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Modeling of Consumer Buying Behaviour Using Z-Number Concept

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ABSTRACT
Consumer behaviour has always been of a great interest in marketing research. The consumer buying behaviour has become an integral part of strategic market planning and includes mental, emotional and physical activities. The consumer behaviour and decision-making process are usually subject to uncertainties related to influences of socio-cultural, psychological and personal factors. In this paper, the *Z*-number concept is applied for handling uncertainties in analysing the consumer buying behaviour.

KEYWORDS
Consumer behaviour; Consumer decision-making; Organized retail market; Data uncertainty; Fuzzy logic; Z-number

1. Introduction

A consumer is considered to be an individual who purchases, or has the capacity to purchase goods and services offered for sale by marketing institutions in order to satisfy personal or household needs, wants or desires (Nicosia, 1966). Understanding the behaviour of consumers is the key for the success of business organizations.

Kotler (1977) and Kotler and Armstrong (2001) noticed that consumer buying behaviour is how individuals, groups and organizations select, purchase, use and dispose of products, services, ideas or experience to meet the consumers' demand. According to Blackwell, Miniard & Engel (2006), "consumer behaviour is the actions and decision processes of people who purchase goods and services for personal consumption".

The knowledge of consumer behaviour helps the marketer to understand how the consumers thinks, feels and selects from alternatives like products, brands and how the consumers are influenced by their environment, the reference groups, family, and so on. In the marketing context, the term "consumer" refers not only to the act of purchase itself, but also to patterns of aggregate buying, which includes pre-purchase and post-purchase activities. Pre-purchase activity concerns searching for products that might satisfy a consumer and post-purchase activity concerns satisfaction related to the purchased item in use.

There is a wide range of factors of consumer behaviour. Hoyer, Macinnis, and Pieters (2012) considers four broad categories of these factors:

1. Marketing factors: Product design, price, promotion, packaging, place (4P), marketing environment such as physical arrangement, interior design and decoration, lighting, music, smell and cleanliness (Baker, 1987) sales promotion and time factor.
2. Personal factors: Age, gender, personality, lifestyle, education, occupation and income level.
3. Psychological factors: Buying motivation that drives consumers to develop a purchasing behaviour, perception through which a consumer selects, organizes and interprets information around selective attention, and which inspires distortion and retention of information in a given situation.
4. Social factors: Social status, reference groups, family and lifestyle.
5. Cultural factors: Religion, nationality, age group, social class (lower, middle and high income), etc.

The classical approach used today allows to estimate the relationship between input (external and internal factors) and output (consumer buying behaviour) from a probabilistic point of view. This approach embraces only statistical uncertainty, but it does not handle imprecision, uncertainty and reliability inherent in marketing data.

There are different uncertainty handling methods developed for dealing with processing of uncertain data; probabilistic approach, possibility approach, information gap decision theory, interval analysis, robust optimisation etc. (Aliev, Fazlollahi, & Aliev, 2004; Attoh-Okine & Ayyub, 2005; Soroudi & Amraee, 2013).

Fuzzy logic found its application in marketing research, portfolio analysis, customer segmentation, performance measurement, managerial decisions, etc. (Neophytos, 2009; Sajeev, Bruce, & Roland, 2000).

The book of Meier and Donzé (2012) covers a great variety of fuzzy logic applications in management and marketing, including marketing planning, portfolio techniques, etc.

Kaufmann (2012) introduced the data mining methodology and inductive fuzzy classification in predictive analysis of individual marketing campaign for the online channel service provider.

Büyüközkan, Çifçi, and Güleryüz (2011) evaluated the service quality in the healthcare sector in Turkey using the fuzzy analytic hierarchy process methodology.

Andrea, Tettamanzi, Pannese, and Santalmasi (2007) described an application of evolutionary algorithms in terms of the predictive modeling of customer behavior in a business environment.

A fuzzy logic application perspective on a global market entry and application of fuzzy logic to country risk assessment was examined by Joshua, Eunsang, and Richard (1993).

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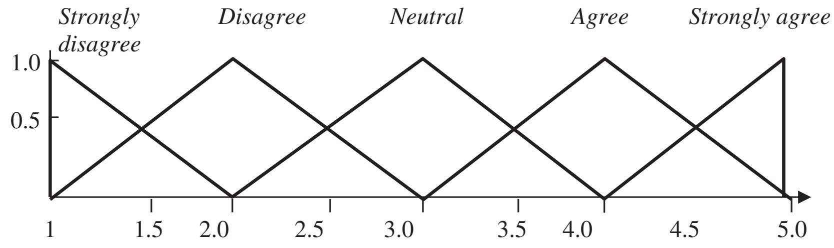

Figure 1. Representation of Likert Scale by Fuzzy Membership Functions.

A rule based approach to determine the market value is proposed by Priya, Renuka, and Rajni (2013). In this model, the product quality, price, brand loyalty, packaging and flavours are used as input variables.

Neshat et al. (2011) developed a fuzzy expert system to evaluate final customer's satisfaction based on 4p marketing factors, (price, product, place and promotion).

Aly and Vrana (2005) proposed a marketing-mix setting model based on the fuzzy expert system. The model is applicable to changing business environments in agriculture.

Umoh and Isong (2013) described customer loyalty analysis and its relations with management by incorporating the fuzzy logic approach.

Ganideh, Elahee, and Aljanaideh (2012) applied Adaptive Neuro-Fuzzy Inference System (ANFIS) to examine the influence of socio-psychological variables as dogmatism, conservatism and world-mindedness on Jordanian consumers' national identity.

Unfortunately, the existing works on consumer behavior are based either on statistical or fuzzy approaches. However, the real-world information is characterized by a combination of fuzzy and probabilistic uncertainties. In order to deal with this issue, Prof.. Zadeh introduced the concept of a Z-number as a new direction in uncertain computation.

The concept of Z-number has potential for many applications, especially in the economics, decision analysis, marketing, risk assessment, prediction, anticipation and rule-based characterization of imprecise functions and relations (Aliev, Huseynov, Aliyev, & Alizadeh, 2015; Purvag, 2015; Zadeh, 2012). The application of Z-number modeling of psychological research was conducted by Aliev and Memmedova (2015).

The rest of the paper is organized as follows: Section 2 gives the statement of the problem. Section 3 presents the prelimnaries and the basic arithmetic operations over discrete Z-number. The experimental framework and method of conversion of input data into Z-number is given in Section 4. The results of modeling is described in Section 5. The last Section presents the conclusion part.

2. Statement of the Problem and Motivation of Application of the Z-number Concept

(1) In a classical statistical approach, the boundaries of input parameters (such as low, moderate, high or very high) are strict and sharply defined. The marketing data usually is vague, uncertain and partially reliable. The classical statistical approach cannot handle the uncertainty and vagueness inherent to marketing data.
(2) Z-number theory allows to estimate the relationship between the input and output parameters by using the concept of fuzzy information and its partial reliability.
(3) Z-number based approach enables us to use the uncertainty measures to quantify the ambiguity associated with marketing data.

3. Preliminaries

Definition 3.1 A discrete Z-number: The Z-number, Z = (A, B) is the pair of two fuzzy numbers A and B (Aliev et al., 2015; Zadeh, 2011, 2012). The first component, A, is a restriction (constraint) on the values where the real-valued uncertain variable, the second component, B, is a measure of reliability (degree of uncertainty) of the first component A.

Definition 3.2 Operations over Discrete Z-numbers: Let X_1 and X_2 be discrete Z-numbers describing the information about values of $Z_{12} = MIN(Z_1, Z_2)$ and $Z_{12} = MAX(Z_1, Z_2)$. Consider computation of $Z_{12} = Z_1^{*} Z_2$, $^{*} \in \{+, -, \cdot, /\}$. The first stage is computation of $A_{12} = A_1 * A_2$ (Aliev et al., 2015). The second stage involves construction of B_{12}. As a result, $Z_{12} = Z_1 {}^{*} Z_2$ is obtained as $Z_{12} = (A_{12}, B_{12})$.

A scalar multiplication $Z = \lambda Z_1$, $\lambda \in R$ is determined as $Z = (\lambda A_1, B_1)$

Definition 3.3 Z-Arithmetic Mean. In general, the arithmetic mean is an aggregation operator of the simplest structure. Let us consider Z-arithmetic mean, the arithmetic mean for Z-numbers. Let a Z-valued vector $\mathbf{Z} = (Z_1, Z_2, ..., Z_n)$ be given. The arithmetic mean operator $M0$ assigns to any vector $\mathbf{Z}$ a unique Z-number $Z_M = M(Z_1, Z_2, ..., Z_n) = (A_M, B_M)$:

$$M(Z_1, Z_2, ..., Z_n) = \frac{1}{n} \sum_{i=1}^{n} Z_i \qquad (1)$$

Definition 3.4 Jaccard index based similarity of discrete Z-numbers. A Jaccard index similarity $J(Z_1, Z_2)$ of discrete Z-numbers Z_1, Z_2 is defined as follows:

$$J(Z_1, Z_2) = \frac{1}{2} \frac{\sum_{k=1}^{K} \mu_{A_1}(x_k) \cdot \mu_{A_2}(x_k)}{\sum_{k=1}^{K} \left(\mu_{A_1}(x_k)\right)^2 + \sum_{k=1}^{K} \left(\mu_{A_2}(x_k)\right)^2 - \sum_{k=1}^{K} \mu_{A_1}(x_k) \cdot \mu_{A_2}(x_k)} + \\ + \frac{1}{2} \frac{\sum_{k=1}^{K} \mu_{B_1}(x_k) \cdot \mu_{B_2}(x_k)}{\sum_{k=1}^{K} \left(\mu_{B_1}(x_k)\right)^2 + \sum_{k=1}^{K} \left(\mu_{B_2}(x_k)\right)^2 - \sum_{k=1}^{K} \mu_{B_1}(x_k) \cdot \mu_{B_2}(x_k)}$$

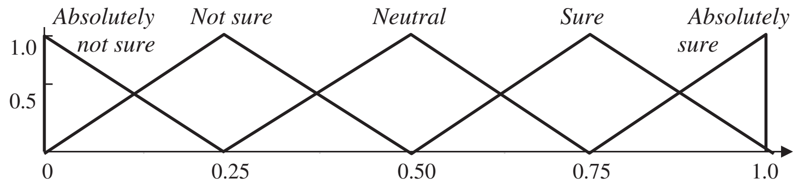

Figure 2. Representation of Reliability with Membership Functions.

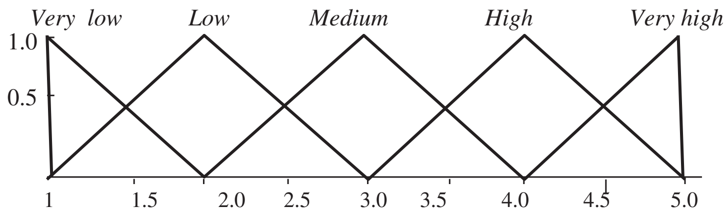

Figure 3. Representation of CBP with Fuzzy Membership Functions.

For a Z-number $Z = (A, B)$, denotes $a_\alpha^L = \min A^\alpha$, $a_\alpha^R = \max A^\alpha, b_\alpha^L = \min B^\alpha, b_\alpha^R = \max B^\alpha$.

4. Methods

The measuring of factors (cmarketing, socio-cultural, psychological and personal factors) of consumer buying behavior are conducted using "Consumer buying behavior of apparels in the retail market" Questionnarie (Retrived from http://www.my3q.com/research/himanshooseth/97377.phtml).

The Questionnaire consists of two parts:

1. Demographic information, including age, occupation, monthly income and gender.

2. Twenty-five (25) questions related to marketing, socio-cultural, psychological and personal factors such as; product quality, price, promotion, brand loyalty, variety of clothing, service quality, shopping atmosphere, ambiance, reference group, personal characteristics of consumers and others. The survey was carried out to analyze CBP in May-July 2016. The survey engaged 120 participants from different cultures. The ages of participants ranged between 28—56 years, with the average age becoming 38. In total, 90 completed questionnaries were received from participants. The respondents specified their level of agreement associated to reliability degree through a 5-level Likert scale shown in Figures 1 and 2.

The term Consumer Buying Propensity (CBP) was introduced to express the degree of consumer buying behavior. The codebook for CBP as an overall index is represented in Figure 3.

5. Results of Modeling

Figure 4 shows the Flow-chart of *Z*-number modeling of consumer buying behavior. The 1st step is the conversion of the data gathered from participants into *Z*-numbers *Z1,...Zi,...Zn*. The 2nd step is the aggregations of *Z*-numbers *Zi*, *i*=1,...,*n*, towards the rows (scales). The results of aggregation are Z-numbers $Zc_1,\dots Zc_{25}$. The 3rd step is the aggregation of $Zc_1,\dots Zc_{25}$. At the 4th step, the result Z_{agi} of total aggregation of $Zc_1,\dots,Zc_{25}$ is determined. Finally, the similarity of Z_{agi} with Z_{CBP} (codebook output) is computed to describe consumer buying propensity index.

Now consider an example of numerical computation. Suppose that for the question related to "*Service quality and customer loyalty of the city mall*" 13 participants choose (Strongly agree with Absolutely sure), 33 participants choose (Agree, Sure), 26 participants choose (Neutral, Neutral), 8 participants choose (Disagree, Not sure) and 3 participants choose (Strongly disagree, Not sure). The overall CBP for the population is determined below. First, for each scale the average value over all the population (90 participants) was computed. For this purpose, each *Zci*-number evaluation was defined. The product of a chosen scale value and the frequency of appearance in population (the percentage of the people who choose this evaluation) were computed. Then, all the products were aggregated to obtain average Z-number evaluation of CBP. The following *Zci*-number results for "*Service quality and customer loyalty of the city mall*" were obtained:

$$Zc_1 = (2.97\ \ 3.94\ \ 4.70)(0.51\ \ 0.58\ \ 0.64)$$

$$Zc_2 = (2.74\ \ 3.70\ \ 4.50)(0.53\ \ 0.60\ \ 0.66)$$

$$Zc_{25} = (2.80\ \ 3.77\ \ 4.60)(0.46\ \ 0.54\ \ 0.61)$$

Using the arithmetic mean (1), we have:

$$Z_{CBP} = \frac{\sum_{i=1}^{25} Z_{C_i}}{25} = \frac{(2.98\ 3.94\ 4.7)(0.51\ 0.58\ 0.64) + \dots + (2.8\ 3.8\ 4.6)(0.46\ 0.54\ 0.61)}{25} =$$
$$= \frac{(66\ \ 90.42\ \ 103)(0.60\ \ 0.66\ \ 0.7)}{25} = (2.64\ \ 3.61\ \ 4.12)(0.60\ 0.66\ 0.7)$$

By calculating the Jaccard index based similarity, this study has found out that the linguistic approximation of the obtained Z-number is Z_{CBP} = (Medium, sure) and $J(Z_1, Z_2) = 0.51$).

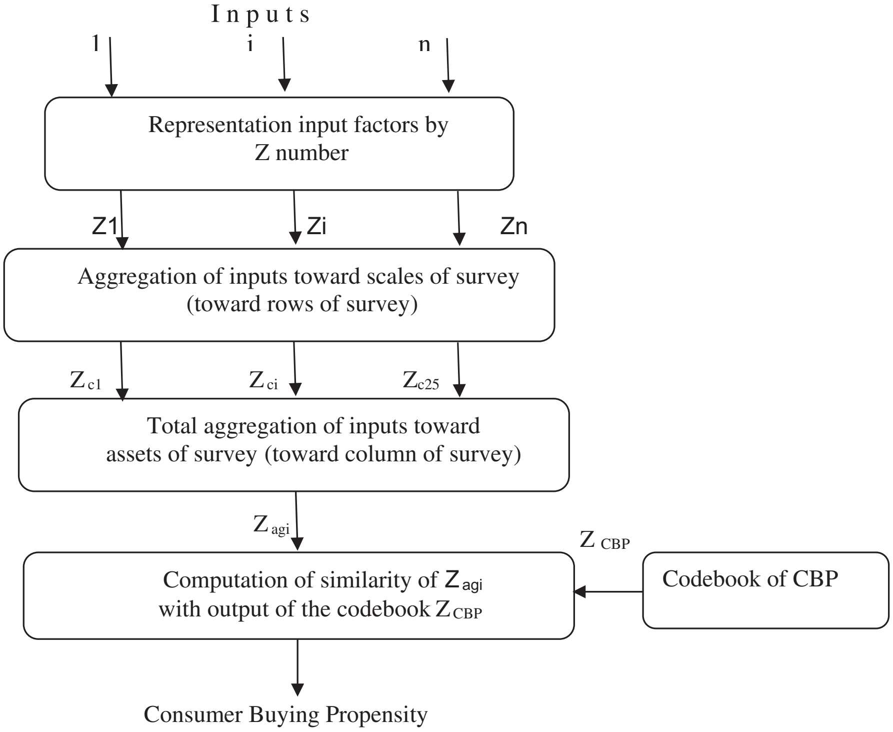

Figure 4. Flow-chart of Z-number Modeling of Consumer Buying Behavior.

Conclusion

This paper is devoted to establish the relationship between marketing, social, cultural, economical and personal factors and consumer buying behavior by using the Z-number approach.

The developped flow-chart presents the step by step modeling of consumer buying behaviour through the use of the Z-number concept. The application of Z-number modeling allows to handle uncertainty, imprecision and vagueness of marketing data and their partial reliability.

The adequacy of the model is proven through the computer simulation using real data from organized retail market.

The results of this study can provide an effective approach to determine CBP in retail market.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor

Gunay Sadikoglu was born in Baku, Azerbaijan. In 2005 she entered to Near East University, North Cyprus, Faculty of Business and Administration. Between 2008 and 2009 she continued her studies at the Anglia Ruskin University in England. She graduated from the Department of Business Administration at Near East University in 2010. In 2013 she received her M.Sc. degree at School of Tourism and Management, Near East University. At present she is a lecturer at Near East University and pursues her Ph.D. Her research interests include marketing research, applications of fuzzy logic in marketing modeling, influence of psychological variables on consumer behavior, and decision making.

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