MARKET ANALYSIS VIA CRISPY-FUZZY LOGIC

M.T.M. Dewasurendra and U.N.B. Dissanayake

Department of Mathematics, Faculty of Science, University of Peradeniya

Introduction

Alfred Marshall put forward the Law of Demand in the latter part of the nineteenth century; it explicitly state that the consumer price (***P***) has a greater impact on the demand function (***D***) than the other economic factors in the market economy and the relationship between them is reciprocal (Smith, 1991). Present day studies indicate that reciprocal law does not hold in market structures due to the evolutionary process in the market economy and the consumer behaviour. This reciprocal law can be modified in a hyper plane to incorporate other factors; namely, Service, Location, Appearance and Substitutions available in the market. Our aim is to show that the demand function depends on many factors other than the consumer price.

In science, uncertainty represents an undesired state and to investigate such situations, various techniques have been introduced. In this study, we utilize fuzzy logic as a novel tool in the analysis of market models. The main objectives of this study are to introduce three fuzzy variables; namely, Service (S), Location (L) and Appearance (A) to the market structure, to investigate the dependence of the demand function with respect to these fuzzy variables, and to compare the results with *Marshallian* law of demand.

Methodology

To perform fuzzy-reasoning methods in market models, we need inference rules and they are expressed in IF-THEN format; IF-THEN rules used in fuzzy reasoning are called "fuzzy IF-THEN rules" (Tanaka and Niimura, 1991).

Here we shall use *Mamdani's* method in fuzzy logic and the details are given below:

Consider a simple two rule system with two antecedents and one consequent.This is analogus to a dual-input and single-out put fuzzy system.

Rule 1
If x is A_1 and y is B_1 THEN z IS C_1

Rule 2
If x is A_2 and y is B_2 THEN z IS C_2
Where, A_1, A_2, B_1, B_2, C_1 and C_2 are fuzzy sets.

Let x_0 and y_0 be the input for the premise-parts variables x and y, respectively. Let us denote this input as (x_0,y_0) and reasonig process for the input (x_0,y_0) as follows.

Step 1
Measure the adaptability of each rule for the input (x_0,y_0)

Adaptability of Rule 1:
$W_1 = \mu_{A_1}(x_0) \wedge \mu_{B_1}(y_0)$

Adaptability of Rule 2

$$W_1 = \mu_{A_2}(x_0) \wedge \mu_{B_2}(y_0)$$

Step 2

Apply the adaptability obtained in step 1 to the fuzzy sets in the consequence part to obtain the conclusion of each rule.

Conclusion 1

$$\mu_{C_1'} = W_1 \wedge \mu_{C_1}(z) \quad for all\ z \in Z$$

Conclusion 2

$$\mu_{C_2'} = W_2 \wedge \mu_{C_2}(z) \quad for all\ z \in Z$$

Step 3

Aggregate the conclusion of each rule obtained in step 2 and make the final conclusion.

$$\mu_{C'}(Z) = \mu_{C_1'}(Z) \vee \mu_{C_2'}(Z)$$

Since the final conclusion is not practical because it is a fuzzy set and therefore we shall convert in to a crispy set via *defuzzification* methods. This method can be easily extanded and will hold for fuzzy rule-bases with any number of antecedents and consequents.

The data was collected using 26 people who want to select a quality garment from the *Kandy* Market. A qualitative survey was conducted to determine fuzzy IF-THEN rules and the Survey questionnaire was prepared using *Likert* scale to determine the level of agreement of a person. Collected data was used to determine fuzzy IF-THEN rules by considering positive to negative relationship to the Demand. Input variables and output variable were defined as fuzzy sets along with membership functions. Then *Mamdani's* method was used via *Matlab* software to find out Demand values for crispy inputs and multiple regressions were utilized via *Minitab* software to determine the impact of fuzzy factors: namely, Service (S), Location (L) and Appearance (A) on the demand function (D) in addition to the price function (P).

Results and Discussion

Regression equation for the demand vs. price & service

$$D = 527 - 0.163P + 1.17S - 0.000338P^2 - 0.00491S^2 + 1.02\sqrt{P} - 6.86\sqrt{S}$$

$$R\text{-}Sq = 53.6\,\%$$

Regression equation for the demand vs. price and location

$$D = 48.1 - 1.20P - 1.48L + 0.00401P^2 + 0.00586L^2 + 7.10\sqrt{P} + 8.41\sqrt{L}$$

$$R\text{-}Sq = 74.1\,\%$$

Regression equation for the demand vs. price and appearance

$$D = 51.0 - 1.17P + 1.58A + 0.00388P^2 - 0.00638A^2 + 6.91\sqrt{P} - 8.97\sqrt{A}$$

$$R\text{-}Sq = 74.9\,\%$$

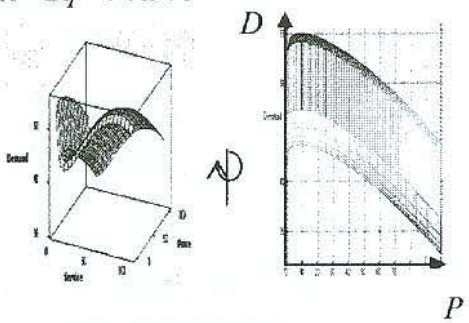

Figure 1. Surface diagram for the demand vs. price and service

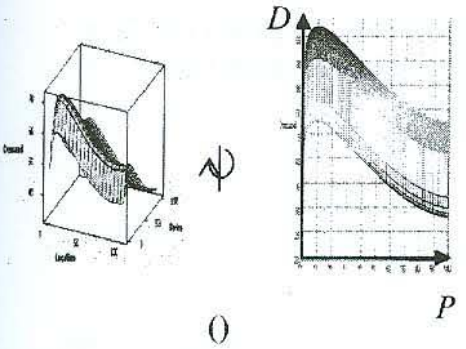

Figure 2. Surface diagram for the demand vs. price and location

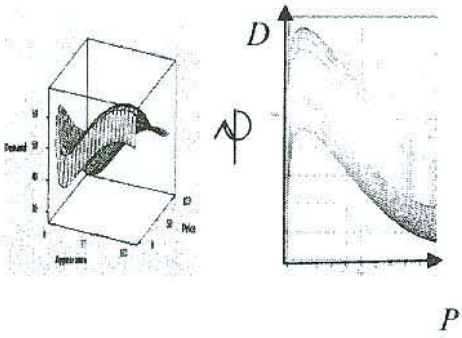

Figure 3. Surface diagram for the demand vs. price and appearance

From the above depicted surface diagrams (Figures 1, 2 and 3) it is noted that the price is not the only independent variable that affects the demand function. Moreover, from the surface diagrams it is noted that there is a positive, non-linear relationship between price and demand at low price-levels. Thus, in general, the reciprocal law of demand and the law of diminishing marginal utility are invalid for low price-levels in market structures.

References

Tanaka, K. and Niimura, T., (1991).An Introduction to Fuzzy Logic for practical application, first published in Japanese by Rassel, Inc.

Smith, A.W. (1991). Understanding Economics, Glencoe/McGraw-Hill Educational Division