The Energy Resource Regression Forecast Model in T–fuzzy Data *†

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Abstract

This paper builds a new kind of energy resource regression forecast model with T–fuzzy variables, which is used to deal with the T–fuzzy variables gained by measures and tests in reality world. Shown by numerical examples this model is effective.

Keywords: T–fuzzy variables, energy resource, regression forecast model, crude oil.

1 Introduction

Having developed some basic concepts, built a regression forecast model with T-fuzzy variables and applied it to energy resource forecast, the paper gets a satisfactory result.

2 Basic theory

In [1][2] can be read the definition and conception of triangular fuzzy number.

Definition 1. Let $P(R)$ be a subspace consisting of the support $T(R)$ of all non-negative elements. For each $(x,\underline{\xi},\overline{\xi})_T \in P(R)$, $x-\underline{\xi}\geq 0$, then $P(R)$ is a cone in $T(R)$ and a closed convex subset of $T(R)$ with respect to topology induced by d, here

$$d(\tilde{x},\tilde{y})^2=(x-y-(\underline{\xi}-\underline{\eta}))^2+(x-y+(\overline{\xi}-\overline{\eta}))^2+(x-y)^2,\quad \tilde{x},\tilde{y}\in P(R) \tag{1}$$

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Definition 2. Let $\tilde{x}_p = (\tilde{x}_{p_1}, \ldots, \tilde{x}_{p_N})$, we partition the set of natural number $1, 2, \ldots, n$ into two exhaustive, mutually exclusive subsets $J(-)$ and $J(+)$, one of which may be empty. Each partition associates a binary multi-index $J = (J_1, J_2, \ldots, J_n)$ defined by $j_p = \{0, \text{ if } p \in J(+);\ 1, \text{ if } p \in J(-)\}$.

Especially, $J_0 = (0, 0, \ldots, 0)$, $J_1 = (1, 1, \ldots, 1)$.

Theorem 1. Suppose that the datum set $\tilde{x}_{1_i}, \tilde{x}_{2_i}, \ldots, \tilde{x}_{n_i}$ and $\tilde{y}_i$ are given by the model

$$\tilde{y}_i = \beta_0 + \beta_1 \tilde{x}_{1_i} + \ldots + \beta_n \tilde{x}_{n_i} \tag{2}$$

the systems $S(J)$, i.e. $\partial\gamma(\hat{\beta}_0(J), \hat{\beta}(J))/\partial\hat{\beta}_j = 0$, which has the unique solution $\hat{\beta}_j (j = 0, 1, \ldots, n)$ for all conal indices, where $\tilde{x}_{p_i} = (x_{p_i}, \underline{\xi}_{p_i}, \overline{\xi}_{p_i})_T$, $\tilde{y}_i = (y_i, \underline{\eta}_i, \overline{\eta}_i)_T$.

Proof. Classify the observation data $w_i, z_{1_i}, z_{2_i}, \ldots, z_{p_i} (i = 1, 2, \ldots, 3N)$ by subscripts and we might as well let $i = 1, 2, \ldots, N$, which correspond to the small fluctuating data, and the other data correspond to $i = N + 1, \ldots, 3N$. Therefore, $w_i = y_i$ to each p, $z_{p_i} = x_{p_i}$ when $i = 1, 2, \ldots, N$; $w_i = y_i - \underline{\eta}_i$ to each p,

$$z_{p_i} = \begin{cases} x_{p_i} - \underline{\xi}_{p_i}, & if \quad j_p = 0, \\ x_{p_i} + \overline{\xi}_{p_i}, & if \quad j_p = 1, \end{cases}$$

when $i = N + 1, \ldots, 2N$, and $w_i = y_i - \overline{\eta}_i$,

$$z_{p_i} = \begin{cases} x_{p_i} + \overline{\xi}_{p_i}, & if \quad j_p = 0, \\ x_{p_i} - \underline{\xi}_{p_i}, & if \quad j_p = 1, \end{cases}$$

when $i = 2N + 1, \ldots, 3N$, so, we change the model (2) into

$$\hat{w}_i = \hat{\beta}_0 + \hat{\beta}_1 z_{1_i} + \ldots + \hat{\beta}_n z_{n_i} (i = 1, \ldots, N) \tag{3}$$

Then, let

$$\gamma(\hat{\beta}_0, \hat{\beta}) = \sum_{i=1}^{3N} d(\hat{\beta}_0 + \hat{\beta}_1 z_{1_i} + \ldots + \hat{\beta}_n z_{n_i}, w_i)^2$$

and $\partial\gamma(\hat{\beta}_0(J), \hat{\beta}(J))/\partial\hat{\beta}_j = 0$, we obtain the standard equations. And we can obtain the unique solution for $\hat{\beta}_j(J) (j = 1, 2, \ldots, n)$ after solving these equations.

3 Building Model

The steps to build model (2) can be concluded as follows:

1^0. Work out a sequence table by observation data and classify the data by Definition 2.

2^0. Change the observation $\tilde{x}_{p_i}$ and the dependent variables $\tilde{y}_i$ into non-fuzziness by Theorem 1.

3^0. Calculate $\hat{\beta}_j (j = 1, \ldots, n)$:

$$r_i = \frac{n \sum z_{p_i} w_i - \sum z_{p_i} \sum w_i}{\sqrt{[n \sum z_{p_i}^2 - (\sum z_{p_i})^2][n \sum w_i^2 - (\sum w_i)^2]}} \tag{4}$$

and

$$s = \sqrt{\left((\sum z_{p_i}^2 (\sum z_{p_i})^2 / n - (\sum z_{p_i} w_{p_i} - (\sum z_{p_i})(\sum w_{p_i})/n\right) / (n-2)}$$

4^0. Decision. If $r > r_{0.05}$, then a test goes through.

5^0. A forecast model is:

$$w' = \hat{\beta}_0^1 - 2S + \hat{\beta}_1 z, \quad w'' = \hat{\beta}_0^2 + 2S + \hat{\beta}_1 z.$$

4 Application in Numerical Example

Example: The needed petroleum is arranged for a Western Developed Country during 1965 and 1981 as follows,

Table 1

years	1965	1967	1969	1971
demand(Ktoe)	(8.05,0.020.03)	(8.28,0.01,0.02)	(8.5,0.02,0.01)	(8.5,0.02,0.01)
1973	1975	1977	1979	1981
(8.94,0.05,0.03)	(9,0,0.01)	(9.04,0.01,0.02)	(9.18,0.02,0.03)	(9.28,0.03,0.04)

Try to forecast the country's petroleum demanded in 1998.

From the data in Table 1, we know that each datum represents a cone and a figure of cone construted by its top and a linear distribution, therefore, applying the method above to it, we obtain:

1^0. Divide the T−fuzzy data annually into two, one is $\{65, 69, 73, 75, 81\}$,denoting $J(-)$, and the other is $\{67, 71, 77, 79\}$, denoting $J(+)$.

2^0. Non-fuzzify it. Classify the data into three parts:

One is

$$(8.5, 0.02, 0.01)_T, \ (9, 0, 0.01)_T, \ (9.28, 0.03, 0.04)_T;$$

another is

$$(8.28, 0.01, 0.02)_T, \ (8.94, 0.05, 0.03)_T, \ (9.18, 0.02, 0.03)_T;$$

and the other is

$$(8.05, 0.02, 0.03)_T, \ (8.7, 0.01, 0.03)_T, \ (9.04, 0.01, 0.02)_T.$$

Therefore, the needed petroleum can be turned into

Table 2

years	1965	1967	1969	1971	1973	1975	1977	1979	1981
demand(Ktoe)	8.03	8.27	8.5	8.73	8.97	9	9.06	9.16	9.28

3^0. List Table

Table 3

t	0	1	2	3	4	5	6	7	8	$\sum = 36$
w	8.03	8.27	8.5	8.73	8.97	9	9.06	9.16	9.28	$\sum = 79$
t^2	0	1	4	9	16	25	36	49	64	$\sum = 204$
w^2	64.48	68.39	72.25	76.21	80.46	81	82.08	83.9	86.1	$\sum = 694.87$
tw	0	8.27	17	26.19	35.88	45	54.36	63.42	74.24	$\sum = 324.36$
$\bar{t}=\sum t/9=4$, $\bar{t}^2=16$, $\bar{w}=\sum w/9 \approx 8.778$										

and estimate parameter $\hat{\beta}_0$, $\hat{\beta}_1$:

$$\hat{\beta}_1 = \frac{\sum t_i w_i - n\bar{t}\bar{w}}{\sum t_i^2 - n\bar{t}^2} \approx 0.1392 \tag{5}$$

$$\hat{\beta}_0 = \bar{w} - \hat{\beta}_1 \bar{t} \approx 8.2212 \tag{6}$$

Substitute (5) and (6) for (3), then

$$\hat{w} = 8.2212 + 0.1392t.$$

4^0. Test

From (4), we calculate the following

$r = 1.652$, while $r_{0.05} = 0.666$, we have

$$r > r_{0.05}.$$

then, a test goes through.

Again

$$s = \sqrt{\frac{1.426 - 0.1392 \times 8.352}{7}} \approx 0.194.$$

$$w' = \hat{\beta}_0^1 + 0.1392t = 7.8332 + 0.1392t,$$

$$w'' = \hat{\beta}_0^2 + 0.1392t = 8.6092 + 0.1392t.$$

5^0. Forecast

$$w''_{1998} = 7.8332 + 0.1392 \times 16.5 = 10.13,$$

$$w''_{1998} = 8.6092 + 0.1392 \times 16.5 = 10.906.$$

Such that

$$y = ((w''_{1998} + w''_{1998})/2, 0.382 \times (w''_{1998} - w''_{1998})/2, 0.618 \times (w''_{1998} - w''_{1998})/2)_T$$
$$= (10.518, 0.1482, 0.2398)_T,$$

i.e. the petroleum needed for the country in 1998 is a bit more than 10.518(ktoe), which tallies with practice.

5 Conclusion

There are many methods which can be used to obtain T-fuzzy data, and the regular methods are those in [4] as follows,

1^0. Direction; 2^0. Fitting;

3^0. Information; 4^0. Construction.

We can prevent original information from distortion if we describe it with T-fuzzy data. If we use the 'determination' mentioned in the paper, we can lessen the loss of information, so that the model mentioned here can be used in more complex systems.

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