Expert Systems with Applications 36 (2009) 11764–11771

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Using fuzzy TOPSIS method for evaluating the competitive advantages of shopping websites

Chia-Chi Sun *, Grace T.R. Lin

Institute of Technology Management, National Chiao Tung University, No. 1001, Ta-Hsuch Rd., Hsinchu 300, Taiwan

ARTICLE INFO

Keywords:
Shopping website
Technology acceptance factors
Website service quality
Specific holdup cost
Fuzzy TOPSIS

ABSTRACT

Taking into consideration technology acceptance factors, website service quality and specific holdup cost factors, this research explores how shopping websites to establish their competitive advantages through these dimensions. We begin with an examination of the literature on shopping websites about its competitive advantages upon which we propose a conceptual framework. Then this research adopts the fuzzy TOPSIS as the analytical tool that determines the weights of each criterion. Fuzzy theory provides a proper tool to encounter with uncertainties and complex environment. The purpose of this paper is to use the fuzzy TOPSIS method based on fuzzy sets in solving MCDM problems. From our research results, the security and trust are the most important factors for improving the competitive advantage of shopping website. Moreover, the PCHome and Yahoo Taiwan rank the first two positions for shopping websites. This paper draws on the research results for implications of managerial practice, and then suggests some empirical tactics in order to enhance management performance for the website shopping industry.

1. Introduction

Based on International Telecommunication Union (ITU) data, the worldwide online population was 870 million, which represents 14% of the universal population at the end of 2004 (ITU, 2005). The advent of the Internet over the last decade has meant radical changes for retail trading for many goods markets. The fact that e-commerce itself can be classified as a kind of information technology and that many business activities are done through the computer and Internet, including product transactions, advertising, selling services, etc., reveals the core issue of how Internet businesses can make themselves the customers' most trusted and shopped websites.

Previous studies have emphasized that the issue of consumer purchase process is important (i.e., Butler & Peppard, 1998; Dan, Ferrin, & Raghav, 2008; Rita & Henriette, 2004). Particularly, shaped during the online purchase process, consumers' attitudes and beliefs regarding convenience and security concerns have significant effects on their intention to purchase online (Limayem, Khalifa, & Frini, 2000). Shanker, Smith, and Rangaswamy (2000) also contended that service provided during and following the purchase is essential to e-consumers' repeat purchases.

On the other hand, while a number of studies have documented the significant role of website technology factors and service quality in influencing competitive advantage of online shopping website (i.e., Anderson & Srinivassn, 2003; Devaraj, Fan, & Kohli, 2002; Flavian, Guinaliu, & Gurrea, 2006; Ribbink, Riel, Liljander, & Streukens, 2004; Shih, 2004; Szymanski & Hise, 2000), little is so far known about the reflection of customer-related factors in the same regard. Hence, this research will move forward to another perspective and discuss how factors such as specific holdup cost or habit issue, together with external factors, affect the competitive advantage of online shopping website as a whole.

In the literature, there is no fuzzy logic method aimed at prioritizing the shopping websites. The main purpose of this paper is to provide practitioners with a fuzzy point of view to traditional research for dealing with imprecision and at obtaining the prioritization of criteria measurement dimensions. We take the shopping websites of Taiwan for pursuing our case purposes. This research invites 12 experts that evaluate different shopping websites via the proposed fuzzy TOPSIS method. The fuzzy TOPSIS is used to determine the weights of evaluation criterion and rank the alternatives of four shopping websites. This research looks forward to provide some empirical tactics in order to enhance management performance for the website shopping industry.

The reminder of this paper is as follows: Section 2 reviews the prior research that relates the advantage of shopping websites. Section 3 presents the methodology, fuzzy TOPSIS. Section 4 introduces the research design, which includes the research framework, research procedure, and empirical results. Section 5 presents some managerial implications and ways of improving efficiency. Limitation and future research direction are discussed in Section 6.

* Corresponding author. Tel.: +886 35712121x57520; fax: +886 35726749.
E-mail addresses: samsun0712@gmail.com, samsun0712.mt95g@nctu.edu.tw (C.-C. Sun).

0957-4174/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2009.04.017

2. What are competitive advantages for shopping website?

In this paper attention will be given mainly to online B2C transactions. This study begins by establishing a conceptual framework through a review of related theories and literature. There are three topics of conceptualization considered in this section: technology acceptance factors, website service quality and specific holdup cost.

2.1. Technology acceptance factor

Websites are essentially a type of information technology. Direct confrontation is an Internet transaction platform. Shopping websites allow customers to choose products based on their own needs and then provide businesses transaction platforms through interactive communications to fulfill the transactions. However, for the customer to easily consume online, he/she must first find the website useful and easy to use. This takes account of information search, Internet subscription, payment methods, etc.

A good number of previous studies adopt technology acceptance factors as a measure of willingness of customers to consume online. Davis (1989) proposed the technology acceptance model (TAM) to explain and predict user acceptance of information systems (IS) or information technology (IT). Davis (1989) defined PU as "the degree to which a person believes that using a particular system would enhance his or her job performance," and defined PEOU as "the degree to which a person believes that using a particular system would be free of effort." Within TAM, PU is a major factor, and PEOU is a secondary factor in determining system usage. Davis (1989) then also suggested that PEOU has a positive, indirect effect on system usage through PU.

Shih (2004) argued that individual attitudes toward e-shopping are strongly and positively correlated with user acceptance. His empirical research results (2004) confirmed that perceived ease of use of trading online (PEOUT) and perceived usefulness (PU) significantly determine individual loyalty toward e-shopping. It also confirmed the significant effect of PEOU of the Web on PEOUT, which in turn affects PU as well. However, PU was not found to affect user acceptance significantly. Additionally, user satisfaction with the Internet/WWW and perceptions of information, system, and service were shown to affect user acceptance significantly. On the other hand, recent findings also suggested that customer satisfaction in the online environment is significantly higher than in traditional channels as a result of ease of use in acquiring information. Ease of use can also affect transaction costs when it pertains to information search (Shanker et al., 2000).

Based on above discussion, technology acceptance factor contains four criteria about the competitive advantage of shopping websites. There are Efficiency, Practical, Ease Use and Time-Saving. Efficiency means that the browse function in the shopping website can increase customers' shopping efficiency. Practical means that the credit function in the shopping website can raise customers' shopping efficiency. Ease Use means that the operations of the shopping website are easy to understand and convenient to use. Time-Saving means that the shopping website saves customers a lot of other related shopping time.

2.2. Website service quality

For Parasuraman, Zeithaml, and Berry (1985, 1988a), service quality (SERVQUAL) is measured in 10 phases: accessibility, communication, capability, courtesy, trustworthiness, reliability, responsiveness, safety, tangibility, and understanding with customers. Parasuraman et al. (1988a, 1988b) also reduced the 10 to 5: tangibility, reliability, responsiveness, assurance, and empathy.

In electronic commerce, service quality measures have been applied to assess the quality of search engines and factors associated with Web site success. However, consumers' perceptions of online service quality remain unexplored. There are indications that electronic commerce service issues go beyond product price and may be the reason for consumers' preference for the channel. Yang, Wu, and Wang (2009) used four dimensions of SERVQUAL, which include reliability, responsiveness, assurance, and empathy, to measure the users' cognition of SERVQUAL in online channel. Keeney (1999) developed a means-ends objectives network for Internet commerce. The means objectives represent aspects of the customer's desired e-service experience (e.g., assure system security, maximize product information, maximize ease of use) and are operationalized by e-service process attributes during the customer's interaction with the e-service.

Relevant to service dimensions of the website, Devaraj et al. (2002) reported results of a study that measured consumer satisfaction with the e-commerce channel through constructs prescribed by three established frameworks, namely technology acceptance model (TAM), transaction cost analysis (TCA), and SERVQUAL. The study found that TAM components – perceived ease of use and usefulness – are important in forming consumer attitudes and in strengthening the e-commerce channel. This study found empirical support for the assurance dimension of SERVQUAL as a determinant in e-commerce channel satisfaction.

On the other hand, when the customers perceive better website service quality such as special treatment benefits, they will have more e-satisfaction; when the customers feel e-satisfaction of the website, they will be more e-loyalty; when the website is responsiveness, it will influence directly the customers' e-loyalty (Lai, Chen, & Lin, 2007). Furthermore, based on data from an online questionnaire of customers of an e-banking service, Oliveira (2007) employed structural equation modelling to examine the link between website service quality and customer loyalty. His research found a strong and significant link between the two constructs, suggesting that this relationship also holds in e-service settings.

According to above discussion, website service quality contains four criteria about the competitive advantage of shopping websites. There are Communication, Confident, Security and Trust. Communication means that the same shopping website personnel or records would remember customers' related consumption habits when customers shopping again. Confident means that customers are confident in buying products in the shopping website. Security means that customers feel secure to buy products in the shopping website. Trust means that customers trust in the shopping website that can provide appropriate service to them.

2.3. Specific holdup cost

Chiu (2006) divided transaction cost into four parts: explicit unit benefit cost, information search cost, moral hazard cost, and specific holdup cost.

With regard to the implicit factors, this study mainly discusses the customer's inner mental perceptions when shopping online. Thus, we will not discuss what explicit unit benefits the shopping website can offer to customers, but will largely measure how much a specific holdup cost would affect customers' e-satisfaction and e-loyalty. It's also because that the issue of familiarity/habit has been overlooked in the study of e-commerce.

In general, specific holdup cost refers to the relative lack of transferability of assets intended for use in a given transaction to other uses. Highly specific assets represent sunk costs that have relatively little value beyond their use in the context of a specific

transaction. The concept of specific holdup cost is similar to that of asset specificity. Coase (1988) has suggested six main types of asset holdup specificity: site specificity, physical asset specificity, human asset specificity, brand names, dedicated assets, and temporal specificity. Customers often develop specialized *knowledge* that would be of limited application outside of the relationship in which it was developed (Williamson, Wachter, & Harris, 1975). Asset specificity arises because this knowledge is specific to a given relationship – specialized vocabularies, for example, could not be transferred to relationships with another partner.

Therefore, in terms of online shopping activities, if the customer is familiar with transaction methods of shopping websites, he will use these shopping websites more. This also allows the customer to spend more effort and time in learning how to purchase from a particular shopping website. In dealing with the specific holdup cost run through it, the customer can possibly be fastened to the shopping website. In this regard, when customers and shopping websites, for example, make a specific holdup cost, customers' e-loyalty will be enhanced.

In terms of above discussion, specific holdup cost contains four criteria about the competitive advantage of shopping websites. There are Familiar, Past Experience, Proficiency and Knowledgeable. Familiar means that customers that understand how to use the shopping website have already spent time to grope and learn. Past Experience means that customers use this shopping website because customers are already used to it. Proficiency means that customers need to spend more time and efforts fumbling and learning it afresh customers give up this shopping website and use another one. Knowledgeable means that customers have infused much time and energies to confirm that this shopping website fits in with customers' needs and preferences.

3. The fuzzy TOPSIS method

This study uses this method to evaluate the shopping website alternatives performance and rank the priority for them accordingly. TOPSIS views a MADM problem with m alternatives as a geometric system with m points in the n-dimensional space. The method is based on the concept that the chosen alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution. TOPSIS defines an index called similarity to the positive-ideal solution and the remoteness from the negative-ideal solution. Then the method chooses an alternative with the maximum similarity to the positive-ideal solution (Wang & Chang, 2007). It is often difficult for a decision-maker to assign a precise performance rating to an alternative for the attributes under consideration. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. This section extends the TOPSIS to the fuzzy environment (Yang & Hung, 2007). This method is particularly suitable for solving the group decision-making problem under fuzzy environment. We briefly review the rationale of fuzzy theory before the development of fuzzy TOPSIS. The mathematics concept borrowed from Ashtiani, Haghighirad, Makui, and Montazer (2008), Büyüközkan, Feyzioğlu, and Nebol (2007) and Wang and Chang (2007).

Step 1: Determine the weighting of evaluation criteria

A systematic approach to extend the TOPSIS is proposed to solve the estimation of shopping websites under a fuzzy environment in this section. In this paper the importance weights of various criteria and the ratings of qualitative criteria are considered as linguistic variables (as Table 1) (Chen, Lin, & Huang, 2006).

Step 2: Construct the fuzzy decision matrix and choose the appropriate linguistic variables for the alternatives with respect to criteria

Table 1
Linguistic scales for the importance of each criterion.

Linguistic variable	Corresponding triangular fuzzy number
Very low (VL)	(0.0,0.1,0.3)
Low (L)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
High (H)	(0.5,0.7,0.9)
Very high (VH)	(0.7,0.9,1.0)

$$\widetilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array}, \quad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \tag{1}$$

$$\tilde{x}_{ij} = \frac{1}{k}(\tilde{x}^1_{ij} + \tilde{x}^2_{ij} + \cdots + \tilde{x}^k_{ij})$$

$$\tilde{x}_{ij} = \frac{1}{k}\left(\tilde{x}^1_{ij} + \tilde{x}^2_{ij} + \cdots + \tilde{x}^k_{ij}\right)$$

where $\tilde{x}^k_{ij}$ is the rating of alternative A_i with respect to criterion C_j evaluated by expert, and $\tilde{x}^k_{ij} = (a^k_{ij}, b^k_{ij}, c^k_{ij})$.

Step 3: Normalize the fuzzy decision matrix

The normalized fuzzy decision matrix denoted by $\widetilde{R}$ is shown as following formula:

$$\widetilde{R} = [\tilde{r}_{ij}]_{m\times n}, \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n \tag{2}$$

Then the normalization process can be performed by following formula:

$$\text{where} \quad \tilde{r}_{ij} = \left(\frac{a_{ij}}{c^+_j}, \frac{b_{ij}}{c^+_j}, \frac{c_{ij}}{c^+_j}\right) c^+_j = \max_i c_{ij}$$

The normalized $\tilde{r}_{ij}$ are still triangular fuzzy numbers. For trapezoidal fuzzy numbers, the normalization process can be conducted in the same way. The weighted fuzzy normalized decision matrix is shown as following matrix $\widetilde{V}$:

$$\widetilde{V} = [\tilde{v}_{ij}]_{m\times n}, \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n \tag{3}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \tag{4}$$

Step 4: Determine the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS)

According to the weighted normalized fuzzy decision matrix, we know that the elements $\tilde{v}_{ij}$ are normalized positive TFNs and their ranges belong to the closed interval [0,1]. Then, we can define the FPIS A^+ and FNIS A^- as following formula:

$$A^+ = (\tilde{v}^+_1, \tilde{v}^+_2, \ldots, \tilde{v}^+_n) \tag{5}$$

$$A^- = (\tilde{v}^-_1, \tilde{v}^-_2, \ldots, \tilde{v}^-_n) \tag{6}$$

where $\tilde{v}^+_j = (1,1,1)$ and $\tilde{v}\bar{j} = (0,0,0), j = 1,2,\ldots,n$.

Step 5: Calculate the distance of each alternative from FPIS and FNIS

The distances (d^+_i and d^-_i) of each alternative A^+ from and A^- can be currently calculated by the area compensation method.

$$d^+_i = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}^+_j), \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n \tag{7}$$

$$d^-_i = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}^-_j), \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n \tag{8}$$

Step 6: Obtain the closeness coefficient and rank the order of alternatives

The CC_i is defined to determine the ranking order of all alternatives once the d_i^+ and d_i^- of each alternative have been calculated. Calculate similarities to ideal solution. This step solves the similarities to an ideal solution by formula:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1, 2, \ldots, m \tag{9}$$

According to the CC_i, we can determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives.

In the last years, some fuzzy TOPSIS methods were developed in the different applied field. Lin and Chang (2008) adopted fuzzy TOPSIS for order selection and pricing of manufacturer (supplier) with make-to-order basis when orders exceed production capacity. Chen and Tsao (2008) is to extend the TOPSIS method based on interval-valued fuzzy sets in decision analysis. Ashtiani et al. (2008) used interval-valued fuzzy TOPSIS method is aiming at solving MCDM problems in which the weights of criteria are unequal, using interval-valued fuzzy sets concepts. Mahdavi, Mahdavi-Amiri, Heidarzade, and Nourifar (2008) designed a model of TOPSIS for the fuzzy environment with the introduction of appropriate negations for obtaining ideal solutions. Büyüközkan, Feyzioğlu, and Nebol (2007) identified the strategic main and sub-criteria of alliance partner selection that companies consider the most important through Fuzzy AHP and fuzzy TOPSIS model and achieved the final partner-ranking results. Abo-Sinna, Amer, and Ibrahim (2008) focused on multi-objective large-scale non-linear programming problems with block angular structure and extended the technique for order preference by similarity ideal solution to solve them. Wang and Chang (2007) applied fuzzy TOPSIS to help the Air Force Academy in Taiwan choose optimal initial training aircraft in a fuzzy environment. Li (2007) developed a compromise ratio (CR) methodology for fuzzy multi-attribute group decision making (FMAGDM), which is an important part of decision support system. Wang and Lee (2007) generalized TOPSIS to fuzzy multiple-criteria group decision-making (FMCGDM) in a fuzzy environment. Kahraman, Çevik, Ates, and Gülbay (2007) proposed a fuzzy hierarchical TOPSIS model for the multi-criteria evaluation of the industrial robotic systems. Benítez, Martín, and Román (2007) presented a fuzzy TOPSIS approach for evaluating dynamically the service quality of three hotels of an important corporation in Gran Canaria island via surveys. Wang and Elhag (2006) proposed a fuzzy TOPSIS method based on alpha level sets and presents a non-linear programming solution procedure. Chen et al. (2006) applied fuzzy TOPSIS approach to deal with the supplier selection problem in supply chain system.

4. Empirical evidence from shopping websites

Regarding the evaluation of the shopping website, 12 experts were invited to survey four alternatives using the research framework shown in Fig. 1. Through the literature investigation and experts' opinions, the committee finally adopted 12 criteria. This research framework includes 12 evaluation criteria, such as Efficiency (C1), Practical (C2), Ease Use (C3), Time-Saving (C4), Communication (C5), Confident (C6), Security (C7), Trust (C8), Familiar (C9), Past Experience (C10), Proficiency (C11) and Knowledgeable (C12). In addition, there are four alternatives of shopping websites that encompass Taiwan Yahoo (A1), PCHome (A2), Unimall (A3) and eBay (A4).

After the construction of the hierarchy the different priority weights of each criteria, attributes and alternatives are calculated using the fuzzy TOPSIS approach. The comparison of the importance or preference of one criterion, attribute or alternative over another can be done with the help of the questionnaire. The method of calculating priority weights of the different decision alternatives is discussed following part.

Step 1: Determine the linguistic weighting of each criteria

We adopt fuzzy TOPSIS method to evaluate the weights of different criteria for the online shopping websites. Following the

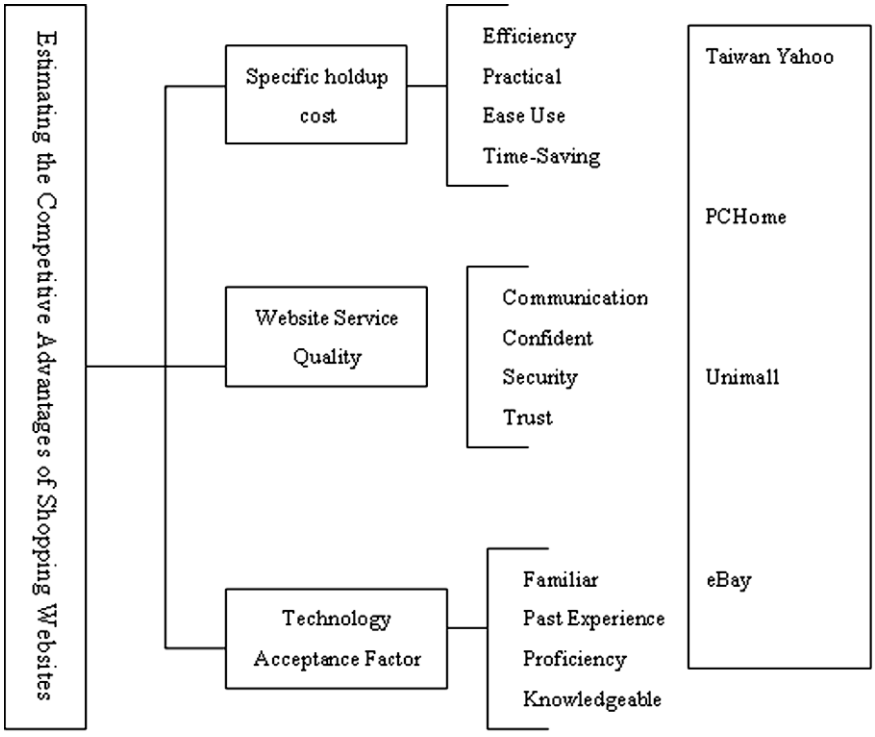

Fig. 1. Research framework.

Table 2
Weights of each criterion.

		BNP	Rank
C1	(0.58,0.78,0.94)	0.769	3
C2	(0.58,0.78,0.93)	0.767	4
C3	(0.57,0.77,0.92)	0.750	5
C4	(0.52,0.72,0.88)	0.703	10
C5	(0.31,0.48,0.68)	0.489	12
C6	(0.55,0.75,0.90)	0.733	6
C7	(0.63,0.83,0.95)	0.806	1
C8	(0.60,0.80,0.94)	0.781	2
C9	(0.40,0.60,0.79)	0.597	11
C10	(0.55,0.75,0.85)	0.716	7
C11	(0.53,0.73,0.88)	0.711	8
C12	(0.53,0.73,0.88)	0.711	8

construction of fuzzy TOPSIS model, it is extremely important that experts fill the judgment matrix. In this study, two website designers, three software engineers, two shopping websites owners and five engineer Management Information Systems experts are involved. From the viewpoint of expert validity, the buildup of most of the operationalizations was based on the literature that caused them to have expert validity.

This research applies the COA method to compute the *BNP* value of the fuzzy weights of each dimension:

To take the *BNP* value of the weight of C1 as an example, the calculation process is as follows:

$$BNP_{w_1} = [(U_{w_1} - L_{w_1}) + (M_{w_1} - L_{w_1})]/3 + L_{w_1} = [(0.94 - 0.58) + (0.78 - 0.58)]/3 + 0.58 = 0.769 \quad (10)$$

Then, the weights for the remaining dimensions can be found as shown in Table 2. Table 2 shows the relative weight of six driving forces of the growth for industrial cluster, which obtained by fuzzy TOPSIS method. The weights for each driving forces are: C1 (0.769), C2 (0.767), C3 (0.750), C4 (0.703), C5 (0.489), C6 (0.733), C7 (0.806), C8 (0.781), C9 (0.597), C10 (0.716), C11 (0.711) and C12 (0.711). From the fuzzy TOPSIS results, we can understand the first two important factors for the competitive advantage of shopping websites are C7 (0.806) and C8 (0.781). Moreover, the less important factor is C5 (0.489).

Step 2: Estimating the performance

This paper focus on determining the best shopping website; so, we assume that questionnaire have collected completely and will start with building dataset that are collected. The evaluators have their own range for the linguistic variables employed in this study according to their subjective judgments (Hsieh, Lu, & Tzeng, 2004).

For each evaluator with the same importance, this study employs the method of average value to integrate the fuzzy/vague judgment values of different evaluators regarding the same evaluation dimensions. The evaluators then adopted linguistic terms (see Table 3), including "very poor", "poor", "fair", "good" and "very good" to express their opinions about the rating of every shopping website regarding each performance criteria, based on the technological data of the four shopping websites listed in Table 4.

Table 3
Linguistic scales for the rating of each cluster policy.

Linguistic variable	Corresponding triangular fuzzy number
Very poor (VP)	(0,1,3)
Poor (P)	(1,3,5)
Fair (F)	(3,5,7)
Good (G)	(5,7,9)
Very good (VG)	(7,9,10)

Table 4
Subjective cognition results of evaluators towards the five levels of linguistic variables.

	A1	A2	A3	A4
C1	(5.33,7.33,9.17)	(4.50,6.50,8.42)	(3.25,5.17,7.17)	(2.67,4.67,6.67)
C2	(4.50,6.50,8.42)	(4.83,6.83,8.67)	(3.17,5.17,7.17)	(3.00,5.00,7.00)
C3	(4.33,6.33,8.33)	(4.67,6.67,8.58)	(3.08,5.00,7.00)	(2.83,4.83,6.83)
C4	(4.67,6.67,8.67)	(4.00,6.00,8.00)	(3.17,5.17,7.17)	(2.45,4.45,6.45)
C5	(3.50,5.50,7.50)	(3.50,5.50,7.42)	(2.42,4.33,6.33)	(2.17,4.17,6.17)
C6	(4.67,6.67,8.42)	(3.50,5.33,7.33)	(2.50,4.33,6.33)	(2.08,4.00,6.00)
C7	(4.17,6.17,8.17)	(4.00,6.00,7.92)	(2.92,4.83,6.83)	(2.67,4.67,6.67)
C8	(4.17,6.17,8.17)	(3.83,5.83,7.75)	(3.00,5.00,7.00)	(2.17,4.17,6.17)
C9	(4.83,6.83,8.67)	(4.67,6.67,8.58)	(3.83,5.83,7.83)	(1.75,3.50,5.50)
C10	(4.67,6.67,8.58)	(4.33,6.33,8.25)	(3.00,5.00,7.00)	(1.67,3.50,5.50)
C11	(5.17,7.17,9.00)	(4.67,6.67,8.50)	(3.50,5.50,7.50)	(1.83,3.67,5.67)
C12	(4.50,6.50,8.42)	(4.08,6.00,7.83)	(3.17,5.17,7.17)	(2.17,4.00,6.00)

Table 5
Normalized fuzzy decision matrix.

	A1	A2	A3	A4
C1	(0.58,0.80,1.00)	(0.52,0.75,0.97)	(0.41,0.66,0.91)	(0.38,0.67,0.95)
C2	(0.49,0.71,0.92)	(0.56,0.79,1.00)	(0.40,0.66,0.91)	(0.43,0.71,1.00)
C3	(0.47,0.69,0.91)	(0.54,0.77,0.99)	(0.39,0.64,0.89)	(0.40,0.69,0.98)
C4	(0.51,0.73,0.95)	(0.46,0.69,0.92)	(0.40,0.66,0.91)	(0.35,0.64,0.92)
C5	(0.38,0.60,0.82)	(0.40,0.63,0.86)	(0.31,0.55,0.81)	(0.31,0.60,0.88)
C6	(0.51,0.73,0.92)	(0.40,0.62,0.85)	(0.32,0.55,0.81)	(0.30,0.57,0.86)
C7	(0.45,0.67,0.89)	(0.46,0.69,0.91)	(0.37,0.62,0.87)	(0.38,0.67,0.95)
C8	(0.45,0.67,0.89)	(0.44,0.67,0.89)	(0.38,0.64,0.89)	(0.31,0.60,0.88)
C9	(0.53,0.75,0.95)	(0.54,0.77,0.99)	(0.49,0.74,1.00)	(0.25,0.50,0.79)
C10	(0.51,0.73,0.94)	(0.50,0.73,0.95)	(0.38,0.64,0.89)	(0.24,0.50,0.79)
C11	(0.56,0.78,0.98)	(0.54,0.77,0.98)	(0.45,0.70,0.96)	(0.26,0.52,0.81)
C12	(0.49,0.71,0.92)	(0.47,0.69,0.90)	(0.40,0.66,0.91)	(0.31,0.57,0.86)

Step 3: Normalize the fuzzy decision matrix

Using Eq. (2), we can normalize the fuzzy decision matrix as Table 5.

Step 4: Establish the weighted normalized fuzzy decision matrix

The forth step in the analysis is to find the weighted fuzzy decision matrix, and the resulting fuzzy weighted decision matrix is shown as Table 6.

Step 5: Determine the fuzzy positive and fuzzy negative-ideal reference points

Then we can define the fuzzy positive-ideal solution (FPIS) and the fuzzy negative-ideal solution (FNIS) as: A^+ and A^-. This is the fifth step of the fuzzy TOPSIS analysis.

$$A^+ = [(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1)]$$
$$A^- = [(0,0,0),(0,0,0)(0,0,0),(0,0,0),(0,0,0),(0,0,0)]$$

Step 6: Estimating the performance and ranking the alternatives

In order to calculate the closeness coefficients of each of the alternatives d_1^+ and d_1^- calculation is used as an example as follows.

Table 6
Weighted normalized fuzzy decision matrix.

	A1	A2	A3	A4
C1	(0.34,0.63,0.94)	(0.30,0.59,0.93)	(0.24,0.52,0.92)	(0.22,0.52,0.88)
C2	(0.29,0.56,0.86)	(0.33,0.62,0.93)	(0.24,0.52,0.85)	(0.25,0.56,0.93)
C3	(0.27,0.53,0.83)	(0.31,0.59,0.91)	(0.22,0.49,0.82)	(0.23,0.53,0.89)
C4	(0.26,0.52,0.83)	(0.24,0.50,0.81)	(0.21,0.47,0.80)	(0.18,0.46,0.81)
C5	(0.12,0.29,0.55)	(0.12,0.31,0.58)	(0.10,0.27,0.55)	(0.10,0.29,0.59)
C6	(0.28,0.55,0.83)	(0.22,0.46,0.76)	(0.18,0.41,0.73)	(0.16,0.43,0.77)
C7	(0.29,0.56,0.85)	(0.29,0.58,0.87)	(0.24,0.51,0.83)	(0.24,0.56,0.90)
C8	(0.27,0.54,0.84)	(0.27,0.54,0.84)	(0.23,0.51,0.84)	(0.19,0.48,0.83)
C9	(0.21,0.45,0.75)	(0.22,0.46,0.78)	(0.20,0.45,0.79)	(0.10,0.30,0.62)
C10	(0.28,0.54,0.80)	(0.28,0.55,0.81)	(0.21,0.48,0.76)	(0.13,0.37,0.67)
C11	(0.30,0.57,0.86)	(0.29,0.56,0.86)	(0.24,0.51,0.84)	(0.14,0.38,0.71)
C12	(0.26,0.510,0.81)	(0.25,0.50,0.79)	(0.21,0.48,0.80)	(0.16,0.42,0.75)

Table 7
Closeness coefficients and ranking.

	d_1^+	d_i^-	CC_i	Rank
Taiwan Yahoo	6.248	6.926	0.526	2
PCHome	6.264	6.985	0.527	1
Unimall	6.779	6.550	0.491	3
eBay	7.103	6.330	0.471	4

Once the distances of cluster policy from FPIS and FNIS are determined, the closeness coefficient can be obtained with Eq. (9). The index CC_1 of first alternative is calculated as:

$$d_1^+ = 6.248 \quad d_1^- = 6.926$$

From the alternative evaluation results in Table 7, the best two online shopping websites are PCHome and Taiwan Yahoo.

$$CC_1 = \frac{6.926}{6.248 + 6.926} = 0.526$$
$$CC_2 > CC_1 > CC_3 > CC_4$$

5. Managerial implication and suggestion

The paper ends with some final comments, based on the main research results mentioned above. The aim of this research is to construct a fuzzy TOPSIS model to evaluate different shopping website and to support the selection of priority mix that is efficient. These factors are to generate a final evaluation ranking for priority among these shopping websites of the proposed model. The importance of the criterion is evaluated by experts, and the uncertainty of human decision-making is taken into account through the fuzzy concept.

From the proposed method, fuzzy TOPSIS, we find out the factors of security and trust are the most important for improving the competitive advantage of shopping website. Moreover, the PCHome and Yahoo Taiwan rank the first two positions for shopping websites.

5.1. Technology acceptance factor

Our research outcome has provided direct support to the notion that the effect of efficiency, practical and ease use factors on competitive advantages of shopping websites, and this is in large part accordant with previous research results (i.e., Chiu, 2006; Flavian et al., 2006; Fullerton, 2005). As noted before, technology and function offered by website operators certainly involve online consumer welfare and convenience in regard to their online purchasing behavior. Thus, shopping websites should provide proper website-related functions in accordance with the customers' needs. Shopping website features should be considered primary in every site design to generate positive perceptions of usefulness, and informativeness, while avoiding irritation; thus enabling consumers to understand the site layout and navigate in their search for products and services offered at the site. Shopping website managers also need to provide useful information about the shopping website to be adopted and to diffuse users' positive experience of using the shopping website to achieve the highest levels of market performance (Lee & Park, 2008). Moreover, they should encourage customers share the use experience and provide various incentives to make voluntary propositions on effective shopping website implementation. Shopping website designers may add human features such as the use of humor, appealing graphics, or 3d virtual models to attract, retain, and motivate consumers to purchase from the site. Therefore, shopping website service providers should continue to improve user friendliness, making the tools easy to use and accessible. This allows the customers to save more time and effort but have a higher shopping efficiency, resulting in enhanced customer satisfaction as well as loyalty.

Aside from this, the study also verifies studies by Shih (2004) and Szymanski and Hise (2000). Shih (2004) contended that perceived ease of use of trading online (PEOUT) and perceived usefulness (PU) significantly determine individual attitudes toward e-shopping. Szymanski and Hise (2000) also pointed out that satisfaction with e-retailing increases as perceptions of convenience become more positive. Therefore, if a shopping website operator wishes particularly to attract non-Internet shoppers, he or she must think of means to increase the website's usefulness. For example, the shopping website can be made simple and easy to understand in order to reduce the customer's shopping time and make Internet shopping more effective. This is because for those e-shoppers who have a high level of Internet familiarity the website operators might need to pay more efforts in meeting their satisfaction, and then winning their loyalty.

5.2. Website service quality

From our research outcome, we note that the effect of security and trust on competitive advantages of shopping websites is basically in accord with what has been concluded in previous research (i.e., Anderson & Srinivassn, 2003; Ribbink et al., 2004; Shih, 2004). Thus, facing Internet competition, Internet shopping industries want to grasp the customers and the first condition is to provide good website service quality to customers. In order to achieve this goal, Hung, Liang, and Chang (2005) pointed out that shopping website operators must first manage to understand the customer groups that are served. The majority of website operators are initially not quite aware of their customers, including related personal or background information. But after some while, customers leave browsing as well as transaction records on the website, even signing on as shopping website VIP members. Toward the end of satisfying the customers, shopping website operators should try to enhance service quality through use of related business analysis and then understand the customers' traits, buying preferences, and shopping habits. In addition, Wang and Huarng (2002) identified nine service quality factors that affect e-satisfaction through content analysis of online customer comments in their research: (1) general feedback on the website design; (2) competitive price of the product; (3) merchandise availability; (4) merchandise condition; (5) on-time delivery; (6) merchandise return policy; (7) customer support; (8) e-mail confirmation of customer order; and (9) promotion activities. These are suggestions for shopping websites to enhance Internet service quality as well as customer e-satisfaction.

Finally and likewise, Internet retailers can also implement different policies to allow customers to trust their service quality more. From the agency theory viewpoint, firms can use three different methods for transaction relations to be more effective: information policies, guarantee policies, and reputation policies (Spremann, 1988). In addition, the expansion of electronic commerce may be expected to lead to an increase in the volume of agency relationships, such as outsourcing or business partnerships (Croson & Jacobides, 1997). Thus the shopping agent is an effective technology that will strengthen e-commerce collaboration, speed up e-commerce globalization, and bring it to success. Its e-service quality rating system will certainly be a useful tool for improving e-service in the global e-commerce environment.

5.3. Specific holdup cost

This research also sheds light on the fact that the dimension of specific holdup cost does not the determinative factor on competitive advantages of shopping websites.

Chiu (2006) divided specific holdup assets into six types: special possessed knowledge assets, special physical facility or service assets, specific assets of loyal customers, intangible specific assets, interior acknowledgement, and special intangible social pressure. We posit that the specific holdup cost has a direct influence on customer e-loyalty because when customers pay specific holdup costs they reap the above benefits and then form a shopping habit that increases their competitive advantage. For example, when a customer spends a long time understanding and familiarizing him/herself with shopping and payment procedures at a certain shopping website, the paid specific holdup cost on related intangible things must increase. But at the same time, the customer also benefits from gaining "special possessed knowledge asset" in the process. This also means that a particular relaxation, ease, trust, security and efficiency must seem apparent when the customer uses this shopping website, resulting in less willingness to switch to another, perhaps unfamiliar, shopping website. On the other hand, the customer will also wish to continue using a particular website to purchase as a result of brand group pressure or a special leader's endorsement. Customer's behavior of repeated purchase will enhance brand awareness and brand image, in turn, build customer loyalty (Keller, 1993). All these illustrate why and how specific holdup cost can bring about enhanced competitive advantage.

However, since what most e-customers chiefly care about is whether they can make the most efficient comparisons among many shopping websites, they are therefore less willing to be pinioned by one specific shopping website. Consequently, when the specific holdup cost between the customer and a certain shopping website is set too high, competitive advantage will drop instead. In addition, because of the above-enumerated types of specific holdup costs, customers can also become loyal patrons of any shopping website. But this competitive advantage after all comes mainly from the holdup situation of customers themselves or from the stickiness of offered unique technologies or services, and not from customers' virtual e-satisfaction with the shopping convenience, product marketing, website facility, or finance security provided by the shopping website. Similarly, analysis of the survey data collected from Forker and Stannack (2000) indicates that buyers and suppliers have a better "shared understanding" (smaller satisfaction gap) within the "competitive" relationship than within the "cooperative" relationship. Transaction cost such as asset specificity investment is one of the reasons leading to the noted situation.

Campell (1997) put forward the view that the specific holdup cost is concerned in large part with a condition where "repeat purchases occur on the basis of situational cues rather than on strong partner commitment". Composition links thus strengthen value as well as transformation costs and outwin the competitors who cannot offer such special services for customers. The customers are thus fastened to the composition (Campell, 1997). Therefore, aside from fulfilling personal service quality and information level, shopping websites can also provide specific member services through social organization such as chat room links or VIP membership. In short, in order to increase competitive advantage, shopping website operators should make the transfer cost to other websites high, so that the shopping website can maintain a longer transaction relationship with the customers.

The e-customers with a high daily online frequency can more possibly become those investing specific holdup costs in the website shopping. Hence the specific holdup cost is highly relevant to one's habit at this point. So, the websites also need to target who those customers are, and then implement proper strategies as noted to attract them for higher return rates.

6. Limitation and future research direction

The topic discussed in this study is still developing at present; it is hoped to be continually explored with the addition of other factors such as cultural and social factors affecting competitive advantages, thus enriching the research contents. Therefore, we hope that succeeding studies can adopt a wider range of constructs to make the whole study share more benefits. Finally, Internet products' distinctions can also affect customers' decisions to shop on the websites or not. From a management perspective, consumers in fact treat high-involvement and low-involvement products with different behavioral models. The product's unit price influences the desires of consumer for Internet shopping as well. Thus, we propose that much research is needed to discover the effects of different product characteristics on customer e-shopping.

References

Abo-Sinna, M. A., Amer, A. H., & Ibrahim, A. S. (2008). Extensions of TOPSIS for large scale multi-objective non-linear programming problems with block angular structure. *Applied Mathematical Modelling, 32*(3), 292–302.

Anderson, R. E., & Srinivassn, S. S. (2003). E-satisfaction and e-loyalty: A contingency framework. *Psychology and Marketing, 20*, 123–138.

Ashtiani, B., Haghighirad, F., Makui, A., & Montazer, G. A. (2008). Extension of fuzzy TOPSIS method based on interval-valued fuzzy sets. *Applied Soft Computing*. doi:10.1016/j.asoc.2008.05.005.

Benítez, J. M., Martín, J. C., & Román, C. (2007). Using fuzzy number for measuring quality of service in the hotel industry. *Tourism Management, 28*(2), 544–555.

Butler, P., & Peppard, J. (1998). Consumer purchasing on the Internet: Processes and prospects. *European Management Journal, 15*(6), 600–610.

Büyüközkan, G., Feyzioğlu, O., & Nebol, E. (2007). Selection of the strategic alliance partner in logistics value chain. *International Journal of Production Economics, 113*(1), 148–158.

Campell, A. (1997). What affects expectations of mutuality in a business relationship? *Journal of Marketing, 56*, 55–68.

Chen, C.-T., Lin, C.-T., & Huang, S.-F. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. *International Journal of Production Economics, 102*(2), 289–301.

Chen, T.-Y., & Tsao, C.-Y. (2008). The interval-valued fuzzy TOPSIS method and experimental analysis. *Fuzzy Sets and Systems, 159*(11), 1410–1428.

Chiu, J. S. (2006). *Strategic marketing analysis: Framework and practical applications*. Taipei: BEST WISE.

Coase, R. H. (1988). The nature of the firm: Origin. *Journal of Law, Economics and Organization, 4*(1), 3–17.

Croson, D. C., & Jacobides, M. G. (1997). Agency relationships and monitoring in electronic commerce. *International Journal of Electronic Commerce, Special Issue on Information Technology and Economics, 1*(3), 65–82.

Dan, K. J., Ferrin, D. L., & Raghav, R. H. (2008). A trust-based consumer decision-making model in electronic commerce: The role of trust, perceived risk, and their antecedents. *Decision Support Systems, 44*(2), 544–564.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Devaraj, S., Fan, M., & Kohli, R. (2002). Antecedents of B2C channel satisfaction and preference: Validating e-commerce metrics. *Information Systems Research, 13*(3), 316–333.

Flavian, C., Guinaliu, M., & Gurrea, R. (2006). The role played by perceived usability, satisfaction and consumer trust on website loyalty. *Information and Management, 43*, 1–14.

Forker, L. B., & Stannack, P. (2000). Cooperation versus competition: Do buyers and suppliers really see eye-to-eye? *European Journal of Purchasing & Supply Management, 6*(1), 31–40.

Fullerton, G. (2005). The service quality–loyalty relationship in retail service: Does commitment matter? *Journal of Retailing and Consumer Service, 12*, 99–111.

Hsieh, T.-Y., Lu, S.-T., & Tzeng, G.-H. (2004). Fuzzy MCDM approach for planning and design tenders selection in public office buildings. *International Journal of Project Management, 22*(7), 573–584.

Hung, S. Y., Liang, T. P., & Chang, C. M. (2005). A meta-analysis of empirical research using TAM. *Journal of Information Management, 12*(4), 211–234.

International Telecommunication Union (2005). *World telecommunication indicators 2005*. Switzerland: ITU.

Kahraman, C., Çevik, S., Ates, N. Y., & Gülbay, M. (2007). Fuzzy multi-criteria evaluation of industrial robotic systems. *Computers & Industrial Engineering, 52*(4), 414–433.

Keeney, R. L. (1999). The value of Internet commerce to the customer. *Management Science, 45*, 533–542.

Keller, K. L. (1993). Conceptualizing, measuring, and managing customer based brand equity. *Journal of Marketing, 57*, 1–22.

Lai, C.-S., Chen, C.-S., & Lin, P.-J. (2007). *The effects of service quality on customer relational benefits in travel website*. Management of Converging Technologies, Portland International Center for Management of Engineering and Technology (PICMET 2007), 5–9 August 2007 (pp. 1133–1140).

Lee, T. M., & Park, C. (2008). Mobile technology usage and B2B market performance under mandatory adoption. *Industrial Marketing Management*. doi:10.1016/j.indmarman.2008.02.008.

Li, D.-F. (2007). Compromise ratio method for fuzzy multi-attribute group decision making. *Applied Soft Computing, 7*(3), 807–817.

Limayem, M., Khalifa, M., & Frini, A. (2000). What makes consumers buy from the Internet? A longitudinal study of online shopping. *IEEE Transaction Systems, Man, and Cybernetics: Part A, 30*(4), 421–432.

Lin, H.-T., & Chang, W.-L. (2008). Order selection and pricing methods using flexible quantity and fuzzy approach for buyer evaluation. *European Journal of Operational Research, 187*(2), 415–428.

Mahdavi, I., Mahdavi-Amiri, N., Heidarzade, A., & Nourifar, R. (2008). Designing a model of fuzzy TOPSIS in multiple criteria decision making. *Applied Mathematics and Computation*. doi:10.1016/j.amc.2008.05.047.

Oliveira, R. C. (2007). Evidences from link between quality and loyalty in e-service: An empirical study. *SISTEMAS & GESTÃO, 2*(1), 1–15.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service and its implications for further research. *Journal of Marketing*(Fall), 41–50.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988a). Communications and control process in the delivery of service quality. *Journal of Marketing*(April), 35–48.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988b). SEVQUAL: A multiple item scale for measuring consumer perceptive of service quality. *Journal of Retailing, 64*(1), 12–37.

Ribbink, D., Riel, A. C. R., Liljander, V., & Streukens, S. (2004). Comfort your online customer: Quality, trust and loyalty on the internet. *Managing Service Quality, 14*(6), 446–456.

Rita, W., & Henriette, L. (2004). Psychological antecedents of institution-based consumer trust in e-retailing. *Information and Management, 42*(1), 159–177.

Shanker, V., Smith, A., & Rangaswamy, A. (2000). *Customer satisfaction and loyalty in online and offline environments*. Working paper. E-Business Research Center, Penn State University.

Shih, H. P. (2004). An empirical study on predicting user acceptance of e-shopping on the web. *Information and Management, 41*(3), 351–368.

Spremann, K. (1988). Reputation. *Garantie Information, 58*(5/6), 613–629.

Szymanski, D. M., & Hise, R. T. (2000). E-satisfaction: An initial examination. *Journal of Retailing, 76*(3), 309–322.

Wang, M., & Huarng, S. A. (2002). An empirical study of internet store customer postshopping satisfaction. *Information Systems Special Issue, 3*, 632–638.

Wang, T. C., & Chang, T. H. (2007). Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment. *Expert Systems with Applications, 33*, 870–880.

Wang, Y.-M., & Elhag, T. M. S. (2006). Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment. *Expert Systems with Applications, 31*(2), 309–319.

Wang, Y.-J., & Lee, H.-S. (2007). Generalizing TOPSIS for fuzzy multiple-criteria group decision-making. *Computers & Mathematics with Applications, 53*(11), 1762–1772.

Williamson, O. E., Wachter, M. L., & Harris, J. E. (1975). Understanding the employment relation: The analysis of idiosyncratic exchange. *Bell Journal of Economics, 6*(1), 250–278.

Yang, H.-E., Wu, C.-C., & Wang, K.-C. (2009). An empirical analysis of online game service satisfaction and loyalty. *Expert Systems with Applications, 36*(2), 1816–1825.

Yang, T., & Hung, C.-C. (2007). Multiple-attribute decision making methods for plant layout design problem. *Robotics and Computer-Integrated Manufacturing, 23*(1), 126–137.