Product Selection in Internet Business,
A Fuzzy Approach

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DECLARATION:

“I, Hasan Furqan hereby declare that:

• The work in this paper is my own work;

• The main base of this project is the article of B.K.Mohanty and B.Aouni; “Product selection in internet business: a fuzzy approach” (Journal; International Transactional In Operational Research, 2009); and

• This dissertation has not been previously submitted in full or partial fulfillment of the requirements for any equivalent or higher qualification at any other educational institution.”

Hasan Furqan
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Product Selection in Internet Business: a Fuzzy Approach

Introduction

In traditional or even online customer is considered to be the King of the Market. “It is the customer who determines what a business is”¹. Marketing has the responsibility within a firm to reflect customers’ goals, needs and wants. Many tools exist to identify these, including sales calls, surveys, focus groups, test markets, trial samples and statistical analysis of purchase data. Results from these studies reveal opportunities for new designs and features as well as show recent failures. “The rediscovery of the customer is a byproduct—perhaps the most important one—of the onset of the information revolution”²

Despite understanding individual differences of their customer base, marketers have always had to settle for the compromise product and marketing solutions. Companies have thousand, even millions of customers. They all are somewhat different, with different locations, different purchasing histories and different preferences.

In any business whether it is online or traditional, a customer evaluates all available products as a whole before ranking them according to his or her own preferences. The ranking is specific to a particular customer and it normally depends on the number of products available to the customer in the market and how the product features satisfy to his/her likings. A customer’s preferences for the products and hence their rankings are implicit in his/her mind and are difficult to express explicitly.

Choosing the right product or service is easy when the needs and product offerings are simple and there are few alternatives but this is not the situation for the many product categories e.g. an online store carrying digital camera has hundreds of these cameras vary by size, speed, format, lenses and tens of other attributes.

Marketers have developed different approaches to better understand the needs and want of the customers and the relative offering by the companies to fulfill these needs.

Following is the table proposed by marketers, presented here with slight modification that highlights these approaches and the situations where they best fits in.

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The identification process starts with the customer’s needs identification and we have four basic approaches as discussed one by one in the following

1- **Rules-Based Systems**
   
   Rules based systems work best when the important product attributes are quantifiable and the user needs are not extremely complicated e.g. Yahoo! offers information on a vast array of topics. It uses a very simple and quantifiable rule “Show the closest teams” and “Show the closest weather”. They use the Zip code information stored in the customer profile to filter out the huge amount of information.

2- **Endorsement Systems**
   
   It works best when the product needs of consumers do not differ greatly. In this case a simple endorsement can be best. Consumers need to know that a service provider is competent and has the best quality available.

3- **Case Systems**
   
   The online system begins by surveying users about their product category preferences. When needs of the customers vary widely, the case system searches through its large database of possible choices to help users to narrow their choices from thousands of possibilities to a few highly ranked alternatives.

4- **Collaborative Filtering**
   
   This approach is used when the needs of customers vary widely and the attributes of the products are also vary significantly and quite complex in nature. The system matches different users who seem to share similar tastes or it matches the customer requirement with the products’ attributes itself. These individuals/system can then share recommendations and preferences about difficult to judged products and services.

One of the techniques/tools that the systems use to match the customers requirement with the product attributes, is fuzzy approach.

In the later section, I will discuss fuzzy approach, its implementation with some examples in internet market.

**Evolution of Fuzzy Logic**

The concept of Fuzzy Logic (FL) was conceived by Lotfi Zadeh (1965)\(^3\), a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. This approach to set theory was not applied to control systems until the 70's due to insufficient small-computer capability prior to that time. Professor Zadeh (1978) introduced Probability theory to handle uncertainty in fuzzy systems. The text by Zimmermann (2001) provides a thorough introduction to fuzzy set theory; papers on fuzzy applications were collected in Zimmermann (1999).

Fuzzy Logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Unfortunately, U.S. manufacturers have not been so quick to embrace this technology while the Europeans and Japanese have been aggressively building real products around it.

**Explanation of Fuzzy Logic**

Customers like to have the fullest satisfaction on all the desired attributes of the products. However, the product attributes are in general conflicting, non-commensurable and fuzzy in nature and it is very difficult to satisfy all of them simultaneously. In this situation, a customer makes effort to satisfy most of the attributes rather than all of them. By the process, the customer is attaching some weights to the product attributes. These underlying weights are implicit in customers’ mind. Articulation of these hidden weights will not only make the business more customers focused but also will help the business in analyzing the need of the customers in terms of the product requirements.

The clarification of these weights is a very complex and difficult task. In traditional markets, a sales person can assess these weights to some extent while interacting with the customers and through their body language. However, in e-business where no direct interaction takes place amongst the business partners, the identification of these weights is next to impossible. This problem becomes further complicated when the customers’ requirements regarding the product specifications are imprecise or fuzzy in nature. For example If a customer wants to buy a shirt he fuzzily expresses his requirement on the attributes like percentage of cotton, the style and softness of the fabric and the durability of the shirt. What is required here is an e-business system which integrates fuzzy representations of both the customer’s requirements and the products available and leads to a matching product, as in traditional markets.

Several papers refer to e-business sites like Jango, “Deal Time” (www.dealt ime.com), “decision guide” (www.ActiveBuyersGuide.com) are the earlier e-business market places. These sites collect information regarding the customers about their product preferences along with their prices and based on the

information collected, suggest suitable products to the customers. However, it is difficult for the buyers to decide about an appropriate product in the vast Internet market.

**Procedure**

The procedure of fuzzy logic takes into account

1. Consideration and implementation of multiple product attributes.
2. Each attribute of the available products is compared with the customer’s choices to obtain the degree of similarity between the available products and customer’s requirements.

Let a customer require \( k \) fuzzily defined attributes of a product. Denote the customer’s desired preference levels of these attributes \( E_j \) \((j=1, 2, \ldots, k)\) as L–R fuzzy numbers

\[
E = (E_1, E_2, \ldots, E_k)
\]

Assume that there are \( m \) products available on the Internet. Let their attribute levels be specified as

\[
B_i = (B_{i1}, B_{i2}, \ldots, B_{iK}) \quad (for \ i = 1, 2, \ldots, m)
\]

\( B_{ij} \) represents the \( jth \) attribute level of the \( ith \) product. \( B_{ij} \)s \((i \ and \ j)\) are assumed here to be fuzzy numbers. Initially take an attribute level \( E_j \) (say the \( jth \) attribute) as prescribed by the customer and match this attribute to the corresponding \( jth \) attribute \( B_{ij} \) of all the products. The degree of similarity \( T_{Ej|B_{ij}} \) between \( E_j \) and \( B_{ij} \) can be obtained following the procedure given in Yager (1984). As per this procedure \( T_{Ej|B_{ij}} \) is also a fuzzy number. The information on these degrees of similarities, along with the fuzzy number operations given in Yager (1984), helps the customer predict the probability and hence the expectation of availing a particular attribute level of \( E_j \) in the given market profile. Let the fuzzy number representation of the above expected values be

\[
\text{Exp} \ (E_j) = \left( \text{Exp} \ (E_{j1}), \text{Exp} \ (E_{j2}), \text{Exp} \ (E_{jn}) \right) \quad (for \ j=1, 2, \ldots, k).
\]

If \( l_i \ (j) \) represents the matching or similarity degree between \( B_{ij} \) and \( \text{Exp} \ (E_j) \), we can have the satisfaction level for the \( ith \) product as

\[
P(i) = \sum w_j l_i \ (j), \quad (for \ i = 1, 2, \ldots, m),
\]

Where \( w_j \) are the weights attached to the attributes \( E_j \). The weights used here can be estimated by using the procedure given in Mohanty (1998). After calculating all \( P(i) \) values, we have the best product corresponding to the maximum \( P(i) \) value.

**Fuzzy Representation of the Product Attributes**

In any product purchase, normally a customer expresses his/her desire in multiple product attributes, which in general are fuzzy. For example in a car purchasing problem, the attributes may be price, re-sale value, mileage, maintenance etc. Very often a customer views these attributes fuzzily as shown in the italic words below:

- \( (A, \mu_A) \): Cost should be *around* US$20,000,
- \( (B, \mu_B) \): Cost should be *approximately* US$22,000,
- (C, $\mu_C$): Cost should be closer to US$23,000.
- (D, $\mu_D$): Cost should be more or less US$25,000.

These fuzzy terms can be presented as fuzzy numbers as

$$(A, \mu_A) = (15, 20, 25), (B, \mu_B) = (18, 22, 24), (C, \mu_C) = (17, 23, 25) \text{ and } (D, \mu_D) = (22, 25, 27),$$

Where $\mu_A, \mu_B, \mu_C, \mu_D$ represent the membership function of the fuzzy numbers A,B,C and D respectively. Graphically represented as

![Graphical representation of fuzzy numbers](source)

In Fig:1, on x-axis car prices are presented and on y-axis customer’s satisfaction level corresponding to a price is presented. Taking the fuzzy number “around US$20,000”, we can say that a buyer is fully satisfied (with membership value one) if the car price is US$20,000 and his/her satisfaction level gradually decreases when the car price deviates from US$20,000 and becomes zero when the price is either below US$15,000 or above US$25,000.

In Fig:2 If a company has a car with price US$23,000, the company’s analyst may present the cost of the car for all the customer groups in a single fuzzy term (fuzzy number) as (Price, $\mu_{Price}$)=(15, 23, 25) with membership function $\mu_{PRICE}$.

![Graphical representation of fuzzy terms](source)
Similarity Measure

Now we measure the degrees of similarity between the attribute levels of the available products on the Internet and the desired attribute levels of the customer. Let $B_1, B_2, \ldots, B_m$ be $m$ products available on the internet. Let these products be assessed in terms of the satisfaction levels of the $k$ attributes. We denote the $j$th attribute of the $i$th product as $B_{ij}$ so the $i$th product in terms of the attributes is

$$B_i = (B_{i1}, B_{i2}, \ldots, B_{ik})$$

Similarly we can have the customer’s desired levels of the product attributes as

$$E = (E_1, E_2, \ldots, E_k)$$

$E_j$ $(j = 1, 2, \ldots, k)$ represent the customer’s desired level in the $j$th product.

We have assumed here that the product attributes are in the form of L-R fuzzy numbers, so we have

$$E_j = (E_{jl}, E_{jn}, E_{jr}) \quad \text{(for $j = 1, 2, \ldots, k$)}$$

and $B_{ij} = (B_{ijl}, B_{ijn}, B_{ijr}) \quad \text{(for $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, k$)}$

We need to calculate the similarities between the attribute level $E_j$ and the product attributes $B_{ij}$, in order to determine the satisfaction levels of the customers regarding the available products as,

$$B_{ij} \sim E_j \quad \text{(for $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, k$)}$$

The symbol $\sim$ is used here to represent the similarity. By generalizing equation (3) we have

$$B_{ij} \sim E_j \quad \text{(for $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, k$)}$$

We derive the degree of similarity between $E_j$ and $B_{ij}$

$$T_{Ej[B_{ij}]}(i) = \text{Max} [B_{ij}(x)]$$

$E_j(x) = i.$ \hspace{1cm} (5)

Here $T_{Ej[B_{ij}]}$ represent the extent to which the customer satisfaction level in the $j$th attribute matches $B_{ij}$. By varying over all products, for the attribute $j$ and the customer’s preference on the $j$th attribute, we can have the following set of similarity measures, which are in the form of fuzzy numbers.

$$(T_{Ej[B_{ij}], T_{Ej}[B_{ij}], \ldots, T_{Ej}[B_{mj}]})$$

Equation (6) represent the similarity degrees between the $j$th attribute of the $B_{ij}$ And $E_j$ If we want to know that a customer may get a product with the desired attribute levels. This can be predicted by calculating the probability as given below

$$P_f(E_j) = 1/m \sum T_{Ej[B_{ij}]}$$

The term $P_f(E_j)$ represent the probability of obtaining the customer’s preference level in the $j$th attribute $E_j$. Since each $T_{Ej[B_{ij}]}$ are fuzzy numbers their addition and hence the derived probabilities are again fuzzy numbers. Thus we have
The expected value of the jth attribute under the given market profile can be calculated as

\[ \text{Exp}_j(E_j) = [P_f(E_j)_l \times E_j_l, P_f(E_j)_n \times E_j_n, P_f(E_j)_r \times E_j_r] \]  

From equation (9) it is clear that the expected value is a fuzzy set of fuzzy numbers. The membership function of the fuzzy set represents the flexibility behavior or compromising attitude of the customer while purchasing a product.

**Solution Procedure**

The customer expects to have at least the level prescribed by the expected value given in equation (9) for each product. This needs a comparison of the available products’ attribute levels to the desired expectation. For a minimization (maximization) type attribute (of say Bij), the comparison can be expressed as: “To what extent is the attribute Bij (jth attribute of the ith product) less (greater) than the expected value given in (9)?” Mathematically this can be written as

\[ \text{Max. Min.} \{Bij (x), \text{Exp}_j(E_j) \} = I_i(j) \]  

\[ x \leq y \]

Similarly for an attribute which is of maximization type we can have the mathematical equation as:

\[ \text{Max. Min.} \{Bij (x), \text{Exp}_j(E_j) \} = I_i(j) \]  

\[ x \geq y \]

In equations (10) and (11) fuzzy number comparisons has been made. The quantity \( I_i(j) \) represents the degree of satisfaction of the jth attribute of the ith product. Continuing this procedure over all the attributes and over all the products we have m sets of satisfaction level. They are as given below

\[ [(I_i(1), I_i(2), \ldots, \ I_i(k))] \quad \text{for} \ i = 1,2,\ldots,m \]  

If all the attributes of the ith product are very much up to expectation then ith product can be selected as the best product but generally, for a particular product one attribute may achieve to the fullest extent, another to some extent, and another may be to a negligible extent. In this situation, a customer needs to compromise, and the degree of compromise depends on his/her attribute preferences. If \( W_j \) represents the weights attached to the attribute j, following the weighted average method given in Mohanty, (1998), we can have the satisfaction level for the ith product as

\[ P(i) = \sum W_i I_i(j) \quad \text{for} \ i = 1,2,\ldots,m \]  

Similarly we can obtain the satisfaction level for other products. The product corresponding to the highest satisfaction level is selected as the best product. This can be obtained through the following equation:

\[ P = \text{Max.} \{ P(1), P(2), \ldots, P(m) \} \]

Here, P represents the best product as per the customer’s preference. The next best product and so on can be obtained by maximizing again over P(i) values for the remaining products.

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Conclusion

In this paper I discuss different approaches adopted by different companies to better match the needs of their customers. One of the approaches i.e. fuzzy approach is discussed in detail. Customers’ fuzzy behaviors and their expectations are modeled here by using the concepts of fuzzy logic and fuzzy probability respectively. Customers’ imprecise judgments are treated in terms of fuzzy logic and their compromising attitudes are handled by linguistic quantifiers. Businesses on the Internet are expected to benefit from such a measure as it will help them become more customer-focused and gain competitive advantage.

References