

# Demand Forecast of Human Resources in Starred Hotel Based on Grey Theory and BP Neural Network Combined Model\*

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**Abstract** To properly forecast the hotel human resource demand helps solve the contradiction between supply and demand in hospitality industry, however, the demand forecast of human resources in China counterpart is lagged behind. Aiming at the disadvantages that the human resource demand forecast methods are single and not very accurate, this paper put forwards to set up a combined forecast mode based on a gray theory and BP neural network, and takes Hunan Province starred hotel human resources demand for example in China, and concludes that the combined model forecast results are superior to single methods, so this research is great significance on theoretical research and practical application.

**Key words** Starred hotels; Human resource forecast; Grey theory; BP neural network

## 1 Introduction

China hotel industry has been developed rapidly as its economy's sustained growth, according to the data of 2008 statistical bulletin, which showed that at the end of 2008, the number of starred hotels in China reached 14,099, with 1591400 rooms and 2,934,800 beds, hotel industry has become a pillar industry of tourism. At present, hotel industry competition is human resources competition, as the phenomenon that hotel industry employees' high mobility rate is prevalent, it leads to the contradiction between supply and human resources demand in the hotel, and brings the economic benefits of hotel to a great loss. So the scientific forecast not only can ensure adequate human resources supply but also avoid the service quality decline in the hotel.

Domestic and foreign scholars have done some research in the human resources demand forecast. There are econometric models, time series models, Grey theory and neural network methods and so on. David M. Georgoff and (Murdick, RG 1986) analyzed the advantages and disadvantages of 20 forecasting methods, such as the time frequency and time series method<sup>[1]</sup>; Robert H. (Meehan et al 2002) predicted the human resource demand through establishing needs model<sup>[2]</sup>; (Zhao xi et al 2009) used gray forecast method to predict future human resources demand in manufacturing sector<sup>[3]</sup>; (Cao Shumin et al 2008) analysed the application of BP neural network in the human resources demand forecast<sup>[4-5]</sup>.

Now there are the limitations and low accuracy in the traditional methods, and some combining forecast model can improve accuracy as a good forecast method (Li Tao, 2006)<sup>[6]</sup>, such as (Lei kewei 2007) combined ARIMA and BP neural network method to predict the amount inbound tourists in China<sup>[7]</sup>, and there are no combining methods applied in human resource forecast of China hotel industry. So this paper puts forward to a combining forecast Model based on gray theory and BP Neural Network, and sets Hunan Province starred hotel in China for example, to make contribution to practical guidance for Hunan Province tourism professional project in China.

## 2 Setting up the Grey Neural Network Model

Although the traditional gray theory model has the characteristics with less data required and higher short-term forecast accuracy, so it is more applicable to the data with exponential growth law, and no for greater volatility curves<sup>[8]</sup>; but artificial neural network as a good forecast accuracy method<sup>[9]</sup>, In the application it is easy influenced by topology structure complexity of network and the data complexity, and arises the over-study phenomenon, then leading to low generalization ability<sup>[10]</sup>. Therefore, this paper uses the combined model of gray theory model and BP neural network model, in order to avoid the respective faults.

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Setting up the original data order as:  $X = (x_1, x_2, \dots, x_n)^T$ , using Number i method ( $i=1, 2, \dots, m$ ) as the predict result is  $X_i = (x_{1i}, x_{2i}, \dots, x_{ni})^T$ , then it satisfies the minimum variance criterion:

$$\text{MinQ} \sum_{i=1}^n w_i (X - X_i)^2 \quad \text{s.t.} \begin{cases} \sum_{i=1}^n w_i = 1 \\ w_i \geq 0, i = 1, 2, \dots, m \end{cases} \quad (1)$$

Then the best credibility can be obtained, and then obtains synthetically optimum mode.

Set  $f_1$  as gray model predictive value,  $f_2$  as the neural network predictive value,  $f_c$  as the optimal combination model predictive value. Forecast errors are  $e_1, e_2$  and  $e_c$  respectively, taking corresponding weight coefficient is  $w_1, w_2, w_c$ , and  $w_1 + w_2 = 1$ , then:

$$f_c = w_1 f_1 + w_2 f_2 \quad (2)$$

Error and variance are:  $e_c = w_1 e_1 + w_2 e_2 \quad (3)$

$$\text{Var}(e_c) = \text{Var}(w_1 e_1 + w_2 e_2) = w_1^2 \text{Var}(e_1) + w_2^2 \text{Var}(e_2) + 2w_1 w_2 \text{Cov}(e_1, e_2) \quad (4)$$

Then:  $w_1 = \frac{\text{Var}(e_2)}{\text{Var}(e_1) + \text{Var}(e_2)}, w_2 = \frac{\text{Var}(e_1)}{\text{Var}(e_1) + \text{Var}(e_2)} \quad (5)$

$$f_c = \frac{\text{Var}(e_2)}{\text{Var}(e_1) + \text{Var}(e_2)} f_1 + \frac{\text{Var}(e_1)}{\text{Var}(e_1) + \text{Var}(e_2)} f_2 \quad (6)$$

The model structure is:

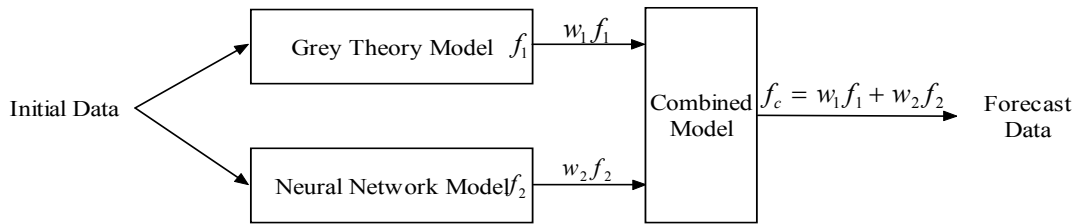


Figure 1 Grey Neural Combined Model

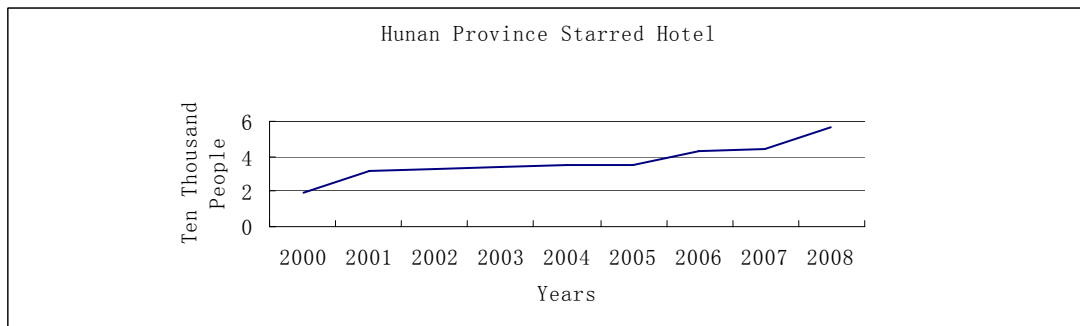
### 3 Empirical Analysis

This paper selects the number of starred hotels practitioners[11] in Hunan Province from 2000 to 2008 to build models as a data sample for statistical analysis, as shown in Table 1 and Figure 2.

Table 1 Number of Employees at Starred Hotel in Hunan Province from 2000 to 2008

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Employee Number	19178	31416	33351	33599	34998	35460	43254	44425	56890

Figure 2 Hunan Starred Hotel Employees from 2000 to 2008



#### 3.1 Grey theory model forecast

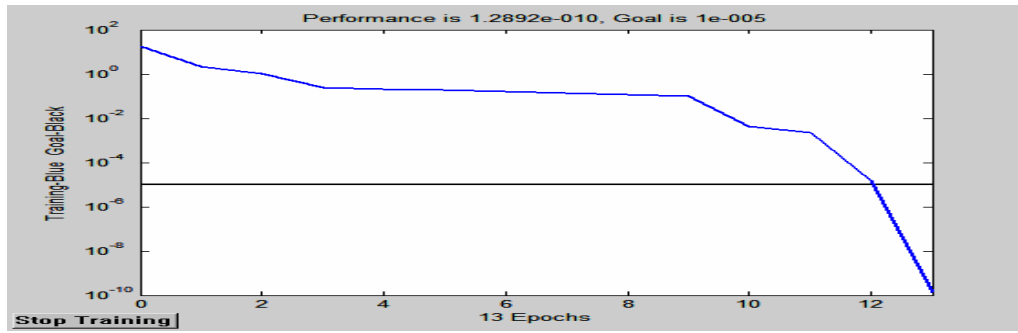
Table 1 and Figure 3 show that although data are limited and the curve doesn't emerge exponential growth, but the total wave is not particularly large and appears upward trend, the above condition is according with gray theory model. This paper uses gray information model which has dynamic equal dimension, with 5 as the sequence length, after having forecasted starred hotels employees one year,

then removing the first year data, using the following year data, then rebuilding the new model and forecasting the next year's starred hotels employees, to ensure the forecast accuracy. Table 2 shows as the last forecast result.

**3.2 BP neural network model forecast**

The hotel employees number are affected by many relevant influential factors, the research shows that welfare, work environment, employees state can affect their flow, but these factors' ultimate impact can be seen in the actual number of hotel employees each year, so this paper does not consider the relevant affective factors, and using the every year actual hotel employees number as analysis objective directly.

This paper uses 2000--2002, 2001-- 2003, 2002 --2004, 2003 -- 2005, 2004 – 2006, 2005--2007 years data as the network target input, and uses 2003, 2004,2005,2006,2007,2008 years data as a network target output respectively. Firstly initializes the data to [-1,1] before network training, then using normalized training data to train the network, input layer, hidden layer transfer function is Sigmoid type, and the output layer is Purelin transfer function. The range of Sigmoid function is [0,1], Setting the maximum study number for 5000 times, the learning goal takes 0.00001 as the square error and setting the initial value of network connection weights is the random number between[-1,1]. It converges to the error range after 12 training times based on Levenberg-Marquardt optimization algorithm, then error relations shown in Figure 3 and the predicted results shown in Table 2.



**Figure 3 Neural Network Computation Steps and the Error Map**

**Table 2 Gray Model and Neural Network Model Forecast Result**

Years	Items Actual value	Grey Model Forecast		BP Neural Network Model Forecast		Grey Neural Network Model Forecast
		Predictive value	Absolute error	Predictive value	Absolute error	
2000	19178	19178	0.0000	---	---	---
2001	31416	31713	0.0297	---	---	---
2002	33351	32773	-0.0578	---	---	---
2003	33599	33867	0.0268	33926	0.0327	33920
2004	34998	34999	0.0001	34870	-0.0128	34883
2005	35460	36178	0.0718	35629	0.0169	35684
2006	43254	37096	0.6158	43270	0.0016	42653
2007	44425	44922	0.0497	44512	-0.0013	44553
2008	56890	49280	-0.7610	56836	-0.0054	56080
2009	---	63540	---	56639	---	57329
2010	---	72714	---	69571	---	69885
2011	---	84932	---	70846	---	72255

**3.3 Grey neural network model forecast**

It can be calculated through the data in Table 2 and variance formula,  $var(e_1) = 0.0994$ ,  $var(e_2) = 0.0111$ , we get  $w_1 = 0.10$ ,  $w_2 = 0.90$  by the formula(12), we can obtain the number of starred hotels practitioners predictive data from 2009 to 2011 in Hunan Province by the formula (13), and as shown in Table 2.

## 4 Conclusion

We can know from the gray model and BP neural networks forecast model, the predicted data and the actual data have large difference from 2006 to 2008 in the gray forecasting model, the main reason is that there are relatively large fluctuations in this two years data, but the BP neural network forecast accuracy is relatively high. From the whole, the combined model's forecast accuracy is superior to single model's forecast accuracy. Second, the predictive number of employees in Hunan-starred hotel from 2009 to 2011 are 57 329, 69 885 and 72 255 people respectively, and the people number is going up, because Hunan tourism industry has entered a rapid and healthy developed period in recent years, and there are many new open starred hotels, so it leads to new increasing employees in starred hotels. The above data can play an important role in planning Hunan Province tourism professional project. In addition, there is little research in the hotel human resource forecasting with combined model, this paper provides a new research direction for human resource demand method. However, the actual employees demand and supply are influenced by many reasons, such as political, economic conditions and critical cultural and physical activities, the forecast result is difficult to get absolute accuracy and the forecast results still need to practical test.

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