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Evaluation for E-Commerce using AHP: Designing the experiment

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Abstract: Despite the spread of e-commerce, customers tend to encounter many problems during their interaction with the websites. For a website to be successful it should be evaluated but this process encounters many difficulties. After referring to the main problems encountered by an e-commerce system, this paper presents the design of an evaluation experiment of e-commerce websites that use a multi-criteria decision-making theory called Analytic Hierarchy Process (AHP). The paper analyses the criteria and methods used in evaluation experiments with AHP. Taking into account this analysis, the focus of the paper is on defining the final set of criteria, estimating their weights and providing guidelines on the different groups of evaluators that could be used.

Keywords: e-commerce evaluation, AHP, evaluation criteria

I. INTRODUCTION

Business competition is constantly increasing and many enterprises use the Web as a tool to attract more customers and implement more orders. Lately, issues related to the website design and special e-commerce features are being considered by companies as they attempt to attract more customers and remain competitive in a changing marketplace (Fink and Nyaga, 2009). However, the only way to ensure an e-commerce site's effectiveness is by performing an evaluation task.

For this purpose, different evaluation experiments have been implemented for the evaluation of e-commerce websites (Liang et al. 2017; Taneja & Arora 2018). Since e-commerce is increasingly becoming a favored distribution channel for products, the need for evaluation of this service is also increasing. Indeed, evaluation experiments of e-commerce websites differentiate in many aspects such as the theory, the criteria, the evaluators, etc. This may be the main reason that explains why an evaluation task is considered complicated to implement and it is often omitted despite its importance. Therefore, the main goal of this paper is to provide a set of design steps that could be followed to implement such an experiment by taking into account the evaluation experiments that already have been implemented in the domain of e-commerce. For this reason, different evaluation experiments for e-commerce have been examined and the input collected has been used for providing the final set of guidelines. The experiments that have been analyzed are using Analytic Hierarchy Process (AHP) (Saaty 1980) Taking into account in this analysis the information about the criteria, the weights of the criteria and formation of the group of evaluators, the focus of the paper is on defining the final set of criteria, estimating their weights and providing guidelines on the different groups of evaluators that could be used.

The rest of the paper is organized as follows: Section II presents the main problems that e-commerce websites encounter and are the reasons for possible failure. Section III presents the first step of an evaluation experiment and this is the selection of the theory that is going to be used, which in our case is the AHP theory. The formation of the group of evaluators is presented in section IV. In Section V, the main steps of the application of the theory that involves the definition of the goals and the criteria of the evaluation. The group of evaluators formed in section IV makes pairwise comparisons of the criteria and section VI describes the estimation of the weights of the criteria based on the evaluators' comparison. The main experiment of the evaluation involves visiting the websites and rating the criteria. For this purpose, different theories could be used for processing these values. The theories that have been most commonly used in e-commerce evaluation experiments are presented in section VII. The implications of the presented work as well as the conclusions drawn by this work are presented in the last two sections of the paper.

II. Common Problems in e-Commerce Websites

The widespread of e-commerce systems is nowadays a fact. However, not all websites successfully turn visitors into customers (Kabir & Hasin 2011). This is due to the fact that these websites often encounter several problems. The most common problems that the e-commerce websites encounter are:

- Bad usability of the website: The system, in this case, is not user-friendly. This may be due to a non-friendly or complicated interface, bad reliability of the system, the non-existence of search, etc.
- Low speed of the websites: The low responsiveness or low load speed are the two main reasons for a potential customer not revisiting an e-commerce website or not completing a buy. Possible reasons for this slowness may be either the technology used or the existence of several images that have not been compressed.
- Limited support to the user. The support provided via help or FAQs is limited, the user interface is not personalized and, therefore, the users end giving up the interaction with the website.
- Bad online communication. The users do not feel that they can communicate with the company behind the website.
- The Problem of Data Security. In many cases, the users do not trust the e-commerce site by providing their information. It is crucial that the users feel safe in providing information about themselves and in proceeding with the transactions.
- Bad Marketing: This means that the visibility of the system is not good and, therefore, the system fails in attracting new customers.
- Bad credibility: This is achieved via broken links, not up-to-date information, not existing privacy, bad quality of products or bad after sale strategy. As a result, the system fails in retaining the existing customers.
- Bad implementation of the transactions. This problem may refer to problems with payment, the safety of transactions, tracking order status, etc.
- The system does not address the needs of each customer: This result in customers that do not find what they are looking for and do not complete the buy.
- Bad provision of services. The distribution of products or the after sale support is not satisfying.
- The presentation of the products is bad and their quality questionable.

These are only a few of the problems an e-commerce system may encounter. As a result, the effective evaluation of websites has become a point of concern for practitioners and researchers (Yen, 2005) from the first steps of e-commerce till today.

III. Selecting the Theory for the Evaluation Experiment

The right selection of theory plays a very important role in the design of the evaluation experiment and the extraction of correct conclusions. Evaluation experiments usually concern the evaluation of one or more e-commerce websites but certainly use a set of criteria for evaluating these sites. Therefore, Multi-Criteria Decision Making (MCDM) theories seem rather appropriate and have been extensively used for such tasks. One of the most popular MCDM theories in the e-commerce domain is AHP. The choice of AHP amongst other MCDM theories is because it presents a formal way of quantifying the qualitative criteria of the alternatives and in this way removing the subjectivity of the result (Tiwari 2006).

Taking into account the fact that AHP has been widely used for evaluating e-commerce websites as well as the differentiation of these experiments, the particular theory has been selected to design an evaluation experiment for e-commerce and provide a set of guidelines. For this purpose, a review on the evaluation experiments that have already been implemented in the e-commerce domain using AHP, have been analysed.

Among the advantages of AHP is that it can be easily used solely (Zhu & Tong 2010; Yu 2010; Zhao 2011; Zhang & Guo 2012; Wang et al. 2012; Presley & Fellows 2013; Qi et al. 2014) or in combination with other methods. Therefore, AHP seems ideal for setting up the initial steps of an evaluation experiment for e-commerce. As an advantage of AHP is that it can be easily combined with other methods, for the next steps of the evaluation experiment, other theories could have been applied (section VII).

IV. Forming the Set of Evaluators

The outcome and the complexity of the experiment are also influenced by the ability and experience of the decision makers. An evaluation experiment may be implemented using experts or users of different level of expertise. Taking into account the participants of an evaluation experiment, the evaluation methods are distinguished to inspection (Zhu

& Tong 2010, Zhao 2011, Zhang & Guo 2012, Wang et al. 2012, Wei et al. 2010, Liu et al. 2015, Masudin & Saputro 2015, Li & Pang 2011, Hou 2012, Li 2015, Qunli & Xiaoge 2010, Soleymaninejad et al. 2016, Zhang 2015, Yu et al. 2011, Kai 2010, Kumar et al. 2017, Li & Chen 2010a, Li & Chen 2010b, Pan & Wang 2011, Wang et al. 2007, Cao et al. 2009, Liu 2011, Yimin et al. 2016, Pan & Wang 2011, Anand & Srivastava 2015, Liu et al. 2013) and empirical methods (Presley & Fellows 2013, Qi et al. 2014, Kabir & Hasin 2011, Zhao & Peng 2007).

In inspection methods, the experts perform the evaluation experiments. Several researchers have reported the advantages of expert-based evaluations (Kabassi 2017) and they mention that those experiments are easier and cheaper compared to empirical methods (Karoulis et al. 2006). Empirical methods, on the other hand, are implemented with the participation of different categories of potential customers of an e-commerce website (Presley & Fellows 2013, Zhao & Peng 2007, Kabir & Hasin 2011, Qi et al. 2014, Cao et al. 2009). These users are asked to access the site performing different tasks, their behavior is observed and/or their opinions are gathered. The number of subjects of empirical evaluation varies considerably. While small sample sizes are acceptable on evaluation experiments (Zhang & Guo 2012), especially in inspection based evaluation experiments, a higher number of participants (Lee & Kozar 2006, Zhao & Peng 2007, Liu 2011, Kabir & Hasin 2011; 2012) with diverse characteristics would have strengthened the statistical model and improved the generality of findings.

In view of these advantages and disadvantages of each method, some evaluation experiments combine inspection and empirical methods and use both users and experts (Kabir & Hasin 2012; Lee & Kozar 2006; Liu 2011; Yu 2010; Dey et al. 2015; Ying & Chun 1010; Liu & Zhang 2010; Chen & Li 2011; Chen & Tang 2012). Taking into account the above, the set of evaluators may involve experts, potential users of the system or a combination of experts and users.

V. GOALS AND CRITERIA OF THE EVALUATION

The first step in the implementation of AHP according to (Zhu & Buchman 2000) is forming hierarchy of goals. For this purpose, the overall goal, the criteria, and the decision alternatives are included in the hierarchy. The overall goal is the e-commerce website evaluation.

In this chapter, we have studied the evaluation experiments of e-commerce sites that use AHP and categorize them into three main groups: inspection evaluations (performed by experts), empirical evaluation (performed by potential users) and mixed evaluations (using a combination of inspection and empirical evaluations). The evaluation experiments that use an inspection method are more common than experiments that use an empirical method. 27 evaluation experiments of B2C e-commerce websites have been found to use AHP.

The empirical evaluation experiments, on the other hand, are not as common as inspection evaluation experiments in the e-commerce domain. Indeed, only five evaluation AHP experiments of e-commerce website have been found to use an empirical method and all refer to B2C businesses. This is probably due to two facts: 1) the application of AHP mainly uses expert evaluators and 2) the use of real users may be difficult and more expensive. More common than empirical evaluations are the mixed evaluation experiments where both inspection and empirical method are used. The combination of the two methods can minimize the disadvantages of each method as it takes the opinion of both experts and real users/customers and benefits from the advantages of both methods. Indeed, six experiments were categorized as mixed evaluations.

The review revealed the most common criteria in evaluating e-commerce (TABLE I). The criteria that are selected to be added in the table are those that are used at least by two evaluation experiments. For example, the criteria Completeness (Pan & Wang 2011), Currency (Kaya 2010), Empathy (Kaya 2010) and Relevancy (Hou 2012) are only reported in one AHP evaluation and, therefore, are not presented in the table. Each criterion is checked with a "1" or a "2" suggesting the level in which the criterion belongs in the experiment that was initially used. Figure 1 shows how the criteria are connected with the most common errors e-commerce websites encounter.

Table 1. Criteria of AHP evaluation experiments using an inspection method

	Soleymaninejad et al. 2016	Kong & Liu 2005	Zhang 2015	Pan & Wang 2011	Anand & Srivastava 2015	Liu et al. 2007	Lee & Choi 2001	Liu et al. 2015	Kim & Lee 2001	Li & Chen 2010	Aydin & Kahraman 2007	Li & Pang 2011	Kaya 2010	Yu et al. 2011	Yimin et al. 2016	Kai 2010	Pan & Wang 2011	Kumar et al. 2017	Wei et al. 2010	Zhang & Guo 2012	Masudin & Saputro 2015	Zhao 2011	Zhu & Tong 2010	Hou 2012	Jun & Yu 2008	Wang et al. 2007	Wang & Liu 2007	Presley & Fellows 2013	Zhao & Peng 2007	Kabir & Hasin 2011	Qi et al. 2014	Cao et al. 2009	Kabir & Hasin 2012	Lee & Kozar 2006	Liu 2011	Yu 2010	Dey et al 2015	Ying & Chun 2010
Subject	Inspection																											Empirical					Combination					
C1-System Quality		1	1										1										1	1	1					1			2	1				
CI1.1-Efficiency								2				1									1			2									1		2			
CI1.2-Usability								1								1																					
CI1.3-Ease to use		1			1						1			2										2			1	1	2	1					2		
CI1.4-Responsiveness/Load speed/Traffic		2				2					2		2			1	2	1		2	2		2	2	2				2	2		2	2	2	1	2	2
CI1.5-Design	1					2						1		1	2	1			1		2		1												2	1	1	2
CI1.6-Interface-Multimedia		2		2	1	2	2	2		1		2		2	2		2		1	2				2	2		2	2		2	2	2			2		2
CI1.7-Navigability - Organisation						2		2	1		2	2									2		2	2	2		2	2						2		2	2
CI1.8-Reliability													2				2								2								1	2	2			2
CI1.9-Availability		2										1										2			2													
CI1.10-Personalisation-Adaptation									2			2	2			1				2				2		2	2	2		1	2	2	1	2				
C2-Content Quality	1	1		1		2		2		2		1	1						1		1		1	1	1		1	1	2	1			2	1	1	1		
CI2.1-Accuracy/Relevanc		2						2	2				2										2	2	2			2		2			2	2		2		2

y/Currency																																							
CI2.2-Up –to date information		2		2		2		2		2							2						2		2		2	2		2					2	2	2	2
CI2.3-Effective information delivery				1																		2										2				2		
CI2.4-Link validity				2		2											2	1				2	2									2		2				
CI2.5-Multilingual												2			2																							
C3-Service Quality		**1**	**1**	**1**		**2**	**2**			**2**			**1**	**1**			**2**			**2**		**1**	**1**	**1**	**2**	**1**								**1**	**1**		**1**	**1**
CI3.1-Online communication	1					2																				2	2			2	2			2		2	
CI3.2-Support (FAQs-Help)		2				2					2					1					1					2	2		2	2		2				2	
CI3.3-Transactions		2		2						2	2					1				2	2		2		1				2	2	2						
CI3.4-Satisfaction				2																																1	1
CI3.5-Payment (alternatives, safety etc.)		2					2				2									2	2		2							2	2	2					
CI3.6-Tracking Order status		2													2																						
C4-Trust-Safety		**1**	**1**	**2**	**1**							**2**		**2**			**2**			**2**	**1**		**1**							**1**		**1**				**2**		
CI4.1-Security		2					2	2			1		2	2		1								2	2					2	2	2	2	2			1	
CI4.2-Privacy		2		2							2						2												1	2	2	2	1				2	
CI4.3-User participation	1					2																																
C5-Product/ Vendor Quality							**1**		**1**		**1**		**1**	**1**		**1**						**1**	**1**			**1**								**1**			**1**	
CI5.1-Brand							2						2																									

CI5.2-Categorisation									2													2	2																
CI5.3-Promotion/ Visibility/Traffic						2	2																																
CI5.4-Search							2		2												2		2									2	2						
CI5.5-Price											2		2	2								2	2			2					2	2		2			2	2
CI5.6-Quality											2									2		2	2								2	2					2	
CI5.7-Detail											2				2							2	2														2	
CI5.8-Distribution							2								1					2			2						2		2	2				2	2	
CI5.9-Marketing						2	2					2													2		1	2			2	2		2				2
CI5.10-Comprehension/Understandability		2																		2					2												
CI5.11-Technology (maintenance)	1	2				2			2						1	1											1		2	1		1	2		1	2		2
CI5.12-After sale/return/exchange																							2						2		2	2						

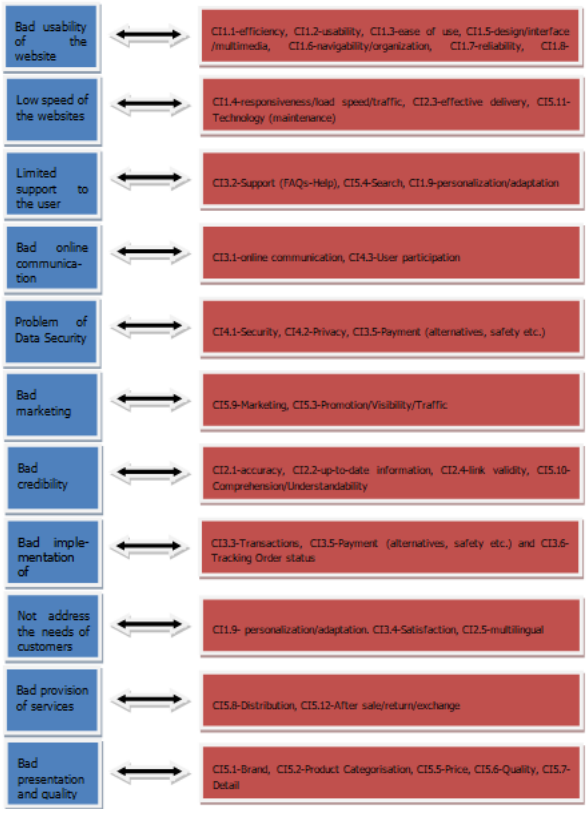

Figure 1. The criteria that are used to prevent potential problems

VI. ESTIMATING THE WEIGHTS OF THE CRITERIA

In order to estimate the weights of the criteria presented in Table I, a matrix for pairwise comparison of the criteria is built for the criteria of the same level. If the evaluation experiment has, criteria structured into two levels (e.g. Kong & Liu 2005, Pan & Wang 2011, Anand & Srivastava 2015, Liu et al. 2007, Liu et al. 2015, Li & Chen 2010a, Aydin & Kahraman 2007, Li & Pang 2011, Kaya 2010, Yu et al. 2011, Yimin et al. 2016, Pan & Wang 2011, Zhang & Guo 2012, Masudin & Saputro 2015, Zhao 2011, Zhu & Tong 2010, Hou 2012, Jun & Yu 2008, Wang et al. 2007, Wang & Liu 2007, Wang et al. 2012, Qunli & Xiaoge 2010, Li 2015) the criteria of each level are compared separately.

As a result, six tables are created for the criteria of the same level for experiments implementing an inspection method. Each of the experts of group A completed the six matrices of the pairwise comparisons of the criteria. Each cell of the final matrix was calculated as a geometric mean of the other ten matrices collected by the human experts. In this step, the principal eigenvalue and the corresponding normalized right eigenvector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalized eigenvector are the weights of the criteria or subcriteria.

One set of weights for the criteria used in evaluation experiments that employ an inspection method. These weights are: $w_{C1} = 0.313$, $w_{C2} = 0.19$, $w_{C3} = 0.116$, $w_{C4} = 0.19$, $w_{C5} = 0.19$, $w_{CI1.1} = 0.218$, $w_{CI1.2} = 0.134$, $w_{CI1.3} = 0.073$, $w_{CI1.4} = 0.198$, $w_{CI1.5} = 0.134$, $w_{CI1.6} = 0.113$, $w_{CI1.7} = 0.073$, $w_{CI1.8} = 0.056$, $w_{CI2.1} = 0.263$, $w_{CI2.2} = 0.303$, $w_{CI2.3} = 0.184$, $w_{CI2.4} = 0.16$, $w_{CI2.5} = 0.09$, $w_{CI3.1} = 0.05$, $w_{CI3.2} = 0.104$, $w_{CI3.3} = 0.199$, $w_{CI3.4} = 0.199$, $w_{CI3.5} = 0.224$, $w_{CI3.6} = 0.224$, $w_{CI4.1} = 0.618$, $w_{CI4.2} = 0.297$ $w_{CI4.3} = 0.086$, $w_{CI5.1} = 0.043$, $w_{CI5.2} = 0.045$, $w_{CI5.3} = 0.154$, $w_{CI5.4} = 0.04$, $w_{CI5.5} = 0.103$, $w_{CI5.6} = 0.116$, $w_{CI5.7} = 0.045$, $w_{CI5.8} = 0.067$, $w_{CI5.9} = 0.199$, $w_{CI5.10} = 0.059$, $w_{CI5.11} = 0.03$, $w_{CI5.12} = 0.1$. The results would not have been exactly the same if AHP was implemented using the geometric mean instead of the eigenvector.

VII. SELECTING THE THEORY FOR THE E-COMMERCE EVALUATION

One of the advantages of AHP is that it can be used solely or in combination with other methods for the evaluation of e-commerce. The main disadvantage when applying solely AHP is that the complexity arises significantly when the

number of alternative e-commerce websites increases. Therefore, it is quite common to use AHP in combination with another theory. AHP is commonly combined with the Technique for Order Preference with Ideal Solution (TOPSIS) (Hwang & Yoon 1981) (Chen & Tang 2012; Soleymaninejad et al. 2016; Zhang 2015, Kumar et al. 2017) or Fuzzy TOPSIS (Dey et al. 2015, Yu et al. 2011, Kabir & Hasin 2012). Fuzzy AHP has been combined with Fuzzy TOPSIS (Kaya 2010; Masudin & Saputro 2015). Additionally, AHP and Fuzzy AHP have been combined with other MCDM theories such as DEA (Li & Chen 2010a) or VIKOR (Aydin & Kahraman 2007).

In order to perform the main evaluation experiment, a new group of evaluators is set. Depending on the theory that is selected to be implemented in the evaluation, the most appropriate method may be different. For example, if solely AHP is implemented an inspection method may be more appropriate whereas if AHP with another theory such as TOPSIS is implemented then an empirical method may also be appropriate. In most theories combined with AHP, the evaluators have to give values to the criteria for the different e-commerce websites that are evaluated and then the estimations vary depending on the theory.

VIII. Implications & Limitations

The conventional approaches to evaluate e-commerce websites simply based on their knowledge experience, checklist method, analog approach, and regression model (Liu et al. 2013). These approaches may provide a set of steps for evaluation; however, they do not consider the relationships between the factors they evaluated. Such a problem may be solved with a multi-criteria decision-making theory like AHP. The particular theory constructs hierarchies of criteria and makes pairwise comparisons.

Indeed, AHP may proved very effective for multi-criteria decision-making problems. The particular theory help decision-makers understand and simplify the problem by using hierarchies. This may prove very effective in website evaluation and, therefore, AHP has been used in several evaluation experiments of websites. Each website is evaluated in terms of some criteria and give a final value by the determined weight coefficient. Taking into account the popularity of AHP and the advantages of the theory in evaluating websites, this paper uses AHP for designing an evaluation experiment for one or more e-commerce websites.

Despite the advantages AHP has, the theory mathematical calculations and the number of pairwise comparisons which increase as the number of alternatives and criteria increases or changes (Jadhav & Sonar 2011). As a result the application of the theory may prove time consuming Therefore, in this paper, we have implemented the first steps of the experiment and made the estimation of the weights of the criteria. The set of the criteria together with their weights can be used by any researcher in the evaluation of one or more e-commerce websites. This can simplify the process of evaluating e-commerce websites so that more evaluation experiments are performed.

Another limitation, which is sometimes referred in evaluation experiments of websites that use AHP, is focused on the usage of the measurement scale for the value of the utility function, which is basically numerical and probabilistically judgmental. This fact induces the evaluation problem (Yuen & Lau 2008) but can be overcome with the use of Fuzzy AHP (Kong & Liu 2005, Liu et al. 2007, Jun & Yu 2008, Wei et al. 2010, Kabir & Hasin 2011, Chen & Li 2011, Liu et al. 2015, Masudin & Saputro 2015).

IX. Conclusions

Taking into account the necessity of evaluation experiment in the e-commerce domain and the advantages that the use of the AHP theory has in the implementation of such experiments, the paper proposes that basic steps of such an experiment and a set of the most common criteria used in such an experiment. For this reason, common evaluation experiments of e-commerce systems that have employed AHP are used.

The evaluation experiments that have been examined are categorized into three groups depending on the method used: inspection, empirical or combination of the two methods. The analysis of these experiments revealed that the most common method to implement an evaluation experiment is the inspection method because it is easier and cheaper than an empirical method that involves several users of different backgrounds, knowledge and characteristics.

The complexity of the evaluation experiment of a website using AHP is further increased by the usage of several criteria (Nilashi & Janahmadi 2012). As a result, we try to simplify the process by proposing the hierarchies of criteria that are most commonly used in e-commerce evaluation using AHP as a basis for the experiment. These hierarchies have two levels of criteria, refer to the kind of the method used and may be used by other researchers for e-commerce website evaluation.

Solely AHP, or in combination with other theory or theories, can really improve the implementation of an evaluation experiment of e-commerce websites. Its advantages are multiple and involve structuring a decision-making problem into a hierarchy and helping evaluators to understand. In this way, the evaluation experiment is more

comprehensible and its implementation is simplified. Another main advantage of the particular theory is that it supports relationships between the factors and the criteria that are evaluated.

The evaluation phase of an e-commerce website is of major importance and should never be omitted because it is rather important in ensuring its success. For this reason, this paper tries through the directions and criteria that it provides to simplify this process and make it easy for everyone to implement an evaluation experiment of their e-commerce application.

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