Chapter 39
Fuzzy Data Mining with TOPSIS for Fuzzy Multiple Criteria Decision Making Problems

Chin-yao Low and Sung-nung Lin

Abstract In this study, we purpose a common fuzzy multiple criteria decision making model. Different with formerly studies, a new concept—fuzzy data mining scheme is adopted for considering in the model to establish a fuzzy multiple criteria decision making with time weight (FMCDMTW) model. In this study, a real case of fuzzy multiple criteria decision making (FMCDM) problem to be considering. The problem under investigated is a FMCDM problem with multiple appraisers, and the data considered is combined with historic data and recent data. Since the evaluated criteria proposed in the literature cannot be defined precisely and numerically, fuzzy linguistic terms can be used to aggregate them numerically. It not only conforms to human cognition but also benefits interpretation. Furthermore, notice that the data considered contains certain amount of historic data. As a result, fuzzy time weighted technique is adopted to resolve this issue.

Keywords Auction website · FMCDM · Fuzzy data mining · Fuzzy time weighted · TOPSIS

39.1 Introduction

According to the development of the internet network, consumer behavior had been changed. E-commerce becomes one of the main shopping ways. E-commerce is a way engaged in the business activity through the internet, and its target and range include inside/outside enterprises and individual consumer. Its business activity's content includes goods, service trade, network auction, financial

C. Low (✉) · S. Lin
Department of Industrial Engineering and Management, National Yunlin University of Science and Technology, Yunlin, Taiwan
e-mail: g9621804@yuntech.edu.tw

exchange, network advertisement, etc. Among them, the auction website has taken the majority of e-commerce, and is growing up continuously constantly.

The development of the auction website has not only changed people's life but also changed its consumption habit. Consumers don't need to go out and can stay at home and surf the Net and buy the goods needed. And utilize the auction website to have several advantages to buy the goods, price flexible, goods various in style, rate of exchange easy, 24-h marketing and have no regional constraint etc. The factors which the auction website could operating continuously, totally depend on users, whether would like to continue using and trading the platform and doing a deal. In other words, the service performance of the auction website has determined whether this website can manage continuously. Therefore, how to measure the auction website effectively to manage and serve performance, not only the subject that website's operator cares about, but also an important reference indicator while choosing the trade platform of consumer.

The first job of setting up the performance assessing method is to propose the effective assessment criterion. There is no standard measure criterion for auction website. Therefore, it is quite difficult to set up the effective assessment criterion accorded with subject of assessing. Especially when assess and plan executors have no professional knowledge set up of the criterion; the setting-up of the criterion must gather the relevant specialty personage's opinion. However, it is obtained face to face that the professional personage's opinion is difficult, or need to spend a lot of cost and time. For overcome this difficulty, this research propose one utilize literature review to replace expert opinion probe into method—'fuzzy time weighted' effectively originally.

Assess the criterion in performance about the auction website; quite a lot of literatures propose different assessment criteria. In order to choose the really important assessment criterion objectively and effectively, give consideration to the applicability of gradual progress with time of the criterion at the same time. This research is summing up the assessment criterion that relevant literature, arrange in an order and select the assessment criterion that the research institute need by way of fuzzy time weight (Hoffman and Novak 1996; Hung et al. 2003).

To consider the criterion of auction website service performance, will often be influenced by the appraiser experience subjectively, course the result indistinct and uncertainty, in addition, the assessment of auction website service performance are not assess the criterion singly can be satisfied, must consider a lot of assessment criteria at the same time. So, after the ones that finish assessing criterion, this research continues utilizing the criterion of assessing to set up the auction website to deal in the performance questionnaire. What the questionnaire topic made use of linguistic variable in the fuzzy method to express appraiser's linguistic variable is fuzzy, the ones that assessed the criterion after building and constructing, then appraised to the behavior in assessing the criterion of website by the user of auction website. Finally, serve to apply fuzzy theory and combine multiple criterion decision method tool TOPSIS come assessment opinion to combine persons who assess while being arithmetical performance, thus build and construct the assessment result that an auction website serves performance. The performance

and competitive ability that this method can not merely offer service of understanding the one's own one in the auction website, can still offer consumers to choose the best auction website of a service performance (Troy and Shaw 1997; Zadeh 1965, 1975).

39.2 Methodology

39.2.1 Fuzzy Theory

The fuzzy theory had been proposed by Professor Zadeh. He viewed its human cognitive process (mainly in order to think deeply and deduce). Uncertainly, it come by the way of mathematics expression, and mathematics that is traditional is from having only 'True' and 'False's two value logics (Binary logic). Expand to the continuous n-value (Continuous multi-value) with gray area Logic. And the fuzzy theory utilizes under the jurisdiction of the function (Membership Function). Value come, describe one speciality of concept, come, shows from 0 to 1 element which belong to a certain concept of intensities with 1 number value that asks also, the ones that call this element to assembling in this value are under the jurisdiction of degree (Membership grade). Expect that discourse domain

$$U = \{x_1, x_2, \ldots, x_n\},$$

and the fuzzy set of discourse domain U, $\widetilde{A}$ present as

$$\left\{ \left(x_1, u_{\underset{A}{\sim}}(x_1)\right), \left(x_2, u_{\underset{A}{\sim}}(x_2)\right), \ldots, \left(x_n, u_{\underset{A}{\sim}}(x_n)\right) \right\}$$

$u_{\underset{A}{\sim}}(x_i)$ means the degree of membership of x_i in set $\widetilde{A}$.

The linguistic variable is in the appointed fuzzy set that is used for describing the natural language under the land, can turn into narration of natural language with logic person who infer logic narrate, and the linguistic variable regards word or sentence in the natural language as the parameter that is worth instead of the regarding counting as value. For example the persons who assess experience the appraisal which the network shop service performance, can utilize 'very unsatisfied', unsatisfied, 'ordinary', 'satisfied', 'very satisfied' the sentences of five kinds of yardstick express and serve the quality intensity of the performance, and can turn into number value for language purpose via the expert, change into relevant fuzzy numbers (Hsu and Chen 1996; Kaufmann and Gupta 1991; Klir and Yuan 1995; Langari and Zadeh 1995; Mendel 1995; Zadeh 1965, 1975).

39.2.2 Multiple Criterion Decision Methods

In true world, most decision questions have a lot of assessment criteria, it was not the single indicator that be weighed, but each criterion cannot turn into the same unit to compare, so utilize many criterion decision technology carry on decision of assessment method to born because of answering. Common many criteria decision method as if the analytic approach of the level (AHP), For example: Bi (Chow et al. 1994) AHP and apply the research that is assessed to supplier's performance; In addition SMART analytic approach and TOPSIS. And TOPSIS is by Hwang and Yoon (Van Heck and Ribbers 1997) Multi Criteria Analysis Model. The method, this theoretical foundation supposes promptly every assessment indicator all has a dull characteristic that increases progressively or decreases progressively, it is solved and so-called ideal solution (Grant and Schlesinger 1995; Hung et al. 2003). It is all criterion optimum value that make up (the greatest one of attribute value of the interests; the minimum one of attribute value of the cost). Shoulder the ideal to solve on the contrary (Negative-ideal Solution). It is all criteria difference make up the most (the minimum one of attribute value of the interests; the largest one of attribute value of the cost). Evaluate for select scheme calculate with Euclid Distance, in order to assess indicator comparing to degree of approximation that ideal solve, the scheme chosen answers and the ideal distance that is solving is being shortest, it is farthest and shoulder the distance that the ideal is being solved. TOPSIS has assessed the law and has already been accepted and employed the order of all kinds of trades to compare and assess extensively in the educational circles. For example: Wang, Xu (The National Library 2011), employ research of assessing operation performance of listed company of TOPSIS method; Wang, Chen (The National Library 2011), assess the listed company of the computer and manage the performance with the financial indicator.

According to motive and purpose of this research, we carry on collection and arrangement of literature and relevant materials, added in more than 20 foreign research quoted in the thesis by 105 theses and dissertation, by fuzzy time weight method, according to assess criterion occurrence number, relevance and time weight remit, appear 5 indices, total 25 items auction website serve assessment criterion of performance mainly exactly, and assess the criterion of these to make into the questionnaire, regard user of the auction website as testees and carry on questionnaire investigation. And then assess two big auction websites (Yahoo & Return) at present service performance. The questionnaire one is mainly divided into two major parts. First, it is importance degree comparing and assessing the performance of serving and assessing the criterion. Second and assess the satisfaction of assessing the criterion; And via the questionnaire retrieving, the rated value to two major auction websites that utilize the fuzzy theory and evaluate the weight of the service criterion project of network shop and person who assesses integration, utilize the decision method TOPSIS method of many criteria finally, get rank order and good and bad detail that two auction websites serve performance (Lambert and Sharma 1990; Parasuraman et al. 1985).

39.2.3 Assesses and Service Performance Criterion Appraise

The research of the auction website belongs to quite young subject, but numerous relevant research issues. This research analyzes and quotes use to extract out the measure criterion of managing performance of auction website which this research institute needs to relevant literature. The main facts are involved in 105 theses (The National Library 2011).

First, in order to overcome the difficulty that the expert opinion has, reduce the relevant cost which assesses the necessary expenditure of the homework at the same time. This research uses the way in which the literature probes into to produce the criterion of assessing, look at every literature the same expert, analyze and combine assessment performance relevant components of managing the performance in each literature with the auction website, use to extract the important assessment criterion.

Network auction has been just the trade form coming out in development in recent ten years; the user is at the stage of break-into this kind of transaction formally. So, with the progress of relevant science and technology and gradual progress of time, the user, to the performance that the auction website shows, concerned angle and proportion are being produced and changed constantly. Because performance of user's service for auction website varies with gradual progress of time greatly; the turnover auctioned adds a new line of consumer's consciousness with all increasing on day too. While the literature is put in order, we find though the time block that relevant literature are issued is not big, but service performance that consumers mind has some changes every year (Bellman and Zadeh 1970; Chen and Hwang 1992; Day 1984).

In order to further assess and consider objectively because the time array produced and assessed the criterion change, this research is during the process of putting the literature in order, the assessment criterion of putting forward various years is entrusted to different weights respectively. The assessment criterion after gathering together wholly is according to issuing number of times and relevance, it issues times fuzzy weight on taking advantage of, in order to get the real weight of the criterion. Analyzing the domestic master's thesis quoted will issue times and all lie between in 1998 to 2010 because of this research institute, and foreign most literature definitely also and. So, we build the fuzzy time weight of setting up and belong to one degree of functions as shown in Fig. 39.1.

This research is set out by the user view, through the collection and gathering together wholly of the literature, by weight method of fuzzy time, calculate according to assessing the occurrence number of the criterion and time weight, score according to criterion weight order elect 5 construct surface, total 25 items auction website serve assessment criterion of performance mainly (The National Library 2011; Angehrn 1997; Athanassopoulos 2000; Beam 1999; Bellman and Zadeh 1970; Cheng 1994; Fornell 1992; O'Connor and O'Keefe 1997; Kim and Stoel 2004; Nielsen and Tahir 2005; Parasuraman et al. 1988; Paul 1996; Simon 2001).
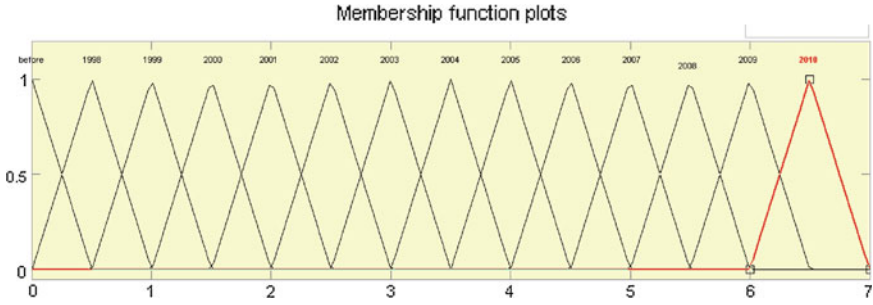
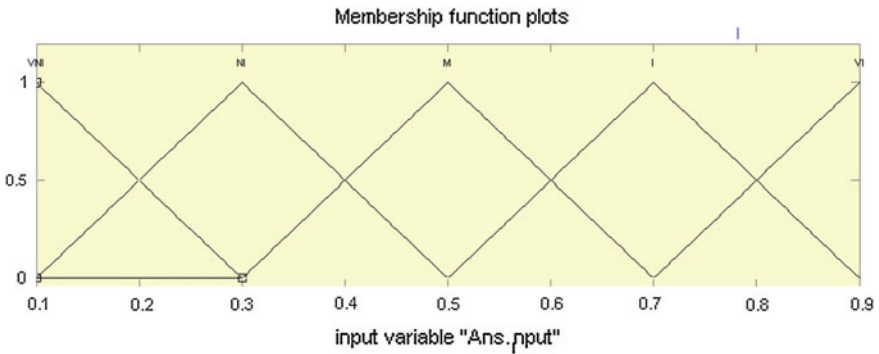**Fig. 39.1** Ownership function that assess the weight of criterion

Fig. 39.2 Assess the ownership function of the criterion 'importance'

39.2.4 Assess and Serve the Criterion Weight of the Performance

After receiving the criterion of assessing, we entrust the criterion to the weight of different levels through the fuzzy way to define with justice, make by favorable follow-up study and questionnaire. Assess the detail as follows:

Step1: Determine to assess the semantic parameter of the criterion importance and count fuzzily

It is because in design of questionnaire utilize by Likert scale with five grade scale, can utilize person who assesses each person by different linguistic variable. To expresses the important measurement value of degree of each assessment criterion of persons who assess, as shown in Fig. 39.2.

Step2: Calculate every fuzzy weight of assessing the criterion

$$
\begin{aligned}
\widetilde{w}_j &= (l_j, m_j, u_j), \quad j = 1, 2, \ldots, n \\
l_j &= \underset{i}{Min}\{l_{ij}\}, \quad i = 1, 2, \ldots m
\end{aligned}
\tag{39.1}
$$

$$m_j = \left(\prod_{i=1}^{m} m_{ij} \right)^{1/m}, \quad i = 1, 2, \ldots, m$$

$$u_j = \underset{i}{Max}\{u_{ij}\}, \quad i = 1, 2, \ldots, m$$

(39.2)

Step3: Each assess the solving and melting fuzzily of fuzzy weight of the criterion

Its main purpose is to change the fuzzy weight of 25 assessment criteria into a clear single number value (Ofj), Can learn importance degree and priority of each assessment criterion, and often the fuzzy method to melt of the opinion includes 'the maxima–minimum set method', 'the greatest average law' and 'center law', among them it is the simple and most easy method to calculate too that it is the most general that center law is and is adopted, so, this research utilizes center law to change the fuzzy weight of n assessment criteria, the conversion method is as follows:

$$of_j = \frac{l_j + m_j + u_j}{3}, \quad j = 1, 2, \ldots, n$$

(39.3)

39.2.5 Combines the Rated Value to the Auction Website of Persons Who Assess

Utilize questionnaire that retrieve, serve the measurement of the performance. Serving the measurement step of the performance about the network shop proves as follows:

Step1: Determine to assess the semantic parameter of criterion satisfaction and count fuzzily

Utilize the special five grade yardstick scale too, come, weigh person who assess to each assessment criterion satisfaction, utilize different and fuzzy language purpose parameters (very unsatisfied, is unsatisfied, ordinary, satisfied, very satisfied) To express the measurement value of each assessment criterion satisfaction, as shown in Fig. 39.3.

Step2: Combine every indicator of assessing in the assessment value of satisfaction of auction website

$$\widetilde{X}_{tj} = \left(l_{tj}, m_{tj}, u_{tj} \right)$$

$$l_{tj} = \underset{i}{Min}\left\{ l_{tj}^{i} \right\}, \quad i = 1, 2, \ldots m$$
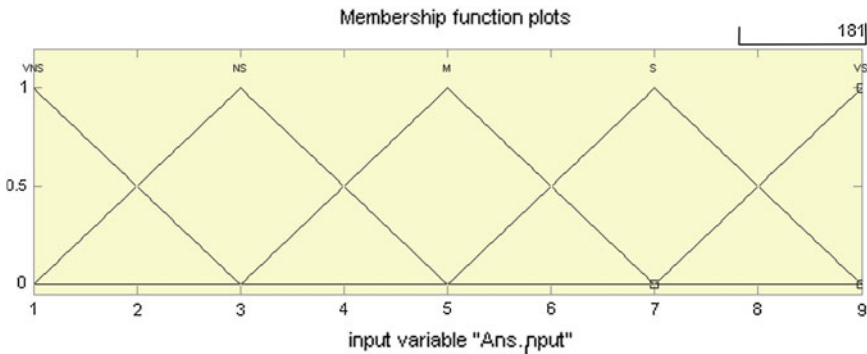
(39.4)

Fig. 39.3 Assess the ownership function of the criterion 'satisfaction'

$$m_{tj} = \left(\prod_{i=1}^{m} m_{tj}^{i} \right)^{1/m}, \quad i = 1, 2, \ldots, m$$

$$u_{tj} = \underset{i}{Max}\left\{ u_{tj}^{i} \right\}, \quad i = 1, 2, \ldots, m \tag{39.5}$$

39.2.6 Utilizes Service Performance of Every Network Shop of Commenting Amount of TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) proposed Hwang and Yoon in 1981 were mainly used for solving the decision problem of many criteria; its basic idea lies in defining and solving positive ideal solution and negative ideal solution. First, so-called and ideal to solve, mean, and take the place of select scheme benefit most heavy or cost minimum criterion value. On the contrary, shoulder ideal solving minimally for benefit or heaviest criterion value of cost, that is to say this method purpose lies in looking for a best scheme, and scheme this distance 'positive ideal solution' to close most, from 'negative ideal solution' most far.

According to the concept of TOPSIS, we can be defining out and solving and shouldering the ideal to solve fuzzily ideally fuzzily, utilize fuzzy decision matrix to calculate the fuzzy distance that counts of trigonometry, get each auction website to solving and is being defeated by the distance that the ideal is being solved ideally, utilize the common performance indicator (OPI) finally Value is come to arrange in an order, find out and serve the best auction website of the performance. The operation step is as follows:

Step1: Set up and assess matrix and weight matrix fuzzily

$$\widetilde{D} = \left[x_{tj} \right]_{k \times n}, \quad t = 1, 2, \ldots, k, \quad j = 1, 2, \ldots, n \tag{39.6}$$

$$\widetilde{W} = \left[w_j\right]_{1\times n}, \quad j = 1, 2, \ldots, n \tag{39.7}$$

$\widetilde{x}_{tj}$ and $\widetilde{w}_j$ are calculate assess fuzzy weight of criterion with assess merger fuzzy service performance value of criterion each under the auction website in t websites each in Sects. 39.3.1 and 39.3.2.

Step2: Assess the matrix regularization fuzzily

$$\widetilde{r}_{tj} = \left(\frac{l_{tj}}{u_j^+}, \frac{m_{tj}}{u_j^+}, \frac{u_{tj}}{u_j^+}\right), \quad j \in B \tag{39.8}$$

$$u_j^+ = \max_t u_{tj} \quad if \ j \in B$$

Step3: Build and construct the fuzzy decision weight matrix of the regularization

$$\widetilde{V} = \left[\widetilde{v}_{tj}\right]_{k\times n}, \quad t = 1, 2, \ldots, k, \quad j = 1, 2, \ldots, n \tag{39.9}$$

where

$$\widetilde{v}_{tj} = \widetilde{r}_{tj} \otimes \widetilde{w}_j \tag{39.10}$$

Step4: Determine to be shouldering the ideal to solve

$$\widetilde{v}_j^+ = \sigma_{\min d\left(\widetilde{v}_{tj}, \widetilde{v}_j^{+*}\right)} \left\{\widetilde{v}_{tj}, \quad t = 1, 2, \ldots k\right\}, \quad j = 1, 2, \ldots n \tag{39.11}$$

$$\widetilde{v}_j^- = \sigma_{\min d\left(\widetilde{v}_{tj}, \widetilde{v}_j^{-*}\right)} \left\{\widetilde{v}_{tj}, \quad t = 1, 2, \ldots k\right\}, \quad j = 1, 2, \ldots n \tag{39.12}$$

where the absolutely positive solution $\widetilde{v}_j^{+*}$ and negative solution $\widetilde{v}_j^{-*}$ is:

$$\widetilde{v}_j^{+*} = (1, 1, 1)$$
$$\widetilde{v}_j^{-*} = (0, 0, 0)$$

Step5: Calculate that is shouldering the ideal and solving the distance Calculate method as follows:

$$d_t^+ = \sum_{j=1}^n d\left(\widetilde{v}_{tj}, v_j^+\right), \quad t = 1, 2, \ldots k \tag{39.13}$$

$$d_t^- = \sum_{j=1}^n d\left(\widetilde{v}_{tj}, v_j^-\right), \quad t = 1, 2, \ldots k \tag{39.14}$$

Step6: Calculate every auction website service performance indicator (OPI) with arranging in an order

The movements arranged in an order finally, the good and bad order of performances of the service that the result arranged in an order offers for every auction website.

$$OPI_t = \frac{d_t^-}{d_t^+ + d_t^-} \quad t = 1, 2, \ldots, k \qquad (39.15)$$

39.3 Results

39.3.1 Process

This research gathers together and exactly appears 5 and mainly indices via collection and arrangement of literature and relevant materials, total 25 assessment criteria that service performance of auction website, and assess the criterion of these to design into a questionnaire, the sample is the website user who often use the auction website (Yahoo and Return). Testee send out it questionnaire by investigation of carrying on, last questionnaire of 60 copies together this research, retrieve 59 part questionnaires, the effective questionnaire 57 part among them, the effective questionnaire rate is 95 %. 57 persons who assess evaluate 25 service performances that two major auction websites include to assess importance degree of the criterion, appraise to the satisfaction of this criterion while using this website actually to the persons who assess, then we utilize the fuzzy theory and TOPSIS method, calculate the common performance indicators of two major auction websites, ask the good and bad level of service performance of two major auction websites.

39.3.2 Results

According to the analysis described above, the good and bad orders of the service performances of two domestic auction websites are: Yahoo is expressively better than Return, found finally the buyer presented the obvious difference to two major domestic service satisfaction of auction website as in Tables 39.1 and 39.2.

Table 39.1 Each assess shouldering the distance that the ideal is being solved of the criterion

Auction website	d_i^+	d_i^-
Yahoo	0	1.4718
Return	1.4718	0

Table 39.2 Service performance indicator of OPI value with arranging in an order

Auction website	OPI	Sequence
Yahoo	1	1
Return	0	2

39.4 Discussion

Have assessed and contained more criterion and persons who assess more in performance of auction website, it is fuzzy on possessing with assessing the criterion congenitally at the same time, difficult accurate quantization.

Therefore, it is often difficult to exactly amalgamate and verify its objectivity to assess the result. Among the subjects especially as assessing when surface of different literary compositions have either excellent or bad behavior, the whole performances of websites will become quite difficult to arrange in an order. In addition, the assessment criterion needing to be established of expert opinion, must often spend lengthy time and a large amount of cost, on a small scale assessment of plan have more difficultly implement.

To problem characteristic described above, originally research and propose in weight way of fuzzy time, extract the important assessment criterion out to replace and generally remit the whole expert opinion with technology such as Delphi method from the literature. And then through questionnaire way, received the performance appraisal of user's service for comparative theme of website. And will appraise and melt it fuzzily in order to agree with receiving the fuzzy weight inborn and fuzzily of language purpose. Then we arranged the website's performance in an order with TOPSIS.

Through the appraisal of 25 assessment performances, we received two comparative subjects (Yahoo and Return) in this research the performance is arranged in an order. We can be found out by the result of this research, the service performance of Yahoo is far higher than Return.

39.5 Conclusion

Assess the performance of the auction website for the example, this research has combined several kinds of employing extensively and simple and feasible fuzzy theory technology of the present stage, aim at proposing a common procedure of fuzzy much attribute decision, as assess target have many attribute, need many people assess and assess content have fuzzy difficult while quantizing clearly characteristic, the way that this research institute puts forward is suitable for the using of assessment of this kind of problem. Can assess the target to further arrange in an order clearly while combining TOPSIS technology, especially when assessing the target and arranging in an order numerously and difficultly. Choose such as large attribute makes policy regardless of the scheme, if assess the criterion and persons who assess and can be confirmed, can use the way that this research institute put forward to assess and arrange in an order the track case performance.

In addition, this research regards literature as experts, put forward the brand-new literature review concept. Screen the way to assess criterion with the fuzzy time weight, when it is difficult for the expert to investigate expensively and live,

can offer the comparatively economic substituting scheme not losing its objectivity. The weight concept of fuzzy time, though the concept is quite simple, we think we can further probe into the application feasibility in other fields in this kind of concept.

References

Angehrn A (1997) Designing mature internet business strategies: the ICDT model. Eur Manag J 15(4):361–364

Athanassopoulos AD (2000) Customer satisfaction cures to support market segmentation and explain switching behavior. J Bus Res 47:191–207

Beam CM (1999) Auctioning and bidding in electronic commerce: the on-line auction. PhD thesis, University of California, Berkeley

Bellman RE, Zadeh LA (1970) Decision-making in a fuzzy environment. Manag Sci 17(4):141–164

Chen SJ, Hwang CL (1992) Fuzzy multiple attribute decision making: methods and applications. Springer, Berlin

Cheng SW (1994) Practical implementation of the process capability indices. Qual Eng 7(2):239–259

Chow G, Heaver TD, Henriksson LE (1994) Logistics performance: definition and measurement. Int J Phys Distrib Logist Manag 24(1):17–28

Day RL (1984) Modeling choices among alternative responses to dissatisfaction. Adv Consumer Res 11:244–249

Fornell C (1992) A national customer satisfaction barometer: the Swedish experience. J Marketing 1(56):6–21

Grant WH, Schlesinger LA (1995) Realize your customers' full profit potential. Harv Bus Rev 73(4):59–72

Hoffman DL, Novak TP (1996) Marketing in hypermedia computer-mediated environments: conceptual foundations. J Marketing 60(3):50–68

Hsu HM, Chen CT (1996) Aggregation of fuzzy opinions, under group decision making. Fuzzy Sets Syst 79(3):279–285

Hung YH, Huang ML, Chen KS (2003) Service quality evaluation by service quality performance matrix. Total Qual Manag 14(1):79–89

Kaufmann A, Gupta MM (1991) Introduction to fuzzy arithmetic: theory and applications. Van Nostrand, New York

Kim S, Stoel L (2004) Dimensional hierarchy of retail website quality. Inf Manag 41(5):620–632

Klir GJ, Yuan B (1995) Fuzzy sets and fuzzy logic theory and application. Prentice-Hall Inc., Prentice-Hall, NJ

Lambert DM, Sharma A (1990) A customer-based competitive analysis for logistics decisions. Int J Phys Distrib Logist Manag 20(1):17–24

Langari JY, Zadeh LA (1995) Industrial applications of fuzzy logic and intelligent systems. IEEE press, New York

Mendel JM (1995) Fuzzy logic systems for engineering: a tutorial. Proc IEEE 83:345–377

Nielsen J, Tahir M (2005) Homepage usability: 50 websites deconstructed. New Riders, Indianapolis, pp 130–135

O'Connor GC, O'Keefe B (1997) View the web as a marketplace: the case of small companies. Decis Support Syst 21:171–183

Parasuraman A, Zeithaml VA, Berry LL (1985) A conceptual model of service quality and its implications for future research. J Marketing 49:41–50

Parasuraman A, Zeithaml VA, Berry LL (1988) SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality. J Retail 64(1):12–40

Paul P (1996) Marketing on the internet. J Consumer Marketing 13(4):27–39

Simon SJ (2001) The impact of culture and gender on web sites: a empirical study. Data Base Adv Inf Syst 32(1):25–33

The National Library (2011) Electronic thesis and dissertation System. http://etds.ncl.edu.tw/theabs/index.html, Retrieved Dec 2011

Troy JS, Shaw MJ (1997) Characteristics of electronic markets. Decis Support Syst 21:185–198

Van Heck E, Ribbers PM (1997) Experiences with electronic auctions in the Dutch flower industry. Int J Electron Markets 7(4):29–34

Zadeh LA (1965) Fuzzy sets. Inf control 8:338–353

Zadeh LA (1975) The concept of a linguistic variable and its application to approximate reasoning I, II, III. Inf Sci 8:199–251, 301–357; 9:43–80