An Application of the Fuzzy Approach in Estimating Ecotourism demand

Yousef Rostami and Reza Moghaddasi

University of Applied Science and Technology, Tehran Iran.

ABSTRACT

Ecotourism has been a fast growing component of Iran Tourism industrial economy and is, an important export sector for the national economy. Fuzzy Set Theory that was introduced in 1965 by Prof. Lotfi A. Zadeh, has received wide attention in the field of environment and a great number of successful applications. Fuzzy regression model is an alternative to evaluate the relation between independent variables and dependent variable in forecasting models when the data are not sufficient to identify the relation and we have uncertainty in data. With fuzzy logic propositions can be represented with degrees of truthfulness and falsehood. This is strongly connected with human’s inherent ability to make conclusions using uncertain information. Arnold S. and Ilan A.(1994) showed in planning . An LP method with Fuzzy constraints has a significant advantage over the regular LP because it allows reducing the uncertainty while the using same data. In this paper we introduce the application of the fuzzy approach in field of ecotourism by using Fuzzy Regression Analysis (FRA) to determining ecotourism demand function.

INTRODUCTION

Tourism has been the one of the fastest growing component of the Iran economy for the past decade and is an important export sector for the regional economy. Opportunities to participate in outdoor recreation are also an important component of the quality of life for residents of Iran. In recent years, growing awareness among tourism researchers of the link between tourism and natural resource management has resulted in a substantial body of academic literature examining tourism issues under a relatively new set of tourism concepts. Seemingly new forms of tourism, such as nature-based tourism, ecotourism, and sustainable tourism, now are advocated as an environmentally safe basis for economic development in many rural locations worldwide.

Eco-tourism is often defined as sustainable nature based tourism. However, ecotourism also incorporates social and cultural dimensions, where visitors interact with local residents in national park, remote areas or indigenous home lands. Ecotourism activities mainly include stays in natural surroundings and getting to know different landscapes/cultures at local and regional sites and providing residents there with opportunities for sustainable development.

These new forms of tourism are promoted as an environmentally safe war for rural communities to generate income from natural resources. They are advocated particularly in developing countries possess a comparative advantages over developed countries in their ability to provide relatively pristine natural setting (cater 1993). Demand for these new forms of tourism, it is argued arises from increased concern or interest in unique and fragile ecosystems and a growing desire to travel to new and exotic places, and an increasing number of people who have the financial means to do so.

In the late 1980s and 1990s, ecotourism became big business, and it appears to be growing. According to the world trade organization 412 million international tourists spent $225 billion in 1990 (up from 69 million tourists and $6.9 billion in 1960).the only sector accounting for a larger share of world wide exports is agriculture. Although delineating the ecotourism portion of these statistics is difficult .Ziffer estimates indicate that ecotourists from industrialized countries spent about $2 billion dollars in developing countries in 1989. Furthermore, the number of ecotourists is reportedly growing at a rate of about 20% per year.

Corresponding Author: Yousef Rostami, University of Applied Science and Technology, Tehran Iran.
Most of people agree that sustainable development of natural resources and conservation of natural resources, linked with efforts to generate benefits for people living in those areas, is instrumental in ensuring wise resource use and allocation. In order to encourage sustainable development, many new methods of resource use are being examined in addition to traditional means of timber harvest or land clearing for agricultural purposes. Ecotourism has been promoted as one means to generate local employment and income in natural regions without the adverse effects attributed to forest exploitation and agriculture.

Planning is a powerful and necessary tool for using and conservation resources and it can only work effectively if its strengths and limitations are understood. The identification of effective planning methods, both formal and informal, to mediate between and integrate economic development and environmental protection is a critical issue for the design of "sustainable" communities.

In this paper we want to develop a Fuzzy regression model to estimate ecotourism demand function. Fuzzy regression model is an alternative to evaluate the relation between independent variables and dependent variable among the forecasting models when the data are not sufficient to identify the relation or we have uncertainty in data.

The fuzzy sets theory, described by the membership function [10], is identified as an alternative approach to supplement the vagueness description of the planning goals and the uncertainties involved in the parameter values, respectively. In the last two decades, fuzzy sets theory has received wide attention in the field of environmental planning and management. Instead of using point estimation in conventional probability theory, fuzzy set theory can be used to granulate a concept into a set with membership function and thus decreases the amount of required data.

Several approaches have been published suggesting methods to cope with the uncertainty involved in environmental and natural resources systems [5].

Hsiao-Fan Wang and Jia-Chi O-Yang [4] have shown that, the average forecasting error in fuzzy regression model is below 1.85% which in comparison to the most commonly used Quadratic Trend Analysis of 2.91% and the Double Exponential Smoothing Model of 4.29%, has a better performance.

Fuzzy Logic:

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language like most other activities in life and indeed the universe is not easily translated into the absolute terms of 0 and 1. Whether everything is ultimately describable in binary terms is a philosophical question worth pursuing, but in practice much data we might want to feed a computer is in some state in between and so, frequently, are the results of computing. Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but " ~.38 of tallness." Fuzzy logic seems closer to the way our brains work. We aggregate data and form a number of partial truths which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction. A similar kind of process is used in artificial computer neural network and expert systems. It may help to see fuzzy logic as the way reasoning really works and binary or Boolean logic is simply a special case of it.

Fuzzy Sets and Their Operations:

Let X denote a universal set, and \( \mu_A \) the membership function by which the fuzzy set A is defined. Stated in canonical form
\[
\mu_A: X \rightarrow [0,1].
\]

Assume a sample size composed of four people (for simplicity) possessing heights of 5'5", 5'9", 5'11", 6'5". Let this sample be our universe of discourse X, with the set A representing the set :tall people and suppose that tall is six feet and above. The entrepreneur states that 5'5" is definitely short and 6.0'+ is definitely tall. Thus the characteristic function assigns a value of 1 to people who are six feet or taller and a value of 0 to people who are not. A person who is 5'5" is therefore not included in A. A person who is 5'9" is assigned (subjectively, as are all the other elements) by the decision maker the membership grade 0.8. A person who is 5'11" is assigned a membership grade 0.95.

To depict the fuzzy set, a notation compatible with the fuzzy set literature is employed. The fuzzy set A is written as follows:
\[
A = (1.0/6'5", 0.95/5'11", 0.8/5'9")
\]

Where the numerator indicates the membership grade and the denominator indicates the set elements(height). Note that the sum of the membership grade is greater than 1.
Fuzzy regression model:

The fuzzy regression was first introduced by Tanaka et al. in 1982, it is an alternative approach to evaluating the regression between independent variables and dependent variable. Comparison of conventional regression and fuzzy regression can be referred to Wang and Tsaur (2000). The basic model assumes a fuzzy regression equation as below:

\[
\widehat{Y}_i = \tilde{X}_0 X_0 + \tilde{A}_1 X_1 + \ldots + \tilde{A}_N X_N = \tilde{A} \tilde{X}
\]

where \( X=[X_0,X_1,\ldots,X_N]^T \) is a vector of independent variables; \( \tilde{A} = [\tilde{A}_0, \tilde{A}_1, \ldots, \tilde{A}_N] \) is a vector of fuzzy coefficients presented in the form of symmetric triangular fuzzy numbers denoted by \( \tilde{A}_j = (a_j, c_j, a_j) \) with its membership function described as:

\[
\mu_{\tilde{A}_j}(x_j) = \begin{cases} 
1 - \frac{x_j-a_j}{c_j}, & x_j \leq a_j \leq x_j + c_j, \quad \forall j = 1,2,\ldots,N, \\
0, & \text{otherwise.}
\end{cases}
\]

below where \( a_j \) is its central value and \( c_j \) is the spread value, therefore formula (1) can be rewritten as:

\[
\widehat{Y}_i = (a_0, c_0) + (a_1, c_1) X_1 + (a_2, c_2) X_2 + \ldots + (a_N, c_N) X_N.
\]

the above fuzzy regression analysis assumes the crisp input data while the relation between the input and output data is defined by a fuzzy number of which the distribution of the parameter is a possibility function [8].

By applying the extension principle [10], it derives the membership function of fuzzy number \( \widehat{Y}_i \) as shown in (4) and each value of dependent variable can be estimated as a fuzzy number

where the lower bound of \( \widehat{Y}_i \) is \( Y^L_i = \sum_{j=0}^{N} (a_i-c_i) X_j \); the central value of \( \widehat{Y}_i \) is \( Y^C_i = \sum_{j=0}^{N} a_i X_j \) and the upper bound of \( \widehat{Y}_i \) is \( Y^U_i = \sum_{j=0}^{N} (a_i+c_i) X_j \)

\[
\mu(Y) = \begin{cases} 
1 - \frac{|Y-X^C_j|}{c^4|X^C_j|}, & X \neq 0, \\
1, & X = 0, \quad Y 
eq 0, \quad \forall i = 1,2,\ldots,M, \\
0, & X = 0, \quad Y = 0,
\end{cases}
\]

where \( c^4 = (c_0,c_1,\ldots,c_N), \quad a = (a_0, a_1,\ldots,a_N). \)

In order to get the fuzzy regression with minimized fuzziness, the objective function is to minimize the total spread of the fuzzy number \( \widehat{Y}_i \) as (5)

\[
\text{MIN} c^4|X = \text{MIN} \sum_{j=0}^{N} \left[ c_j \sum_{j=1}^{M} |X_{ij}| \right]
\]

and the constraints require that each observation \( Y_i \) has at least \( h \) degree of belonging to \( \widehat{Y}_i \) [6] as \( \mu(Y) \geq h \) \((1 = 1,2,\ldots,M)\), which is equivalent to

\[
1 - \frac{|Y_i-X^C_j|}{c^4|X^C_j|} \geq h \quad \forall i = 1,2,\ldots,M
\]

The above analysis leads to the following linear programming problem [9]:

\[
\text{MIN} \sum_{j=0}^{N} \left[ c_j \sum_{j=1}^{M} |X_{ij}| \right]
\]

s.t.

\[
c \geq 0, \quad \alpha, \quad X_{i0} = 1.0 \leq h \leq 1 \quad \forall i = 1,2,\ldots,M
\]

\[
\sum_{j=0}^{N} a_j X_{ij} + (1-h) \sum_{j=0}^{N} c_j |X_{ij}| \geq Y_i, i = 1,2,\ldots,M
\]

\[
\sum_{j=0}^{N} a_j X_{ij} - (1-h) \sum_{j=0}^{N} c_j |X_{ij}| \leq Y_i, i = 1,2,\ldots,M
\]

Then, formula (1) can be rewritten into

\[
\widehat{Y}_i = (a_0, c_0) + (a_1, c_1) X_{i1} + \ldots + (a_N, c_N) X_{iN}.
\]
each value of dependent variable can be estimated as a fuzzy number

\[ \tilde{Y}_i = \left\{ Y_i^L, Y_i^U \right\} \]

\[ Y_i^L = (\alpha - c)^T X_i; \quad \text{center value of } Y_i \]

\[ Y_i^U = (\alpha + c)^T X_i; \quad \text{the upper of } Y_i \]

where the lower bound of \( Y_i \) is \( Y_i^L = (\alpha - c)^T X_i \), the center value of \( Y_i \) is \( Y_i^{\alpha} = a^T X_i \), the upper of \( Y_i \) is \( Y_i^U = (\alpha + c)^T X_i \), and \( a^T = (a_0, a_1, \ldots, a_N) \).

The degree of fitness of the estimated fuzzy regression equation \( \tilde{Y}_i = \tilde{A}_0 + \tilde{A}_1 X_i \) to the given data \( Y_i \) is measured by index with \( Y_i^h = \left\{ Y_i^L, Y_i^U \right\} \)

\[ Y_i^h = \left\{ Y_i^L, Y_i^U \right\} \]

The value of \( h \) is a membership degree which requires that the collected data are included in the derived fuzzy regression interval at least to the degree \( h \).

\[ \alpha = \left( \alpha_0, \alpha_1, \ldots, \alpha_N \right) \]

As Moskowitz and Kim[13] proposed that if one is confident with the collected data, then a smaller value \( h \) is assigned; otherwise, a larger value \( h \) should be given. Besides, Moskowitz and Kim also suggested that “If the solution for a fuzzy regression model is obtained as \( \tilde{A}_i, M = \left( \alpha_i^*, c_i^* \right) \), then the solution is changed into \( \tilde{A}_i, M = \left( \alpha_i^*, \frac{1 - h_1}{1 - h_2} c_i^* \right) \) when the confident value \( h \) is adjusted from \( h_1 \) to \( h_2 \).” This allows one to evaluate the result with respect to the given value of \( h \). This is important because the value \( h \) affects the spread of fuzzy regression model and the width of fuzzy regression interval. When \( h \) increases, the spread of the fuzzy parameters becomes wider. There are some researches discussed the method of choosing the value of \( h \). Tanaka and Watada[14] suggested that \( h = 0 \) when the data set is sufficiently large, and use comparatively a higher \( h \) as the size of data set becomes smaller. Bardosay, Bogardi, and Duckstein[15] selected an \( h \) value according to the decision maker’s belief in the model, generally recommending an \( h \) value between 0.5 and 0.7. With the property of \( h \), the resultant forecasting interval would provide more flexibility for a decision maker in making decisions.

**Summary and Conclusion:**

Statistical regression has been developed for many years and also has been applied to many fields such as business forecasting, economics, and engineering. For such applications, a large number of collected data or valid distribution forms for the collected data is required. In this paper, an analysis of a fuzzy regression is presented. It has been shown that, in fuzzy linear regression, the central regression line \( Y^{\alpha} \) has the best ability to interpret training data, when the available data are limited and imprecise, and variables are interacting in an uncertain, qualitative, and fuzzy way this technique can provide more confidence insight in the each parameters estimated because of the limits of each variable, rather than single value parameter estimates of conventional demand models.

**REFERENCES**


