SALES FORECASTING OF BOW SAW BLADE USING ARTIFICIAL NEURAL NETWORKS IN INDUSTRIAL BLADE FACTORY IN THAILAND

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Introduction

Forecasting is very important in many types of organizations since predictions of future events must be incorporated into decision-making process. Business firms, in particular, require forecast in many events and conditions in all phases of their operations. For example, total demand for products, demand in each product line, the numbers of workers required in different jobs must be forecasted in order to plan total management effort (Bowerman et al, 2005).

There are many ways to forecast the future. Many firms (especially smaller ones), the entire process is subjective, intuition, and years of experience. There are also many quantitative forecasting models, such as moving average (MA), exponential smoothing (ES), seasonality analysis and regression analysis (Render et al (2003). Furthermore, some advanced forecasting techniques are developed and used in academic institutions and many organizations. For example, there are artificial neural network (ANN), autoregressive integrated moving average (ARIMA) (Samarasinghe, 2007) etc. A blade manufacturing factory, which is located in northern region of Thailand, is selected. The factory is established more than 30 years. Seventy workers are employed. Industrial blades and saws are their main products. Production planning policy of each product is different. Industrial blade production is used a make-to-order policy. On the other hand, saw blade production is used a make-to-stock policy. They sell their products in Thailand and neighbor countries such as Myanmar, Laos People's Democratic Republic, and Cambodia. Total sales volumes of the factory is more than 100 million baht per year.

Management of this factory has never been used any kinds of quantitative forecasting technique in order to forecast their sales volumes. They are interested to use forecasting techniques in sales forecasting. Saw blade is focused because management would like to determine production amounts more precisely. Question may arise which forecasting techniques should be selected for the factory. This study is deployed and compared three classical forecasting techniques with artificial neural network (ANN).

Research Methodology

Moving Average

Moving average is a simple and useful forecasting technique if we can assume the item we are trying to forecast will stay fairy steady over time. The moving average for the preceding *k* periods (where *k* can be any integer >= 2) serves as the forecast for the following period. Mathematically, the k-period moving average can be expressed as

$$\text{k-period moving average} = \sum(\text{Actual value in previous k periods})/k \quad (1)$$

Exponential Smoothing

Let F_t denote the forecast in period t and A_t denote the actual value in period t. The basic exponential smoothing formula is also follows:

Forecast for period (t+1) = forecast for period t + α (actual value in period t – forecast for period t)

$$F_{t+1} = F_t + \alpha(A_t - F_t) \quad (2)$$

Where α is a weight (called a smoothing constant) that has a value between 0 and 1.

Holt-Winter's Additive Exponential Smoothing

Let Y_{t+n} denote the forecast in period t+n. E_t denote the level of expected value in t period. *St* denote the seasonality factor in t period. *p* denote a number of time periods of a season.

$$Y_{t+n} = E_t + nT_t + S_{t+n-p} \quad (3)$$

$$E_t = \alpha(Y_t - S_{t-p}) + (1 - \alpha)(E_{t-1} + T_{t-1}) \quad (4)$$

$$T_t = \beta(E_t - E_{t-1}) + (1- \beta)T_{t-1} \quad (5)$$

$$S_t = \gamma (Y_t - E_t) + (1- \gamma)S_{t-p} \quad (6)$$

Where $0 \leq \alpha \leq 1$, $0 \leq \beta \leq 1$, and $0 \leq \gamma \leq 1$

Artificial Neural Network

The artificial neural networks (ANN), has shown great potential to be an effective tool to handle complex non-linear problems. The ANN method is a biologically inspired computational technique that imitates the behavior and learning process of human brain. It can update itself through learning from training samples. The ANN is widely used in many areas such as pharmaceutical research (Agatonovic-Kustrin and Beresford, 2000), combustion research (Xing et al, (2018). Figure 1 shows the schematic diagram of the topological structure of the ANN model.

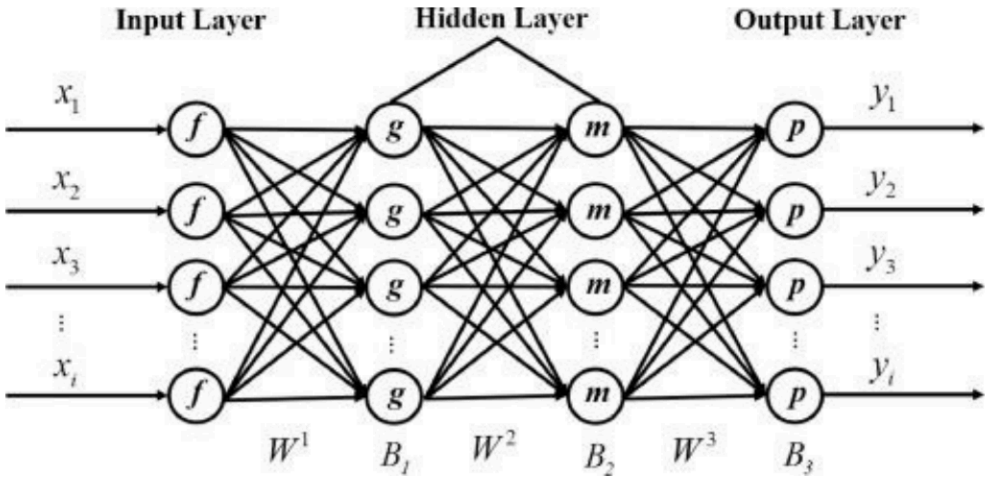

Figure 1 Topological structure of the ANN model

The ANN is composed of three kinds of layer, including input layer, hidden layer and output layer. The input data always flow from the input layer, and then are transferred to the output layer to obtain predictions with the help of activation functions, weight and bias vectors between neurons in the hidden layer. The final output for the ANN with two hidden layers can be expressed as:

$$y = p\{m[g(f(x)W1+B1)W2+B2]W3+B3\} \quad (7)$$

where x and y are the scaled input variables and output target vector respectively. W^i and B_i are the ith weight and biases vector for the ith neuron layer, respectively.

Measuring Forecast Error

Mean squared error (MSE) is computed as the average of the squared values of the individual forecast errors. If we have forecasted and actual values for T periods, the MSE is calculated as

$$MSE = \sum (A_t - F_t)^2 / T \quad (9)$$

There are four sizes of bow saw blade in the factory. There are 12-inch, 21 –inch, 24-inch and 30-inch. Sales data is collected for five years. 24–inch bow saw blade is selected because sales volume of this size is the highest volume. Figure 2 shows sales volumes of each size in five years.

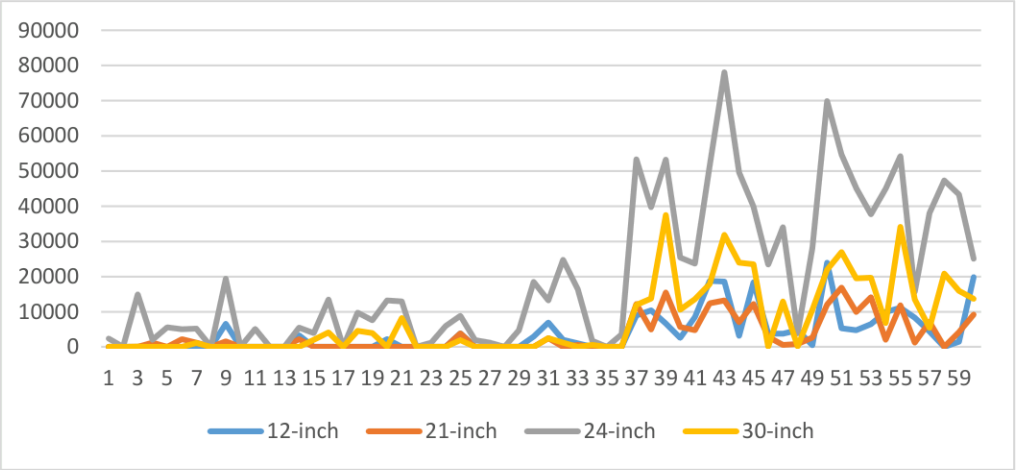

Figure 2 sales volumes of each size of bow saw blade in five years (pieces/month)

Research Results

The following forecasting models are used in this study. There are Moving Average, Exponential Smoothing, Holt-Winter's Additive Exponential Smoothing and Artificial Neural Network, respectively. Figure 3, 4, 5 and 6 show forecasting results of each forecasting model. Furthermore, table 1 also shows the MSE of each forecasting model.

The first three conventional methods are forecasted by using Microsoft Excel. The ANN model is a back-propagation network model using the R statistical program.

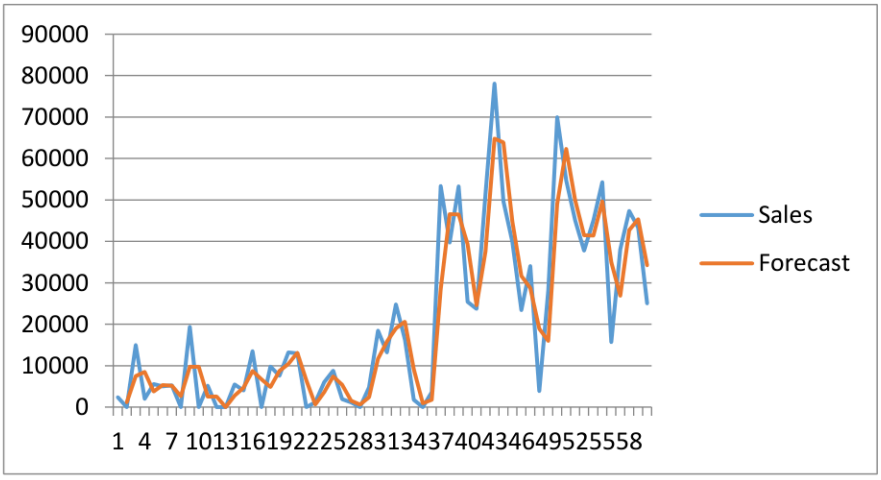

Figure 3 Moving Average forecasting model (2 months)

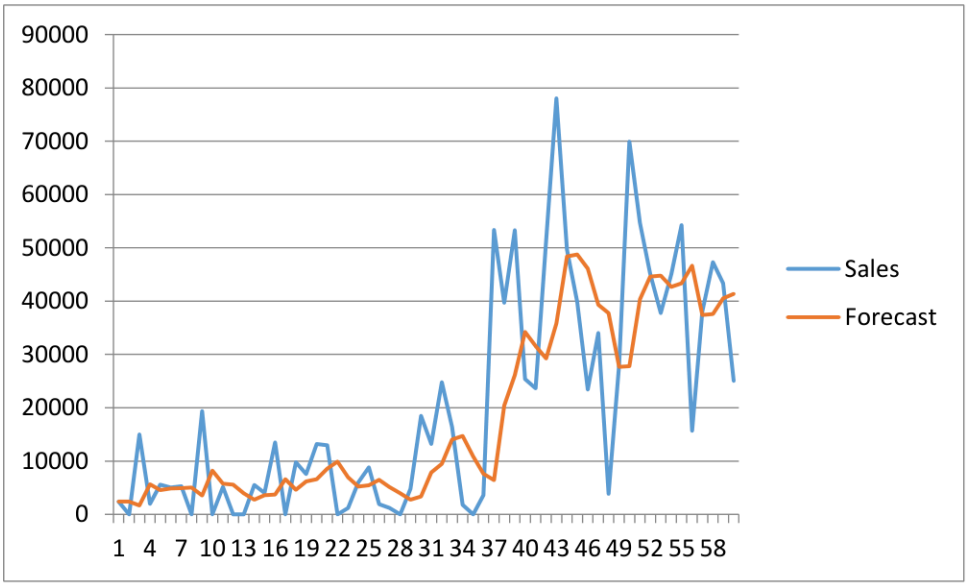

Figure 4 Exponential Smoothing forecasting model (α = 0.2976)

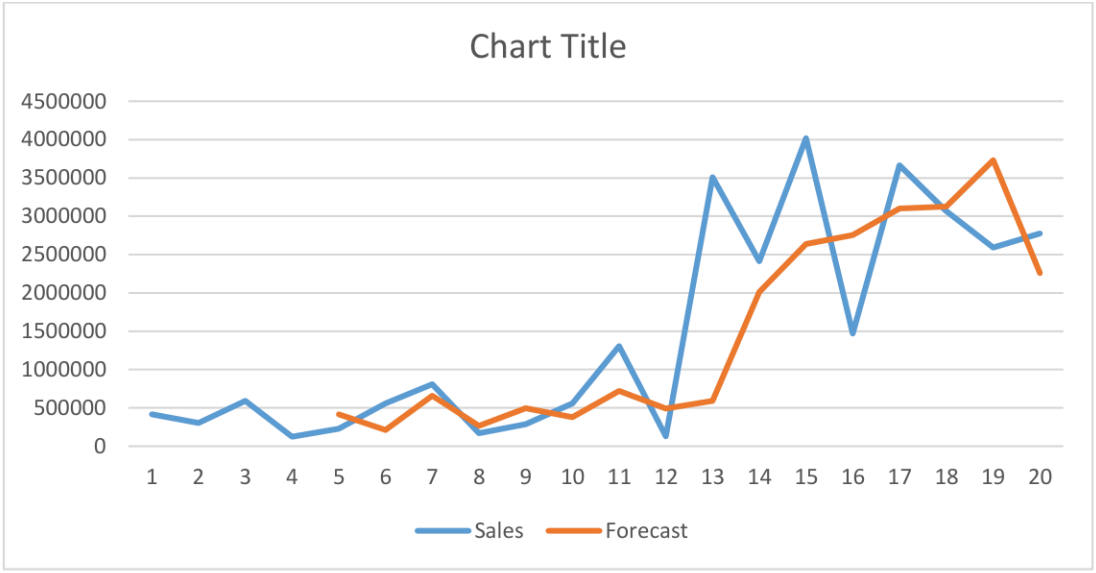

Figure 5 Holt-Winter's Additive Exponential Smoothing forecasting model (α = 0.4348, β = 0.0792, γ = 0.2847)

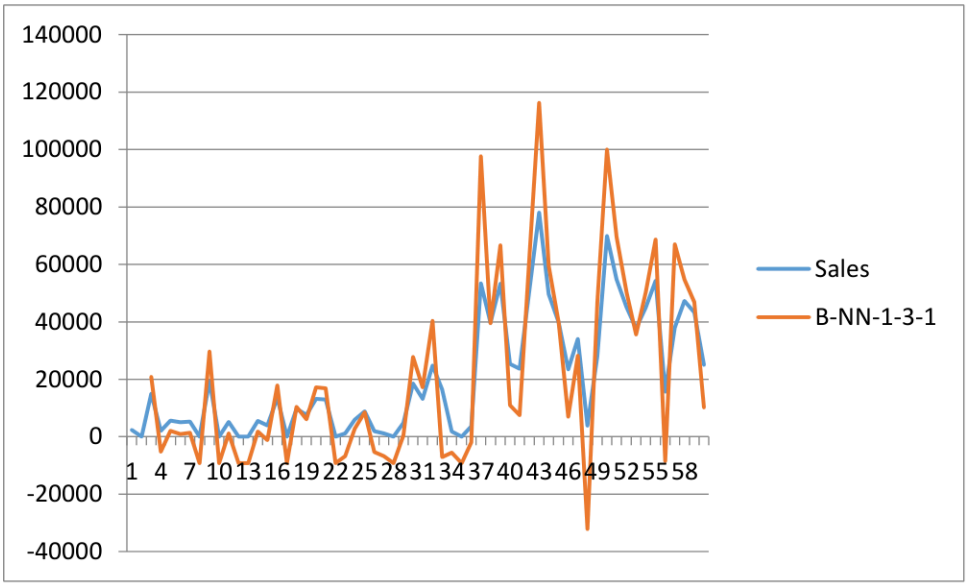

Figure 6 Artificial Neural Network forecasting model

Table 1 The MSE of each forecasting model of bow saw blade

Forecasting model	MSE
1. Moving Average	6.44×10^{7}
2. Exponential Smoothing	2.17×10^{8}
3. Holt-Winter's Additive Exponential Smoothing	9.29×10^{11}
4. Artificial Neural Network	1.99×10^{8}

Table 1 is shown that the MSE of Moving average forecasting model is the lowest value. On the other hand, the MSE of Holt-Winter's Additive Exponential Smoothing forecasting model is the highest value. Therefore, Moving average forecasting model should be chosen to forecast sales volume of bow saw blade.

Conclusion and Discussion

This study is focused to choose a forecasting model which appropriate with the sales volume of bow saw blade. Four forecasting models are studied. Conventional models require basic knowledge. On the other hand, advance models require advance knowledge. According to the results, a conventional model should be chosen.

The ANN model in this study may not fit to the data. Actually, there are many ANN forecasting models. Of course, they are complicated ones. Neural network may not work with some problems. In other words, some problems maybe well suited for the pattern recognition capabilities of a neural network model. Other problems may be best solved with other conventional methods (Tam, 2007).

Management (especially smaller firms) may select a forecasting model by using many criteria e.g. forecast error value, how easy to use, a ready-to-use computer program.

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