Market Forecasting of Super Strength Fiber: Glass Fiber

Sibei Xia
Department of Textiles and Apparel,
Technology and Management
College of Textiles
North Carolina State University
Raleigh, NC 27695-8301

ABSTRACT

The goal of this paper is to forecast the glass fiber market with exponential smoothing model. Five exponential smoothing models are introduced and Holt linear model was selected due to data characteristic and tool limitation. Producer price index: glass fiber, textile-type and all other reinforced and Producer price index: fiberglass plastics products were applied in the forecast model. Parameter optimization was based on minimizing the root mean square error. Values for July 2012 through June 2017 were forecasted.

Keywords: Forecast, Holt, exponential smoothing, glass fiber, producer price index

Introduction

Glass fiber is extruded from thin strands of silica-based or other formulation glass (Wikipedia, 2015). It is one of the oldest fiber used for reinforcement. It is also the most common reinforcement used in non-aerospace applications (Gardner Business Media, 2015). Different glass fiber type has different properties.

Exponential Smoothing Forecast Models

Exponential smoothing methods assume that the recent observations have higher weight in predicting the future value and the weights decays exponentially as the operations get older (Hyndman & Athanasopoulos, 2014). Depending on trend and seasonality of the data, simple exponential smoothing method, Holt's liner trend smoothing method, exponential trend soothing method, damped trend smoothing method, and Holt-Winter seasonal smoothing method can be used for forecasting.

Simple exponential smoothing

This method is suitable for forecasting data with no trend or seasonal pattern (Hyndman & Athanasopoulos, 2014). Equation (1.1) is the forecast equation and equation (1.2) is the trend smoothing equation. $\hat{y}_t$ denotes the forecasted value for time t, y_t denotes the observed value for time t, l_t denotes the smoothed level value for time t, t denotes the time series for observed value and h denotes the time series for forecasted value. α is the smoothing parameter for the level.

Holt's linear trend method

This method allows forecasting of data with a trend. Two smoothing equation is involved, one for the level and the other for the trend (Hyndman & Athanasopoulos, 2014). Equation (1.4) is the forecast equation, equation (1.5) is the level smoothing equation, and equation (1.6) is the trend smoothing equation. b_t denotes the estimate of the trend (slope) at time t. β^* is the smoothing parameter for the trend.

Exponential trend method

Exponential trend method derived from the Holt's liner trend method. It allows the level and the slope to be multiplied rather than added (Hyndman & Athanasopoulos, 2014). Equation (1.7) is the forecast equation, equation (1.8) is the level smoothing equation, and equation (1.9) is the trend smoothing equation.

Damped trend methods

While the Holt's linear method assume the growth rate to be constant in the future, Gardner Jr & McKenzie (1985) introduced a parameter that can dampen the trend to a flat line in the future at some time. Equation (1.10) is the forecast equation, equation (1.11) is the level smoothing equation, and equation (1.12) is the trend smoothing equation. ϕ dampens the trend. If $\phi = 1$, the method is the same as the Holt's linear method.

Holt-Winters seasonal method

Holt and his student Winters (1960) extended the Holt linear method to capture seasonality, which was named Holt-Winter seasonal method. s_t was added to represent the seasonality. (Hyndman & Athanasopoulos, 2014). Equation (1.13) is the forecast equation, equation (1.14) is the level smoothing equation, equation (1.15) is the trend smoothing equation and (1.16) is the seasonal component equation.

Simple exponential smoothing

$$\hat{y}_{t+1|t} = l_t \tag{0.1}$$

$$l_t = \alpha y_t + (1 - \alpha)l_{t-1} \tag{0.2}$$

$$\hat{y}_{T+h|T} = \hat{y}_{T+1|T} = l_T \tag{0.3}$$

Holt's linear trend method

$$\hat{y}_{t+h|t} = l_t + hb_t \tag{0.4}$$

$$l_t = \alpha y_t + (1 - \alpha)(l_{t-1} + b_{t-1}) \tag{0.5}$$

$$b_t = \beta^*(l_t - l_{t-1}) + (1 - \beta^*)b_{t-1} \tag{0.6}$$

Exponential trend method

$$\hat{y}_{t+h|t} = l_t hb_t^h \tag{0.7}$$

$$l_t = \alpha y_t + (1 - \alpha)l_{t-1}b_{t-1} \tag{0.8}$$

$$b_t = \beta^* \frac{l_t}{l_{t-1}} + (1 - \beta^*)b_{t-1} \tag{0.9}$$

Damped trend method

$$\hat{y}_{t+h|t} = l_t + (\phi + \phi^2 + \cdots + \phi^h)b_t \tag{0.10}$$

$$l_t = \alpha y_t + (1 - \alpha)(l_{t-1} + \phi b_{t-1}) \tag{0.11}$$

$$b_t = \beta^*(l_t - l_{t-1}) + (1 - \beta^*)\phi b_{t-1} \tag{0.12}$$

Holt-Winters seasonal method

$$\hat{y}_{t+h|t} = l_t + hb_t + s_{t-m+h_m^+} \tag{0.13}$$

$$l_t = \alpha(y_t - s_{t-m}) + (1 - \alpha)(l_{t-1} - b_{t-1}) \tag{0.14}$$

$$b_t = \beta^*(l_t - l_{t-1}) + (1 - \beta^*)b_{t-1} \tag{0.15}$$

$$s_t = \gamma(y_t - l_{t-1} - b_{t-1}) + (1 - \gamma)s_{t-m} \tag{0.16}$$

Data

Glass fiber producer price index and glass fiber products producer price index are used to study the profit margin of glass fiber product. Two data sets from U.S. Bureau of Labor Statistics are included. First is the Producer Price Index (PPI) on Glass fiber, textile, which covers monthly observations from July 1983 through June 2012. The other is the PPI for All other reinforced and fiberglass plastics products, which covers monthly observations from December 1999 through June 2012. Observation of PPI for all other reinforced and fiberglass plastics products from July 2012 through March 2015 is available for comparison.

Methodology

Due to the limitation of available computing program, only simple exponential smoothing method, Holt's linear trend method and Holt-Winters seasonal method can be implemented. By observation the data, no seasonality was found, but a clear growing trend was found. Therefore, the Holt linear trend model was selected to analyze the three sets data. Initialization was optimized to minimize the root mean square error (RMSE). Values from July 2012 through June 2017 were forecasted. The forecasted result for the PPI for all other reinforced and fiberglass plastics products were then compared with the observed data from July 2012 through March 2015.

Results and Discussion

Figure 1 shows the result for PPI: Glass fiber, textile-type data and Figure 2 shows the result for all other reinforced and fiberglass plastics products. A decreasing trend can be found for glass fiber PPI, while an increasing trend can be found in glass fiber products PPI. This implies an increasing profit margin for glass fiber products. By comparing the predict value from July 2012 through March 2015 for PPI: all other reinforced and fiberglass plastics products, there was big difference between the observed value and the predict value, which implies that Holt's smoothing model is more suitable for short period predicting.
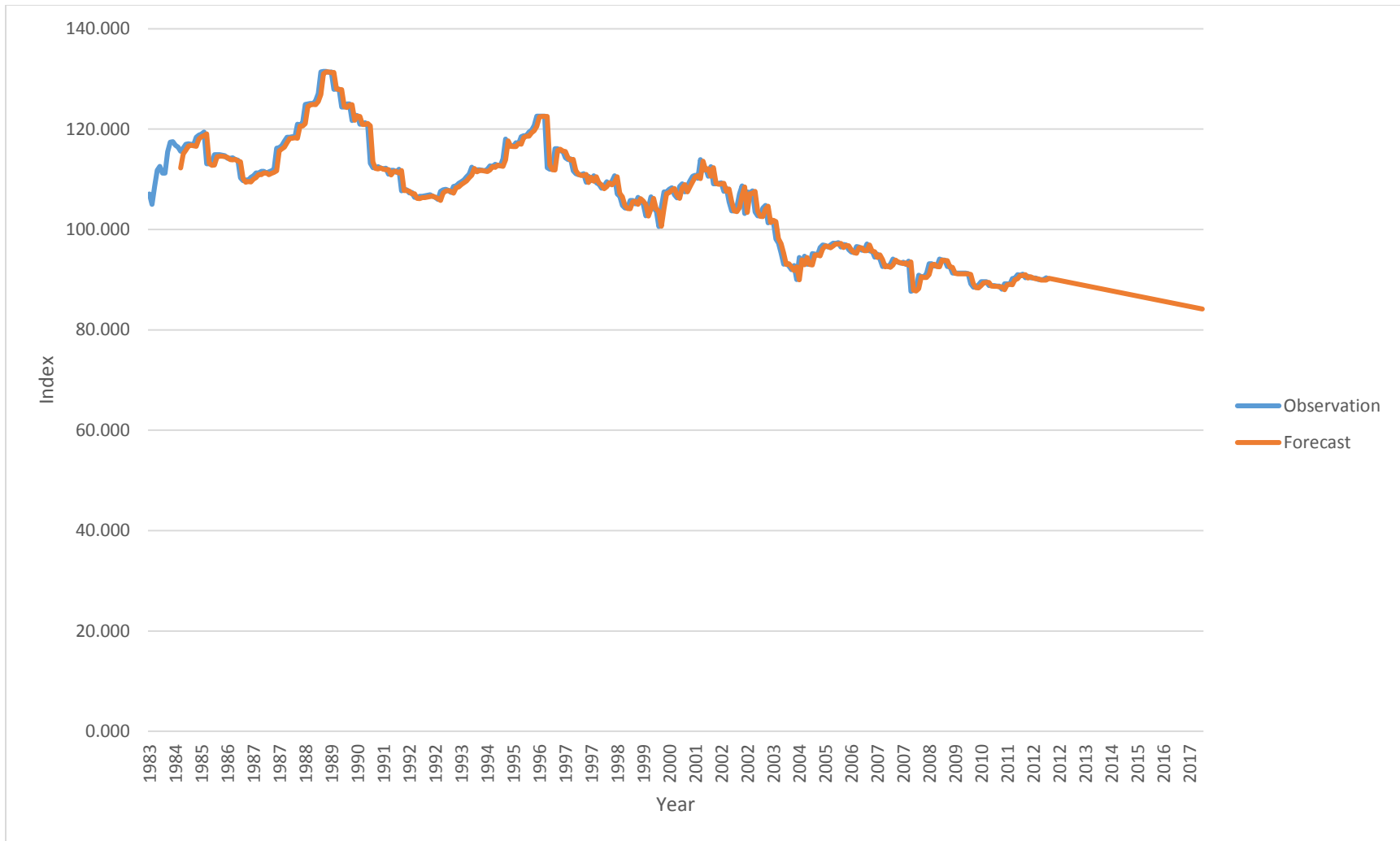
Figure 1: Forecast for PPI: Glass fiber, textile-type with Holt's exponential smoothing method
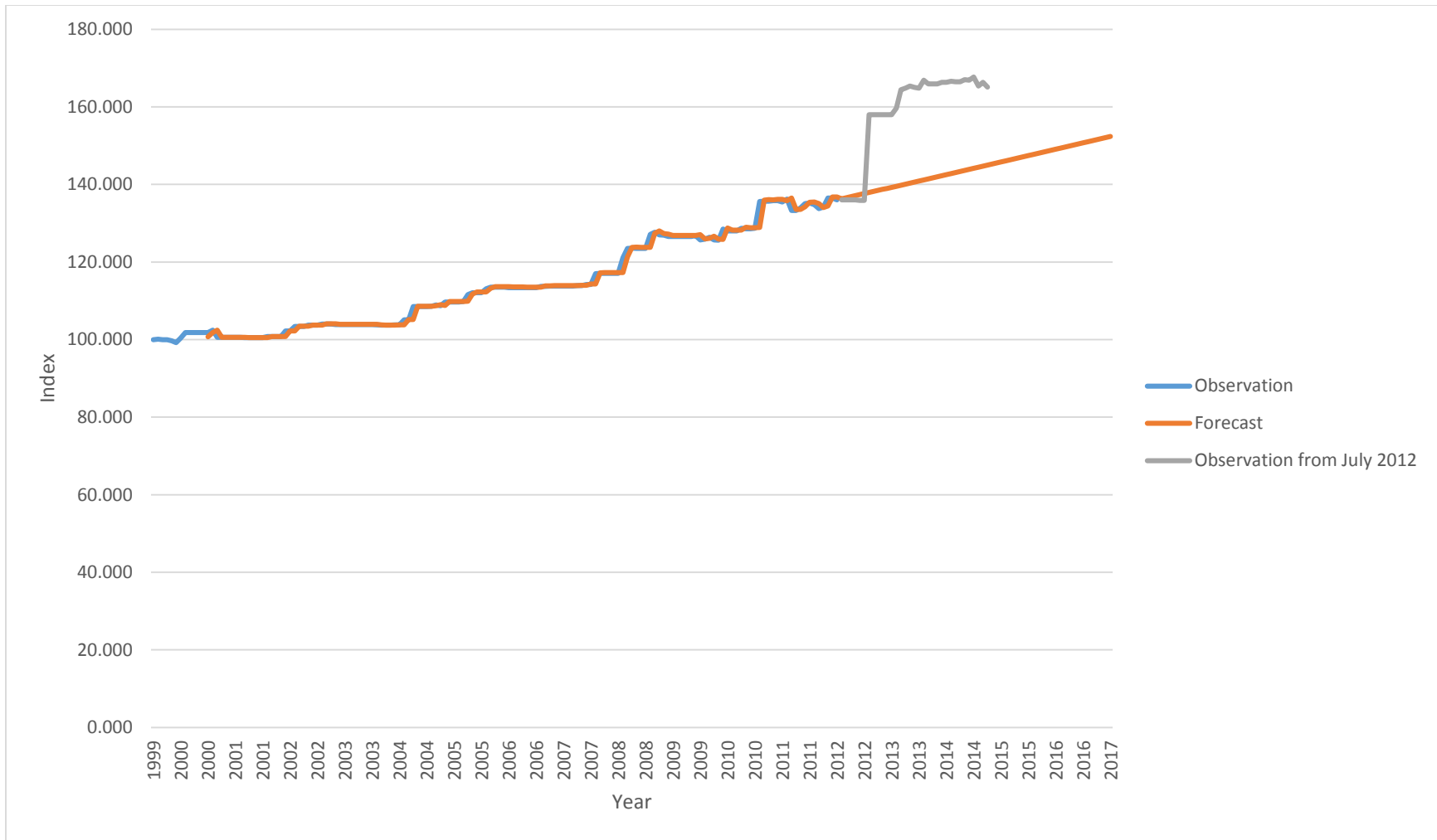RMSE = 1.5612; α = 0.935; β* = 0.008

Figure 2: Forecast for PPI: All other reinforced and fiberglass plastics products with Holt's exponential smoothing method
RMSE = 1.0104; $\alpha = 1$; $\beta^* = 0.01$

Future study

Because of tool limitation, Exponential Smoothing Forecast Models or Damped trend methods was not able to be tested. It would be interesting to forecast with these models and compare their results. It will also be interesting to calculate the confidential interval.

Conclusion

Holt's exponential smoothing method with linear trend was used to predict producer price index for glass fiber and products. Value between July 2012 and June 2017 were forecasted based on historical data. A growing profit margin was found for glass fiber product. By comparing the predicted value with the observed value, we found that the Holt's method is not suitable for long period predicting. Future study can focuses on using other exponential smoothing method and taking into consideration of confidential intervals.

Reference

Gardner Business Media. (2015). Glass Fiber : CompositesWorld. Retrieved May 3, 2015, from http://www.compositesworld.com/zones/glass-fiber

Gardner Jr, E. S., & McKenzie, E. D. (1985). Forecasting trends in time series. *Management Science*, *31*(10), 1237–1246.

Hyndman, R. J., & Athanasopoulos, G. (2014). *Forecasting: principles and practice*.

Wikipedia. (2015, March 16). Glass fiber. In *Wikipedia, the free encyclopedia*. Retrieved from http://en.wikipedia.org/w/index.php?title=Glass_fiber&oldid=651573368

Winters, P. R. (1960). Forecasting sales by exponentially weighted moving averages. *Management Science*, *6*(3), 324–342.