$

Fourth step: Normalizing
Through Saaty normalizing method by dividing each weight matrix elements on the sum of the elements of the matrix, we can obtain the weight of each element in the relevant level.

$$w_i = \frac{w_i'}{\sum w'} \quad (18)$$

Finally, the final normal vector is obtained with the following equation:

$$W = (w_1, w_2, \dots, w_n)^t \quad (19)$$

In which, W is a non-fuzzy number.

CONCLUSION

According to the 186 persons of the statistical sample, 186 pairwise comparisons matrix were obtained. A unit matrix was obtained to collect all views using the geometric mean method. The weight of all the criteria was obtained as described in the following tables after converting the pairwise comparisons matrix to fuzzy numbers (Table 4) using Chang method.

Table 5. Weight and rank of the main criteria.

Main criteria	Normal weight (w)	Rank
Ease of use of the website	0	5
Product Quality	0.264	2
Product Price	0.245	3
Website Design	0	5
Buying speed	0	5
Website Security	0.445	1
Appropriate support of users	0.046	4
$CR^m = 0.0\ 7$ $CR^g = 0.1$ Consistent		

Table 6. Weight and rank of the sub-criteria related to product price.

Product price	Weight	Rank
Search cost reduction	0.234	3
Search efficiency	0	4
Eliminating shift costs	0.470	1
comparing prices and appropriate decision	0.297	2
CR^m = 0.02 CR^g = 0.07 Consistent		

Table 7. Weight and rank of the sub-criteria related to ease of use.

Ease of use of the website	Weight	Rank
succinct information on the webSite	0.69	1
the availability of product information	0	4
ease of using website	0	4
ease of search	0.18	2
convenience of shopping	0.11	3
CR^m =0.03 CR^g = 0.03 Consistent		

Table 8. Weight and rank of the sub-criteria related to website designing.

Website design	**Weight**	**Rank**
Website aesthetics	0	4
Product details	0.389	2
Technical Specifications of website design	0	4
detailed and accurate information	0.45	1
updated information	0.16	3
CR^m = 0.05 CR^g = 0.02 Approximately consistent		

Table 9. Weight and rank of the sub-criteria related to product quality.

Product quality	**Rank**	**Weight**
Quantity and quality of product information	0.99	1
Apparent quality	0	3
variety of technology for showing products quality	0	3
comparing products with different quality	0.001	2
CR^m = 0.02 CR^g = 0.08 Consistent		

Table 10. Weight and rank of the sub-criteria related to shopping speed.

Shopping speed	Weight	Rank
Service delivery speed	0.813	1
Connection speed to the website	0	3
Transactions speed	0.187	2
Page Loading Speed	0	3
CR^m = 0. 1 CR^g = 0. 3 Approximately consistent		

Table 11. Weight and rank of the sub-criteria related to users support.

Appropriate support of users	Weight	Rank
Support of the buying process	0.388	1
Responding to information needs	0.191	3
internet answering and receiving system for users' complaints	0.076	4
Pursuing complaints	0.346	2
CR^m = 0.01 CR^g = 0.03 Consistent		

Table 12. Weight and rank of the sub-criteria related to website security.

Website security	**Weight**	**Rank**
Electronic signature	0	4
Personalizing online deals	0	4
Lack of disclosing the deal	0.287	2
Accuracy of transactions	0.262	3
Lack of providing users personal information to another website	0.451	1
minimizing operational and process errors	0	4
CR^m = 0.02 CR^g = 0.03 Consistent		

According to above tables, among the main criteria, website security criterion with the most weight is in the first rank of effective factors and the criteria of product quality and price and appropriate support are in the following ranks and finally, website design criterion, shopping speed and ease of use with the least weight are the last ranks of the effective factors on the Internet shopping.

The results showed that briefness of information on the website is in the first place of importance among the indicators of ease criteria and quantity and quality of information is in the first place of effective factors among the indicators related to the product quality with a very high weight. Elimination of transport costs among the criteria related to the price is very important for the respondents. The index of providing product details is in the first place of importance in online shopping from the perspective of the respondents among the indicators related to website design criterion. According to the above table, the option of service delivery speed has a higher priority among the indicators of the criteria of the ease of shopping on the Internet. As is obvious from

the results, the index of the lack of providing the personal information of users to others is more important for the respondents among the indicators of website security criterion and it is allocated the highest weight to itself. Finally, respondents have considered the options of supporting the process of buying and ability to return goods more important than other factors among the effective criteria related to appropriate support of users.

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