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A New Type of Combination Forecasting Method Based on PLS

——The Application of It in Cigarette Sales Forecasting*

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ABSTRACT

Cigarette market is a kind of monopoly market which is closed loop running, it depends on the plan mechanism to schedule producing, supplying and selling, but the "bullwhip effect" still exists. So it has a fundamental significance to do sales forecasting work. It needs to considerate the double trend characteristics, history sales data and other main factors that affect cigarette sales. This paper depends on the panel data of A province's cigarette sales; first we established three single forecasting models, after getting the predicted value of these single models, then using the combination forecasting method which based on PLS to predict the province's cigarette sales of the next year. The results show that the prediction accuracy is good, which could provide a certain reference to cigarette sales forecasting in A province.

Keywords: PLS; ARMA; Time Series Method; Combination Forecasting Method; Sales Forecast

1. Introduction

China has the world's largest cigarette production and consumer, the contribution of tobacco excise tax and other taxes have been living in the forefront of the Industry over the years, it plays an important role on the national's economic development and the structure stability of tax revenue. At the same time, this industry is protected by the Tobacco Monopoly Law, during a long-term it is in a monopoly business state, closed and planning is the main operational features of it. As a monopoly market, scientific prediction of cigarette sales can eliminate the "bullwhip effect" in the tobacco supply chain effectively, particularly, it's important in the background of enterprises separation of industrial and commercial in China's tobacco industry. Sales forecasting is the premise of the enterprise's budget management, it is also a benchmark of the performance plan, and the prediction accuracy greatly affect the scientific nature of the decision-making behavior. Therefore, in recent years, many scholars have researched the predicting method of cigarette sales, such as multiple linear regression method, ARMA prediction method, time series forecasting method, extension clustering method, artificial neural networks, gray model [1], these methods mine the essence of sales forecasting in different aspects, however, due to the limitations of a single method, and the data processing accuracy is not high enough, it is necessary to propose a new prediction method, in order to further improve the accuracy of sales prediction.

Based on the above discussion, this paper considers the characteristics of double trend (long-term trend factors and seasonal factors for cigarette sales), history sales data and other main factors that affect cigarette sales. Then depends on A province's cigarette sales panel data, first we established three single forecasting models (ARMA model, Holter-Winter season product model, time series decomposition model), after getting the predicted value of these single models, then using the combination forecasting method which based on PLS to predict the province's cigarette sales of the next year, in order to further increase the sales forecasting accuracy.

2. Literature Review

Sales forecasting is trying to use a specific method to identify specific sales law, but in a seemingly chaotic historical sales data. There are many traditional forecasting methods such as linear prediction method, moving average method, multiple regression method, Box-Jenkins method, Markov chain prediction method and so on [2]. The application of these methods have specific requirements for the sample itself (linear sequence law or the sample size is large enough), however, in practical ap

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plications, the historical sequence of product sales isn't often fully satisfy the linear law or has a insufficient sample size, so the forecasting effect will be affected by a certain degree of influence. In China cigarette sales meet the obvious characteristics of time series, monthly sales data influenced by consumer groups which have obvious seasonal characteristics, therefore it often consistent with the typical characteristics of double trend, and the predicted value tends to have a high correlation with the history of cigarette sales. Prediction methods such as autoregressive moving average model, Holter-Winter season product model [3] and time series decomposition method [4] can solve the problems of cigarette sales forecasting better in practice.

Holter-Winter season product model and time series decomposition method are traditional time series forecasting analysis methods, building a time series model appropriately can effectively eliminate the uncertainties related with the future. Time series method requires the prediction object has a correlation with the current economic trends, at the same time prediction analysis has an extremely short-term meaning, therefore the effect of these two time series analysis methods used for multi-step prediction will be affected [5]. ARMA model is a kind of commonly used stochastic time series model, foreign scholars Robert Yaffee and Monnie McGee said, to short-term forecasting which have stable and seasonal characteristics, ARMA model can get a more reliable prediction result, and can achieve the desired confidence interval [6]. ARMA model has strong flexibility, it can express the various properties of time series that appear in the actual work, but the prediction often requires relatively large amount of data. In addition, to some smoothing methods, when new data can be taken advantage of, updating the ARMA model parameters is not an easy task [7]. These three single forecasting models all have their own characteristics, advantages and disadvantages, when used alone, we can only use a certain point of the effective information. Furthermore, single model will also be affected by the model's set conditions and other factors, therefore, when in predictions, it often demonstrates that the range of information sources is not enough, and the forecasting accuracy is difficult to meet the requirement [8]. The choice of a forecasting method should consider the prediction object, forecasting range, as well as the data and other factors, so we can comprehensive use the advantages of the single prediction method, in this case, the importance of the combination forecasting method has been put on the agenda.

Combination forecasting method is trying to integrate the prediction results of a variety of forecasting methods through the establishment of a combined forecasting model, so as to get a more accurate forecasting range, and for system analysis or decision-making using. In 1969, J.M. Bates and C.W.J. Granger published the article named combination forecasting on Operational Research Quarterly [9], they systematic studied the combination forecasting method for the first time, and it had caused the attention of many forecasting scholars. After the 1970s, combination forecasting research gradually caused the attention of scholars, and published a series of papers about combination forecasting, comparing with individual prediction methods, it has a incomparable advantage in improving the prediction accuracy, and in recent years it received an extensive attention from scholars [8].

The most concerned of combination forecasting is how to calculate the weighted average coefficient, so that the combination forecasting model can be more effective to improve the forecasting accuracy, domestic and foreign scholars have proposed a series of combination forecasting method, commonly has minimum difference method, no constraint least square method, constrained least squares method, Bayes method, recursive combination of prediction method and so on [10]. However, the above combination prediction methods often give different weighted average coefficient depending on the types of single forecasting method. To a single prediction method the weighted average coefficient at each point is the same. However, single prediction method may have high prediction accuracy at one point, lower in forecast accuracy at another point, so it is necessary to discuss a new combination forecasting model, so that the empowerment of the new model can base on the level of fitting accuracy at each point of the single forecasting method.

In addition, because of ARMA model, Holter-Winter season product model and time series decomposition method all belong to the context of the time series method, the prediction results of these three individual forecasting methods generally have a higher correlation, Partial Least Squares method (PLS) can modeling in the case of a limited amount of data and effectively solve this problem [11,12], while absorbing the advantages of each individual prediction model, it also tries as much as possible to improve the prediction accuracy. This paper presents a new combination forecasting method based on PLS, its basic idea is to consider the single prediction method' prediction value as the independent variables, to consider the predict object as the dependent variable, then building the partial least squares regression, its biggest advantage is to consider the independent variable, while also taking into account the information of the dependent variable, so we could get a more reliable combination forecasting results.

In this paper, the general idea is shown in **Figure 1**, in order to ensure the forecasting accuracy of the results in a greater extent, we established three single forecasting models, after getting the predicted value of these single

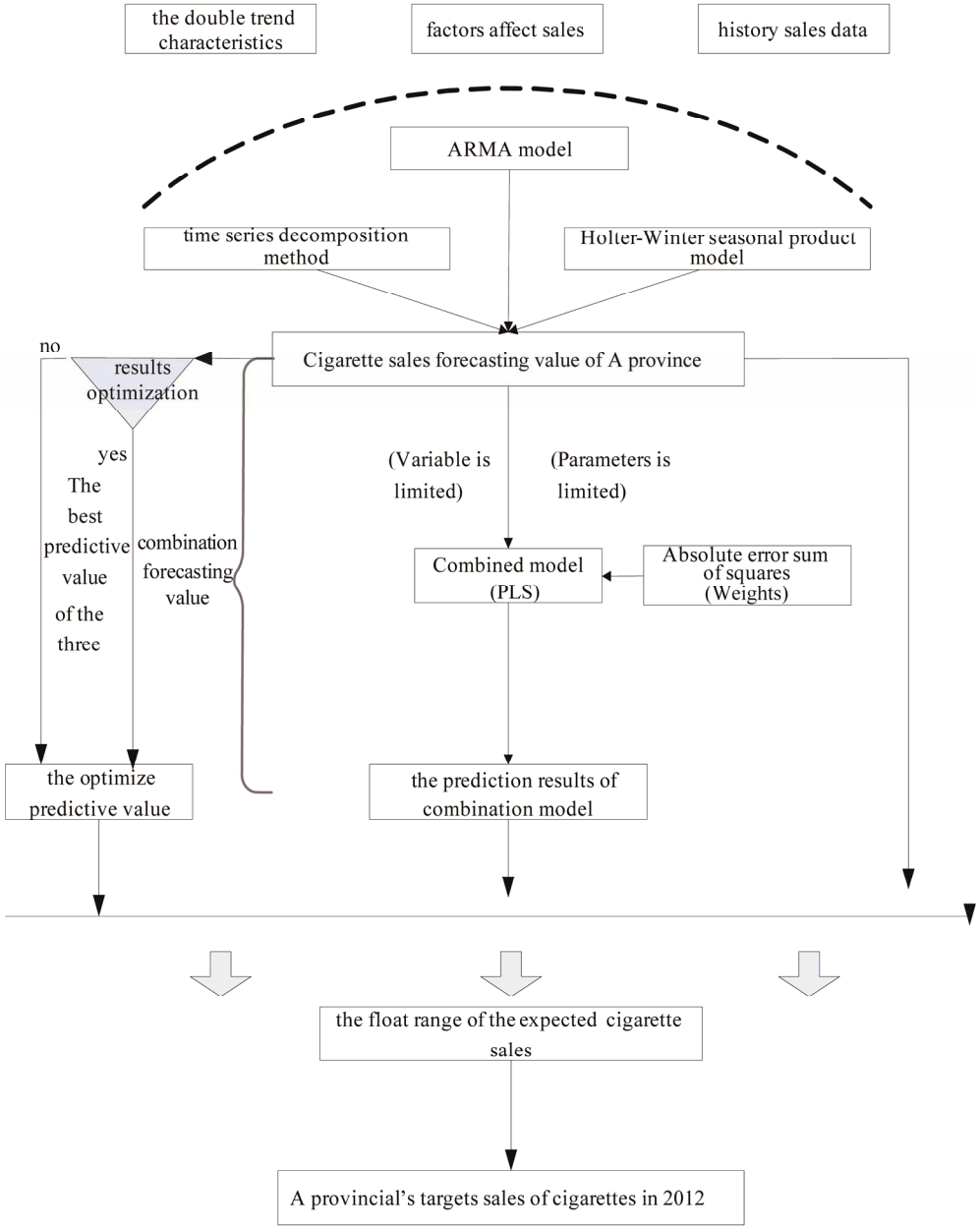

Figure 1. The forecasting process of cigarette sales in this paper.

models, then using the combination forecasting method which based on PLS to predict the province's cigarette sales of the next year, so as to further improve the prediction accuracy.

3. Methods and Principles

3.1. The Principle of ARMA Model

ARMA model is a kind of commonly used stochastic time series model, proposed by G.E.P. Box and G.M. Jenkin, it is also known as the B-J method [13,14]. The basic idea of this method is talked at below, some time series is a set of random variables depends on the time t, although the single sequence values that constitute the time series is uncertainly, however, the changes of the entire sequence has a pattern to follow, analyzing it through the establishment of corresponding mathematical model, we can get a better understanding of the structure and the characteristics of time series, and to achieve the optimized prediction results within the minimum variance [15,16].

There are three basic types of ARMA model, auto-regressive (AR) model, moving average (MA) model, auto-regressive moving average (ARMA) model [17-20].

If the time series y_t is the random error of its current and its early value, as well as the linear function of its

early value, then the (p, q) order autoregressive moving average model is called ARMA (p, q) model, the general form of it is,

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + u_t - \theta_1 u_{t-1} - \theta_2 u_{t-2} - \cdots - \theta_q u_{t-q} \quad (1)$$

In (1), the real parameter ϕ_1, ϕ_2, $\cdots$, ϕ_p, is the autoregressive coefficient, θ_1, θ_1, $\cdots$, θ_q is the moving average coefficient, it's the model's parameters to be estimated.

Introducing the lag operator B, the above equation can be abbreviated as,

$$\phi(B) y_t = \theta(B) u_t \quad (2)$$

3.2. The Principle of Holter-Winter Season Product Model

Holter-Winter season product model belongs to the method areas of multi-parameter exponential smoothing, including non-seasonal model and seasonal product model. Cigarette sales data both have the characteristics of trend and seasonal fluctuations, therefore, this study selected the Holter-Winter season product model [21].

The model has three smoothness indexes α, β and γ ($0 \le \alpha, \beta, \gamma \le 1$).

The prediction model is,

$$\hat{y}_{t+k} = (a_t + b_t k) c_{t-s+k}, \text{ for all } k \ge 1 \quad (3)$$

In (3.3),

$$a_t = a \frac{y_t}{c_{t-s}} + (1-a)(a_{t-1} + b_{t-1}) \quad (4)$$

$$b_t = \beta(a_t - a_{t-1}) + (1-\beta) b_{t-1} \quad (5)$$

$$c_t = \gamma \frac{y_t}{a_t} + (1-\gamma) c_{t-s} \quad (6)$$

s is the length of the seasonal cycle, in here it stands for monthly data, the cycle is 12 months, that is $s = 12$.

If $t = T$ (The last cycle), then the prediction formula is,

$$\hat{y}_{T+k} = (a_T + b_T k) c_{T-s+k}, \text{ For all } k \ge 1 \quad (7)$$

In (7), a_t is the intercept, b_t is the slope, c_t is seasonal factor (seasonal index). It can be seen that they are obtained by smoothing.

Because of the trend term and the season term of this model are obtained by calculating the smoothed value, so this method is similar to other smoothing methods, mainly reflects the changes of recent data, so it is suitable for short-term forecasts.

3.3. The Principle of Time Series Decomposition Method

Traditional time series analysis [22] due the fluctuation of time series to four factors, trend variation (trend, T), seasonal variation (seasonal, S), cyclical variation (circle, C) and irregular variation (irregular, I). Among them, the cyclical variation refers to the cycle changes of years, it usually refers to the economic cycle. Irregular variation namely random variation, the relations between the four variations and the original sequence are summarized as two models,

multiplicative model, Y = TSCI

additive model, Y = T + S + C + I

Among them, multiplicative model is suitable for the case of that T, S and C is interrelated, additive model is suitable for the case of that T, S and C is independent of each other. In this paper we use the multiplicative model to predict the cigarette sales.

The main purpose to decomposition time series is to break down the fluctuations factors of time series, so that the specific circumstances of each part of the fluctuations can be clearly observed, in order to provide the conditions for the in-depth study of the variation of the various parts of fluctuations.

3.4. The Principle of PLS

Partial Least Square (PLS) analysis, is a new type of multivariate statistical data analysis methods which is extracted from the application field, it was proposed by S. Wold and C. Albano (1983) [23], this analysis method is mainly applied to linear regression modeling between multi-dependent variables and multi-independent variables, and it can effectively solve many complex problems that an ordinary multiple linear regression can not solve. S. Wold [24] and Agnar [25] pointed out that it not only can solve the existence of multiple correlation problems in the multiple regression independent variable system, but also can create the regression model when the sample size is less than the number of variables. The PLS regression method is a improvement of the Principal Component Regression (PCR) analysis method, in the process of extracting component, PLS not only takes the information of the independent variables into account, but also taking into account the information of the dependent variables, it overcomes the adverse effects of multicollinearity in system modeling, it can get a more reliable analysis results.

Because this research mainly talks about the prediction of cigarette sales, involving only one dependent variable (cigarette sales), so it is necessary to introduce the regression method of single dependent variable of PLS. Given that the dependent variable is Y and P numbers of independent variables form the independent variables set $X = [x_1, x_2, \cdots, x_p]$, first, PLS regression method extracts t_1 from the matrix, it is required that it should carry the variation information in X as far as possible, it should also have a great relevance with Y. If the regression equation has reached a satisfactory accuracy, then the

algorithm terminates. Otherwise, using the residual information that X has been explained by t_2 and the residual information that Y has been explained by t_1 to do the second round of component extraction, so back and forth, until you can reach a satisfactory statistical accuracy. Assuming that we finally extract m components from X, they are $t_1, t_2, \cdots, t_m$, then PLS will establish the regression between Y and $t_1, t_2, \cdots, t_m$, finally expressed as a regression equation of Y on the original variable X.

4. Data Collection

We obtained A province's actual cigarette annual sales data and monthly sales data (January 2004 to December 2011) from A province's Tobacco Monopoly Bureau (company). Before 2004, the tobacco system's information management is not well organized, sales data was manual recording and incomplete, and some data is lost, so the previous data is not used in this study.

To do monthly cigarette sales forecasting, we use a sample of data from January 2004 to December 2011, namely 8 years, a total of 96 samples, and we also use the data from January 2004 to December 2011 to do comparative analysis.

5. Data Processing

To ARMA model, Holter-Winter season product model, and time series decomposition method, we use EViews 6.0 [15] for data processing. To PLS combined model, this study use SPSS16.0 and SIM CA-P12.0 for data processing.

5.1. The Forecasting Results of Single Prediction Models

Considering that the forecasting steps of a single prediction model is a lot, in view of the reasons of space, in this paper, we give the finally prediction effect fitting figure or other core steps of the three single prediction models.

5.1.1. The Forecasting Results of ARMA Model

By calculating, the software outputs the fitting effect figure of the actual values and the predicted values (**Figure 2**), as can be seen from the **Figure 2**, using ARMA model to predict, the projected trends and the actual development trends is very consistent, we can make an intuitive judgment that the forecasting results is satisfactory. After further calculations, the annual forecasting absolute error range of ARMA model is between –60,419 to –26296.7, the mean relative error is –2.37%, range between –3.16% to –1.45%.

5.1.2. The Forecasting Results of Holter-Winter Season Product Model

By calculating, the annual forecasting absolute error range of Holter-Winter season product model is between –13223.389 to 827.463, the mean relative error is –0.27%, range between –0.75% to –0.05%, from the **Figure 3** we can also make an intuitive judgment that the forecasting results is satisfactory, namely the prediction

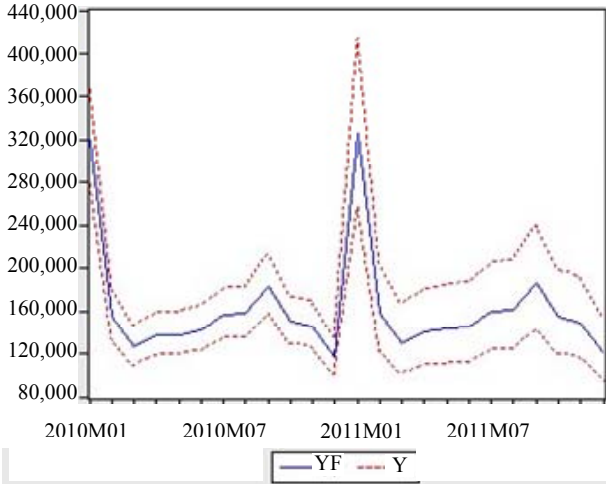

Figure 2. The fitting effect figure of the actual values and the predicted values.

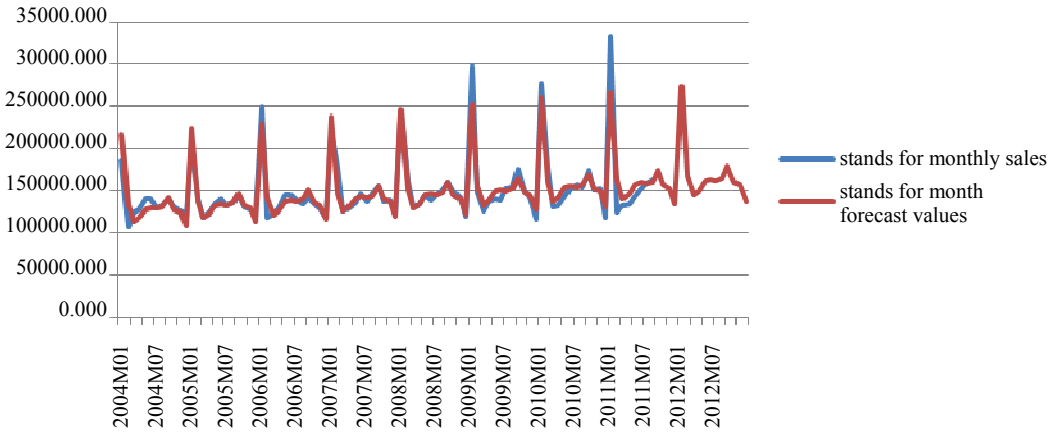

Figure 3. The fitting effect figure of Holter-Winter season product model.

accuracy of Holter-Winter seasonal product model is good.

5.1.3. The Forecasting Results of Time Series Decomposition Model

By calculating, the annual forecasting absolute error range of time series decomposition model is between –14479.355 to 3763.287, the mean relative error is –0.393%, range between –0.853% to 0.202%, from the **Figure 4** we can see that the forecasting results is satisfactory, namely the prediction accuracy of Holter-Winter seasonal product model is good.

5.2. Comparing between the Prediction Results of the Three Single Prediction Models

We use A Province Tobacco Company's sales data during 2004-01 to 2011-12 as the researching object of this study, first we established three single forecasting models to predict the province's cigarette sales of the next year, to compare the prediction accuracy of the three single prediction models, we use forecast absolute error sum of squares as the index to measure the prediction accuracy of the model, prediction error sum of squares is an good indicator to reflect the prediction accuracy, the comparison results of prediction accuracy of the three single forecasting models are shown in **Table 1**. From the comparison results we can see that among the single forecasting models, Holter-Winter model's prediction accuracy is close to the model of time series decomposition, but ARMA model's accuracy is relatively poor.

5.3. Combination Forecasting Model Based on PLS

As we use all the three single prediction models to predict A province's cigarette sales, so there must have a high degree of correlation between the three models' prediction results and the actual sales, in this paper Y_1 stands for the prediction results of Holter-Winter season

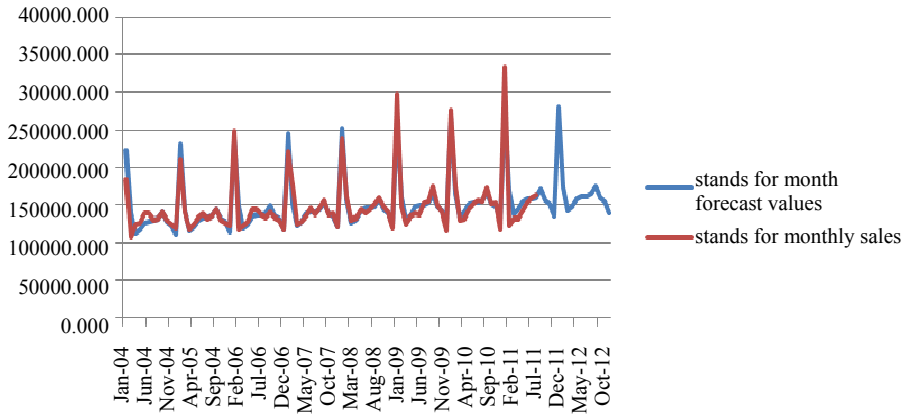

Figure 4. The fitting effect figure of time series decomposition model.

Table 1. The comparison results of prediction accuracy of the three single forecasting models[1].

		2007	2008	2009	2010	2011	E
	Y	1,763,770	1,803,680	1,866,767	1,911,036	1,929,118	
	$\hat{Y}$	1,750,546	1,803,511	1,856,475	1,909,440	1,962,404	
H-W	e	–13,223	–169	–10,292	–1596	33,286	
	e2	174,858,014	28,656	105,922,176	2,546,436	1,107,957,796	1,391,997,774
	$\hat{Y}$	1,761,824	1,812,414	1,863,004	1,913,594	1,964,184	
Time Series	e	–1946	8734	–3763	2558	35,066	
	e2	3,786,674	76,277,981	14,162,321	6,545,233	1,229,624,356	1,540,048,353
	$\hat{Y}$	1,730,314	1,777,383	1,807,824	1,850,616	1,886,675	
ARMA	e	–33455.4	–26296.7	–58943.1	–60,419	–42442.7	
	e2	1,119,262,183	691,515,010	3,474,284,204	3,650,460,757	1,801,383,293	10,736,905,448

*Y stands for the actual sales for the year; $\hat{Y}$ stands for the prediction results; e = $\hat{Y}$ – Y, stands for absolute error; $E=\sum_{t=1}^{5} e_t^2$ stands for the sum of absolute error square.

[1]In view of the reasons of space, this paper just chose the nearly five years' data to compare.

product model, Y_2 stands for the prediction results of time series decomposition method, Y_3 stands for the prediction results of ARMA model, Y stands for the actual sales, we use SPSS16.0 to analysis the correlation between actual values and predicted values, results are shown in the **Table 2**, we can see that there is a high de gree of correlation between the prediction results of three single prediction models and the actual sales, and there is also a high degree of linear correlation between the predicted values, further proof that use PLS for combination forecasting is necessary.

After a preliminary analysis, this article takes the prediction results of the three single forecasting models as the independent variable, takes the actual sales as the dependent variable, then building the partial least squares regression model, when we extract one component, we have extracted 99.9% information of the independent variable and 97.5% information of the dependent variable, at this time the error sum of squares is minimum, then we establish the combination forecast model, prediction results are shown in the **Figure 5**.

We can see from the above figure that the data points which is constituted by predicted values and the original observation values are distributed near the diagonal of the regression graph, further calculation shows that the regression coefficient of original observations and predicted values is 0.9898, this indicates that the difference between predicted values and original values is small, the fitting results is good, further demonstrating that the effect of using this model to analyze A province's cigarette consumption demand is very good, it can greatly improve the prediction accuracy of the cigarette sales in the coming year.

After further calculation, we can get the absolute error and absolute error sum of squares of this combined model, in **Table 3** we can see that the absolute error sum of squares of the combination forecasting model based on PLS is 498,982,516, this value is just the 35.8%, 32.4% and 4.65% of Holter-Winter season product model, time series decomposition model and ARMA model. It is thus clear that, comparing with the single prediction model, the prediction accuracy of the combination forecasting model based on PLS is improved obviously, especially to the ARMA model, PLS combination forecasting model greatly improve its prediction accuracy.

At last, we use PLS combination forecasting model to predict the cigarette sales of A province in 2012, results are shown in the **Table 4**.

Table 2. Results of correlation analysis.

	Y	Y_1	Y_2	Y_3
Y	1			
Y_1	0.986**	1		
Y_2	0.986**	1.000**	1	
Y_3	0.983**	0.998**	0.998**	1

[1]**In confidence (double measure) of 0.01, the correlation is significant; [1]*In confidence (double measure) of 0.05, the correlation is significant.

Table 4. The forecasting results of cigarette sales of A province in 2012[2].

Year	Y_1	Y_2	Y_3	Y_4
2012	2015369.083	2014774.317	1,928,537	1,984,000

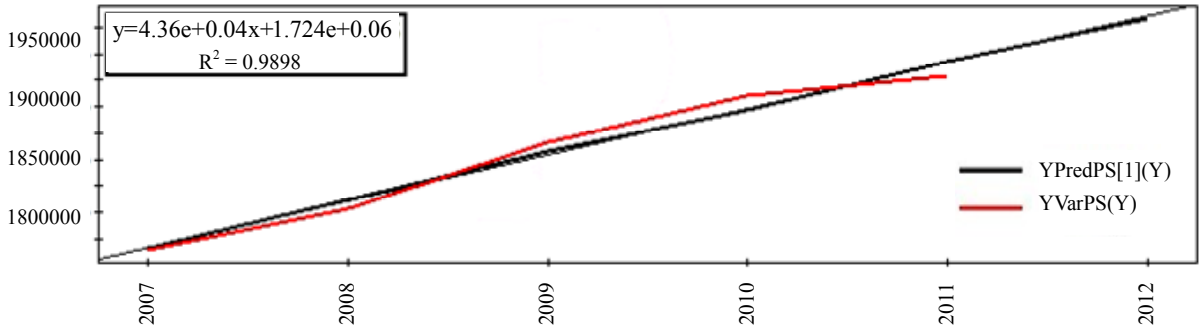

Figure 5. The prediction results of PLS.

Table 3. PLS prediction results analysis.

		2007	2008	2009	2010	2011	E
PLS	Y	1,763,770	1,803,680	1,866,767	1,911,036	1,929,118	
	$\hat{Y}$	1,765,770	1,811,570	1,857,510	1,897,550	1,941,970	
	e	2000.505	7890.018	–9257.15	–13485.6	12851.87	
	e2	4,002,020	62,252,384	85,694,771	181,862,702	165,170,640	498,982,516

[2]Y_4 stands for the prediction results of PLS.

6. Conclusions

In this study, we overview the combination forecasting methods and models, on the basis of summing up the achievements of previous studies, this paper presents a new combination forecasting method based on PLS, and we use it to predict the cigarette sales of A province in 2012. The results here show that, the fitting index between prediction results and actual sales of each single prediction model is good. Comparing with the single prediction model, the prediction accuracy of the combination forecasting model based on PLS is improved obviously, shows that this method can effectively integrated the information of single forecasting methods, it is effective and feasible.

In addition, a major innovation of this article is the way to build the combination forecasting model, it is different from the traditional method of calculating the weighted average coefficient, in this paper, we use the PLS method to establish the regression model, starting to build a new combined model base on the prediction results of the single prediction model, not just a simple calculation of the weighting coefficient, but to give a full consideration to the individual prediction model and try to optimize it, it can be said it is a new way of building the combination forecasting model.

Through this study, we can see that the prediction accuracy of either single or combination model has reached a high level, despite this, it should be noted that the expected cigarette sales given in this study is only a reference value, when in the formulate of the actual sales task, we can not be completely according to it, we should combine with the history sales and the expected developments of A province to development an appropriate and reasonable sales task or scheduler.

REFERENCES

[1] P. Yin, Z.-J. Wang and D.-Y. Xiao, "Prediction of Companies' Failure Risk Based on Various Precision Rough Neural Networks," *Journal of Management Science*, Vol. 23, No. 4, 2010, pp. 15-26.

[2] D. Waters, "Inventory Control and Management," 2nd Edition, John Wiley & Sons, New York, 2005.

[3] W. H. Greene, "Ecomometric Analysis," Prentice-Hall International Inc., New York, 1997.

[4] W. Wimam and S. Wei, "Time Series Analysis Univariate and Multivariate Methods," Addison-Wesley Pub., California, 1990.

[5] W. R. Bell and S. C. Hillmer, "Issues Involved With the Seasonal Adjustment of Economic Time Series," *Journal of Business and Economic Statistics*, Vol. 21, No. 1, 1984, pp. 291-320.

[6] M. L. Peter, S. A. John, H. D. William, *et al.*, "Is Cigarette Smoking in Poorer Nations Highly Sensitive to Price," *Journal of Health Economics*, Vol. 23, No. 1, 2004, pp. 173-189. doi:10.1016/j.jhealeco.2003.09.004

[7] J. E. Hanke and D. W. Wichern, "Business Forecasting," Tsinghua University Press, Beijing, 2006.

[8] Z. Xiao and W. Wu, "The Application of Combining Forecasting Based on PSO-PLS to GDP," *Journal of Management Science*, Vol. 21, No. 3, 2008, pp. 115-122.

[9] J. M. Bates and C. W. J. Granger, "Combination of Forecasts," *Operations Research Quarterly*, Vol. 20, No. 4, 1969, pp. 45l-468.

[10] H.-Y. Chen, "Combination Forecast Method Validity Theory and Its Application," Beijing Science Press, Beijing, 2008.

[11] H.-W. Wang, Z.-B. Wu and J. Meng, "The Linear and Nonlinear Method of Partial Least-Square Regression," National Defence Industry Press, Beijing, 2006.

[12] C. Fornell and J. Cha, "Partial Least Squares, Advanced Methods of Marketing Research," Blackwell, Cambridge, 1989.

[13] S.-Q. Wei, Y. He and W. Jiang, "The Combination Prediction of GDP Based on ARMA-ARCH," *Journal of Statistics and Decision*, Vol. 14, No. 7, 2007, pp. 92-93.

[14] K. Gilbert, "An ARIMA Supply Chain Model," *Management Science*, Vol. 51, No. 2, 2005, pp. 305-310. doi:10.1287/mnsc.1040.0308

[15] D.-H. Yi, "Data Analysis and EViews Application," China Renmin University Press, Beijing, 2008.

[16] G. Galman and S. M. Disney, "State Space Investigation of Bullwhip with ARMA (1,1) Demand Processes," *International Journal of Production Economics*, Vol. 35, 2006, pp. 322-345.

[17] Y.-H. Ou, "The Prediction of Real Estate Price Index Based on ARMA Model," *Journal of Statistics and Decision*, Vol. 14, No. 7, 2007, pp. 92-93.

[18] Y. Feng and J.-H. Ma, "Demand Forecasting in Supply Chains Based on ARMA (1,1) Demand Process," *Industrial Engineering Journal*, Vol. 11, No. 5, 2008, pp. 50-55.

[19] Y.-H. Xun, "The Application of ARMA Model in Estimates the Impact of Major Emergencies," *Journal of Statistics and Decision*, Vol. 14, No. 7, 2006, pp. 24-26.

[20] S.-J. Li, "Applying ARMA Models to Forecast the Price Index of Ships," *Ship Engineering*, Vol. 29, No. 6, 2007, pp. 71-74.

[21] R. S. Pindyck and L. Daniel, "Rubinfeld Econometric Model and Economic Forecasts," 4th Edition, McGraw-Hill Companies, New York, 1998.

[22] Y. Wan, "Applied Time Series Analysis," China Renmin University Press, Beijing, 2005.

[23] S. Wold, C. Albano and M. Dun, "Pattern Regression Finding and Using Regularities in Multivariate Data," Analysis Applied Science Publication, London, 1983.

[24] S. Wold, C. Albano and M. Dun, "Modelling Data Tables by Principal Component and PLS: Class Patterns and Quantitative Predictive Relations," *Analysis*, Vol. 12, 1984, pp. 477-485.

[25] A. Höskuldsson, "A PLS Regression Methods," *Journal of Chemoetrics*, Vol. 2, 1988, pp. 211-228. doi:10.1002/cem.1180020306

