Forecast of Tourism Revenues in Sanya Using F6(0.004)

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Abstract. *F6(0.004)* is an element of Set *FTSFM 6* of fuzzy time series forecasting model. Its forecasting formula consists of historical data, difference of historical data, difference percentage of historical data and inverse fuzzy number. *F6(0.004)* was used to analyze historical data during 2006-2014 and forecast data of tourism revenues in 2015 in Sanya, thus providing new method for time series forecasting.

Introduction

Song et al. firstly applied fuzzy set to research time series forecast model in 1993 [1]. After that, they discussed a classic case—registration number forecasting problem in Alabama University during 1971-1992. Jilani et al. firstly proposed inverse fuzzy number for fuzzy time series model in 2007 [2]. Saxena et al. applied inverse fuzzy number concept to propose fuzzy time series forecasting model with high accuracy. Classic case was discussed to derive unprecedented levels (average forecast error ratio *AFER=0.3406%*; mean square error *MSE=9169*). Wang et al. [4-8] improved forecast accuracy of classic case based on forecasting model of Reference [3]. The work aimed at developing above methods to derive Set *FTSFM 6* of forecasting model by simplifying forecast formula. As an element of *FTSFM 6*, *F6(0.004)* was used to derive *AFER* and *MSE* with high accuracy (*AFER=0.0194%*; *MSE=30*). Therefore, it was a good model for fuzzy time series forecasting. Using *F6(0.004)*, the work discussed forecast data of tourism revenues during 2006-2014 in Sanya to derive AFER and MSE with high accuracy (*AFER=0.0331%*; *MSE=0.0042*). Forecasting accuracy was optimistically expected for tourism revenues in 2015 in Sanya, thus providing new idea for fuzzy time series forecasting.

Set FTSFM 6 of forecasting model

It is denoted that forecast formula is as follows.

$$D_i = C_{i-1} + (1+\psi_i)H_{i-1}, \quad \psi_i = \frac{\mu+1}{\frac{\mu}{H_{i-1}} + \frac{1}{K_i}}, \mu \in (0,1), \tag{1}$$

where D_i is predicted value of historical data in the *i*th year; C_{i-1} historical data in the *(i-1)*th year; ψ_I inverse fuzzy number in the *i*th year; H_{i-1} difference of historical data in the *(i-1)*th year; K_i difference percentage of historical data in the *i*th year; μ membership degree of Element H_{i-1}.

It is assumed that $\mu \in (0,1)$. Then, we obtain forecasting models based on Formula (1). The forecasting models, denoted by *F6(* μ *)*, assemble to form Set *FTSFM 6*.

Definition 1: If $AFER \le 0.3406\%$, and $MSE \le 9169$, then the model will be better for fuzzy time series forecasting in registration number during 1971-1992 in Alabama University.

In classic case research, *F6(0.004)* is used to derive *AFER=0.0194%* and *MSE=30*.Therefore, *F6(0.004)* is a better model for fuzzy time series forecasting. It is also a common forecasting model for FTSFM 6.

Application steps of F6(0.004)

Step 1: Introduce historical data; Step 2: Establish 3 discourse domains of historical data; Step 3: Establish forecasting formula of F6(0.004); Step 4: Forecast historical data by F6(0.004); Step 5: Forecast data of unknown year by F6(0.004).

Tourism revenue forecasting in Sanya by F6(0.004)

Introduction of historical data.

Table 1 Tourism revenues forecasting during 2006-2014 in Sanya by *F6(0.004)*

Year	Tourism Revenues C_i (100 million Yuan)	Difference H_i	Difference Percentage K_i	Predicted Value D_i (100 million Yuan)	$(D_i-C_i)^2$	$\|D_i-C_i\|/C_i$
2006	65.40	-	-	-	-	-
2007	80.11	14.71	-	-	-	-
2008	91.05	10.94	-0.2563	91.03	0.0004	0.000220
2009	103.77	12.72	0.1627	103.78	0.0001	0.000096
2010	139.64	35.87	1.8200	139.72	0.0064	0.000573
2011	160.71	21.07	-0.4126	160.65	0.0036	0.000373
2012	192.22	31.51	0.4955	192.35	0.0169	0.000809
2013	233.33	41.11	0.3047	233.37	0.0016	00000171
2014	269.73	36.40	-0.1146	269.71	0.0004	0.000074
MSE					0.0042	
AFER						0.0331%

Establishing 3 discourse domains. According to Table 1, 3 discourse domains of tourism revenues are set in Sanya.

$$C = \{C_{2006}=65.40, C_{2007}=80.11,\ldots,C_{2013}=233.33,C_{014}=269.73\}.$$

Difference formula $H_i=C_i-C_{i-1}$ is applied to calculate annual difference discourse domain of tourism revenues in Sanya.

$$H = \{H_{2007}=14.71, H_{2008}=10.94,\ldots,H_{2013}=41.11,H_{2014}=36.40\}.$$

Difference percentage formula $K=(H_i-H_{i-1})/H_{i-1}$ is applied to calculate annual discourse domain of difference percentage of tourism revenues in Sanya.

$$K = \{K_{2008}= -0.2563,K_{2009}=0.1627,\ldots,K_{2013}=0.3047,H_{2014}= -0.1146\}.$$

Forecasting tourism revenues during 2008-2014 in Sanya by F6(0.004). As an element of FTSFM 6, F6(0.004) has forecasting formula as follows.

$$D_i=C_{i-1}+(1+\psi_i)H_{i-1},\quad \psi_i = 0.004+1\Big/\left(\frac{0.004}{H_{i-1}}+\frac{1}{K_i}\right), \tag{2}$$

where D_i is predicted value of tourism revenue in the ith year;C_{i-1} tourism revenue in the (i-1)th year;ψ_i inverse fuzzy number in the ith year;H_{i-1} difference of tourism revenue in the (i-1)th year; K_i difference percentage of tourism revenue in the ith year; membership μ=0.004.

Forecasting Formula(2) of F6(0.004) is used to calculate predicted value of tourism revenues during 2008-2014 in Sanya (See Table 1).Table 1 shows that AFER and MSE have high forecasting accuracies (AFER=0.0331%;MSE=0.0042).

Forecasting tourism revenues during 2014-2015 in Sanya by F6(0.004). For lack of difference percentage K_{2015} of tourism revenue in 2015, we cannot directly apply forecasting formula (2) to calculate predicted value of tourism revenue in 2015. It is assumed that tourism revenue in 2015 is related to data in previous years. Then we establish forecasting rule of *F6(0.004)* for tourism revenues in unknown years.

(1) Forecasting rule. It is denoted that difference percentages of annual tourism revenues are K_{t-3},K_{t-2} and K_{t-1} in the *(t-3)*th,*(t-2)*th and *(t-1)*th years. λ is obtained by $\lambda=\{max\{K_{t-3},K_{t-2},K_{t-1}\}-min\{K_{t-3}, K_{t-2}, K_{t-1}\}\}/s$. After that, Forecasting Formula (2) is calculated by using parameters H_{t-1} and $K_1= min\{K_{t-3}, K_{t-2}, K_{t-1}\}$;$H_{t-1}$ and $K_2=min\{K_{t-3},K_{t-2},K_{t-1}\}+\lambda$;…;$H_{t-1}$ and $K_{s-1}=min\{K_{t-3},K_{t-2},K_{t-1}\}+(s-1)\lambda$; H_{t-1} and $K_s=max\{K_{t-3},K_{t-2}, K_{t-1}\}$;$C_{t-1}$.The obtained values are smallest, small, moderate, large and largest predicted values of tourism revenues in the *t*th year according to small to large order. The criterion of Parameter s is that the minimum of FER between predicted and real data is less than 1%.This forecasting rule is called *F6(3-s-1-s+1)* Rule.

(2) Decision method. **Method 1:** The minimum, smaller, larger and maximum predicted values in 2015 have the same sequence with FERs of smallest, small, large and largest predicted values in 2014.**Method 2:** Decision maker determines the sequence based on experience.

Calculating predicted value of tourism revenue in unknown year by *F6(3-6-1-7)*.(1)Forecasting tourism revenue in Sanya in 2014 based on *F6(3-6-1-7)* rule.

It is denoted that 2014 is the unknown year; *s*=6. *F6(3-6-1-7)* rule is used to forecast tourism revenue in Sanya in 2014—the unknown year. According to Table 1, $\lambda=\{max\{K_{2011},K_{2012}, K_{2013}\}-min\{K_{2011},K_{2012},K_{2013}\}\}/6=0.15135$.After that, Forecasting Formula(2) of *F6(0.004)* is calculated by using parameters $H_{2013}=41.11$ and $K_1=min\{K_{2011},K_{2012},K_{2013}\}=-0.4126$; $H_{2013}=41.11$ and $K_2=min\{K_{2011},K_{2012},K_{2013}\}+\lambda=-0.26125$;$H_{2013}=41.11$ and $K_3=min\{K_{2011},K_{2012}, K_{2013}\}+2\lambda=-0.1099$; $H_{2013}=41.11$ and $K_3=min\{K_{2011},K_{2012},K_{2013}\}+3\lambda=0.04145$;$H_{2013}=41.11$ and $K_3=min\{K_{2011}, K_{2012},K_{2013}\}+4\lambda=0.1928$;$H_{2013}=41.11$ and $K_3=min\{K_{2011},K_{2012},K_{2013}\}+5\lambda=0.34415$; $H_{2013}=41.11$ and $K_4=max\{K_{2011},K_{2012},K_{2013}\}=0.4955$;$C_{2013}=233.33$. (See Table 2).

Table 2 Predicted tourism revenues in Sanya in 2014 by using *F6(3-6-1-7)* rule

Year	Type of Predicted Value	Predicted Value in 2014 (100 Million Yuan)	Actual Value in 2014 (100 Million Yuan)	$\lvert D_{2014}-C_{2014}\rvert/C_{2014}$	Sequence of FERs
2014	Smallest	257.41	269.73	4.5748%	4
2014	Smaller	263.66	269.73	2.2504%	3
2014	Small	269.90	269.73	0.0630%	1
2014	Moderate	272.73	269.73	1.1122%	2
2014	Large	282.40	269.73	4.6973%	5
2014	Larger	288.64	269.73	7.0107%	6
2014	Largest	294.89	269.73	9.3278%	7

(2) Forecasting tourism revenue in Sanya in 2015 based on *F6(3-6-1-7)* rule. It is denoted that 2015 is the real unknown year; *s*=6. *F6(3-6-1-7)* rule is used to forecast tourism revenue in Sanya in 2015. According to Table 1, $\lambda=\{max\{K_{2012},K_{2013},K_{2014}\}-min\{K_{2012}, K_{2013},K_{2014}\}\}/6=0.101683$.After that, Forecasting Formula(2) of *F6(0.004)* is calculated by using parameters $H_{2014}=36.40$ and $K_1=min\{K_{2012},K_{2013},K_{2014}\}=-0.1146$;$H_{2014}=36.40$ and $K_2=min\{K_{2012}, K_{2013},K_{2014}\}+\lambda=-0.012917$; $H_{2014}=36.40$ and $K_3=min\{K_{2012},K_{2013},K_{2014}\}+2\lambda=0.088766$; $H_{2014}=36.40$ and $K_3=min\{K_{2012},K_{2013}, K_{2014}\}+3\lambda=0.190449$;$H_{2014}=36.40$ and $K_3=min\{K_{2012},K_{2013}, K_{2014}\}+4\lambda=0.292132$; $H_{2014}=36.40$ and $K_3=min\{K_{2012},K_{2013},K_{2014}\}+5\lambda=0.393815$;$H_{2014}=36.40$ and $K_4=max\{K_{2012},K_{2013}, K_{2014}\}=0.4955$; $C_{2013}=269.73$.The obtained values are sequenced from small to large, thus deriving smallest, small, large and largest predicted values of tourism revenues in 2015 (See Table 3).

According to Decision Method 1, Table 3 shows that recommended sequence of tourism revenues in 2015 is as follows. The first is small predicted value (309.37),with an increase of 14.6962% over that in 2014; the second moderate predicted value (313.09),with an increase of 16.0753%; the third smaller predicted value (305.66),with an increase of 13.3207%;the fourth smallest predicted value (301.94), with an increase of 11.9416%;the fifth large predicted value (316.81),with an increase of 17.4545%; the sixth larger predicted value (320.52),with an increase of 18.8299%; the seventh largest predicted value (324.24),with an increase of 20.2091%.According to Decision Method 2,decision maker determines the sequence of predicted values based on experience.

Table 3 Predicted tourism revenues in Sanya in 2015 by using *F6(3-6-1-7)* rule

Year	Types of Predicted Values	Predicted Value D_{2015} in 2014(100 Million Yuan)	Actual Value C_{2015} in 2014(100 Million Yuan)	$\lvert D_{2015}-C_{2014}\rvert/C_{2014}$	Recommended Sequence
2015	Smallest	301.94	269.73	11.9416%	4
2015	Smaller	305.66	269.73	13.3207%	3
2015	Small	309.37	269.73	14.6962%	1
2015	Moderate	313.09	269.73	16.0753	2
2015	Large	316.81	269.73	17.4545%	5
2015	Larger	320.52	269.73	18.8299	6
2015	Largest	324.24	269.73	20.2091%	7

Summary

FTSFM 6 is a set of fuzzy time series forecasting models. As a common forecasting model of FTSFM 6, *F6(0.004)* was used to forecast data in the past and unknown years. The work proposed recommended and self-decision sequencing methods for predicted values of data in unknown years.*F6(3-6-1-7)* rule of *F6(0.004)* was used to forecast tourism revenue in 2014,thus achieving minimum FER (0.0630%) between large and actual values. Therefore, forecasting accuracy is optimistically expected for tourism revenues in 2015 in Sanya, thus providing new idea for fuzzy time series forecasting.

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