The Forecasting of Durian Production Quantity for Consumption in Domestic and International Markets

Pokterng S.

Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Kengpol A.

Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Abstract

Thailand is one of the world's first exporting countries of fresh and processed durians. Each year in the durian season, there are excess supplies of fresh durians which directly cause a decrease in durian price. The farmers sell their durians at a price which is actually lower than the production cost. This problem recurs every year. The purpose of this research is to design and develop the models which can effectively forecast the quantity of fresh durian production. Firstly, applying the four Time Series models, secondly, applying the Back-propagation Neural Networks (BPN) model to find an accurate forecasting model that can effectively forecast the quantity of durians in Thailand in advance. The findings of the research are the model of Back-propagation Neural Networks of the structure 4-8-1 equal to the least value of Mean Absolute Percentage Error (MAPE). It is in the good level of forecasting, and can be applied to forecast the fresh durian quantity effectively. After attaining the accurate forecasting model, this is applied with the Linear Programming (LP) model to assess the value of appropriate fresh durian in each region in the following year. The data of fresh and processed durians planning can be helpful to the farmer, as they can then make the maximum profit from selling their durians.

Keywords*: Durian, Forecasting, Time Series model, Back-propagation Neural Networks (BPN) model and Linear Programming (LP) model*

1 Introduction

Because of the durian production in 2008, Thailand is one of world's biggest exporters of fresh durians and processed durian products. The durian cultivated areas occupy more than 290,000 acres of Thailand providing durian quantity on 266,975 acres and fresh durian quantity totalled approximately 637,790 tons. Thailand exports all kinds of durians including fresh durians, frozen durians and processed durian products such as durian paste and durian chips. The export value in 2009 was 122.46 million USD according to The Office of Agricultural Economics [1]. However, when the quantity and the export price reports from 2009 and 2008 are compared, the results indicate that the export quantity significantly increased but the export value increased only slightly on the previous year. Durian sale price tends to decrease continually while the production cost continues to increase. In 2009, the average price of durians sold by gardeners was 0.47 USD per kilogram but in 2008, it was 0.54 USD per kilogram so, the price decreased by 12.96%.

According to The Office of Agricultural Economics [1] durian cultivated areas in Thailand are in 26 provinces (see Table 1 and Figure 1). The important areas are in the central part and the south of Thailand. The provinces in the central part such as Chanthaburi, Rayong and Trat provided 50% of total durian production quantity in Thailand. The harvest period is from March to July and the most abundant yield period is from April to May. The provinces in the south such as Chumphon, Surat Thani and Nakhon Si Thammarat provided 30% of the total production. The harvest period is from June to October and the most abundant yield period is from July to August.

Table 1: List of provinces containing durian cultivated areas in Thailand

Northern	**North-eastern**
1. Sukhothai	3. Si Sa Ket
2. Utharadit	4. Nakhon Rachasima
Central	**Southern**
5. Nonthaburi	13. Chumphon
6. Prachinburi	14. Ranong
7. Chachoengsao	15. SuratThani
8. Chanthaburi	16. Phangnga
9. Trat	17. Phuket
10. Rayoung	18. Krabi
11. Chonburi	19. Trang
12. Prachuap Khiri Khan	20. Nakhon Si Thammarat
	21. Phatthalung
	22. Songkhla
	23. Satun
	24. Pattani
	25. Yala
	26. Narathiwat

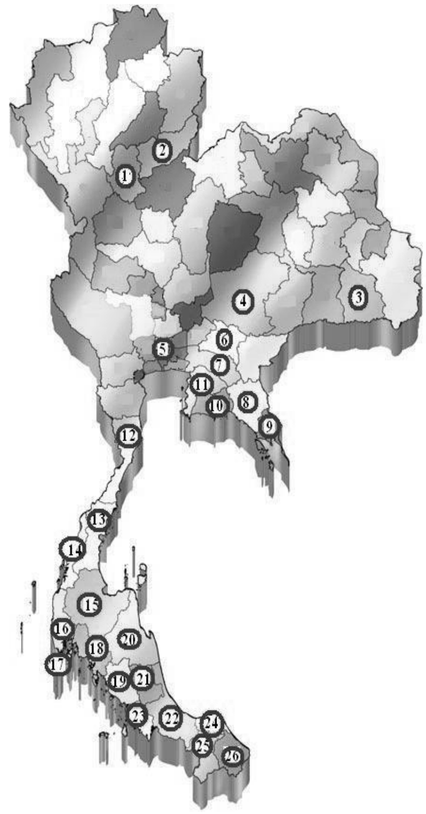

Figure 1: Map of provinces containing durian cultivated areas in Thailand

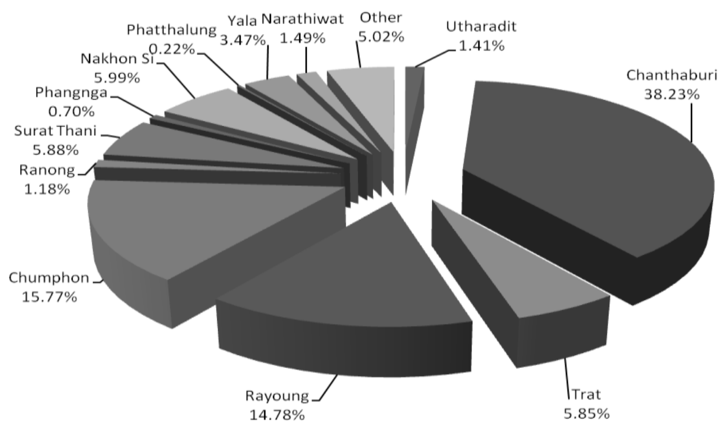

Figure 2: Proportion of fresh durian production quantity in each province in 2008

Proportion of fresh durian production quantity in each province as shown in Figure 2 indicates that the provinces providing the highest durian production quantity are Chanthaburi, Chumphon and Rayong respectively.

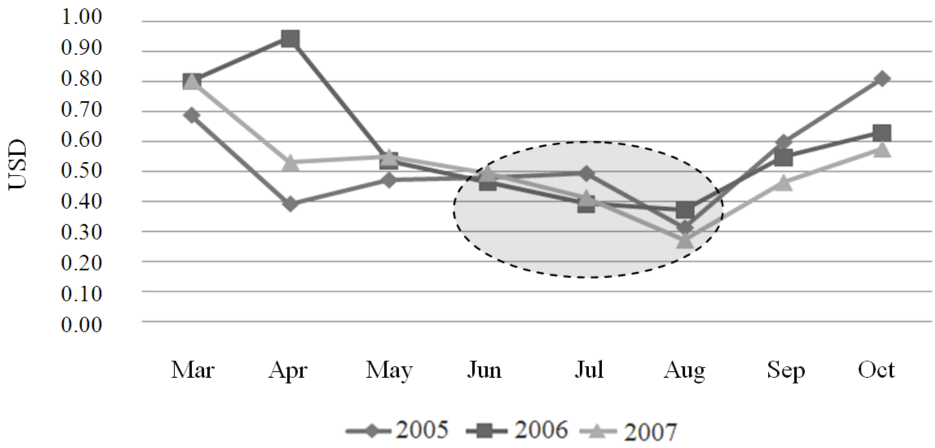

Figure 3: Farmers' sale price in 2005 - 2007 (USD/kg)

There are problems to consider in durian production. First, the durian is a seasonal fruit whose harvest period, in both central and southern regions, is from June to August. The second problem is flooding which spoils the harvest and consequently forces a decrease in the sale price of durian. The data in Figure 3 indicates that farmers' sale price in June and July was very low. In August, the sale price decreased further, beneath the production cost itself. The easy explanation for this is that domestic fresh durian consumption rate during abundant durian period is lower than the durian production rate. Those events have continued to the present date. The problem of declining fresh durian price depends on production quantity [2] as mentioned above. The main reason is that durian farms in each cultivated area did not have enough data to form production plans. These production plans will make use of customers' demand to tell us how many fresh durians and processed durian products should be manufactured each year. Then, to solve these long term problems, the researcher conducted this study to create a forecasting model in order to predict fresh durian production quantity for Thailand. The forecasting model must be accurate enough to give precise data to plan the production quantity of fresh durians and processed durian products. The model, on the other hand, has to be appropriate for each durian cultivating area in Thailand.

This study aims to construct forecasted models by applying accurate mathematical models to forecast fresh durian production quantity in 26 provinces of durian cultivating area in Thailand in advance. The forecast results are going to be used as a basis for planning and determining the appropriate fresh durian production and processed durian production over a long-term period. This developed model is to set solutions to the problems of superabundant durian production and low durian price [3].

2 Literature reviews

There are several research publications relating to the application of mathematical models to construct forecast models for many kinds of work. The details of techniques using mathematical models to forecast and plan for production are as follows:

Co and Boosarawongse [4] forecast Thai rice export by comparing the Exponential Smoothing model and the Autoregressive Integrated Moving Average (ARIMA) model with Artificial Neural Networks (ANNs) model. The result is shown as follows. Mean Absolute Percentage Error (MAPE) of the Back-propagation Neural Networks (BNP) model is less than MAPE of Holts-Winters and Box-Jenkins model.

Prybutok *et al.* [5] study how to forecast the highest ozone quantity each day by comparing 2 Time Series models which are Regression and Box-Jenkins ARIMA with Artificial Neural Networks (ANNs) model. The result shows that the Artificial Neural Networks (ANNs) model is the most accurate forecast model.

Law and Au [6] study the forecast of demand for touring industry. The research aimed to forecast the number of tourists who would go to Hong Kong by comparing the Moving Average technique, the Single Exponential Smoothing technique, Holt's

Exponential Smoothing technique and Regression technique with the Back-propagation Neural Networks (BPN) technique. The result shows that the Artificial Neural Networks (ANNs) technique and Single Exponential Smoothing techniques are the most accurate.

Mukhopadhyay *et al.* [7] study and compare the forecast competence of rough demand between Artificial Neural Networks (ANNs) technique and three Time Series techniques which are Single Exponential Smoothing, Croston's method and the Syntetos-Boylan approximation. The result from Artificial Neural Networks (ANNs) technique is the most accurate forecast model.

Baroutian *et al.* [8] apply three Time Series forecasting techniques, namely Exponential Smoothing, univariate ARIMA model, and Elman's Model of Artificial Neural Networks (ANNs) model, to predict travel demand (i.e. the number of arrivals) from different countries to Hong Kong. Exponential Smoothing and ARIMA are two commonly used statistical Time Series forecasting techniques. The third approach, Neural Networks, is an Artificial Intelligence technique derived from computer science. According to the analysis presented in this paper, Neural Networks seems to be the best method for forecasting visitor arrivals, especially those series without an obvious pattern.

Kaastra and Boyd [9] study the construction of the Artificial Neural Networks (ANNs) model to forecast finance and Economic Time Series model because the Artificial Neural Networks (ANNs) model has the flexibility of estimate function. If there are several parameters, the Forecast Networks model must be improved. The research introduced the guidelines to design Artificial Neural Networks (ANNs) for economic Time Series forecast.

Shabri *et al*. [10] study a hybrid methodology that combines the individual forecasts based on Artificial Neural Network (CANN) approach for modelling rice yields is investigated. The CANN has several advantages over the conventional Artificial Neural Networks (ANNs) model, the statistical the Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing. The results show that the CANN model appears to perform reasonably well and hence can be applied to real-life prediction and modelling problems.

Law [11] applies Neural Networks in tourism demand forecasting by incorporating the Back-propagation learning process into a non-linearly separable tourism demand data. Empirical results indicate that utilizing a Back-propagation Neural Networks (BPN) outperforms Regression models, Time Series models, and Feed-Forward Neural Networks in terms of forecasting accuracy.

Chachiamjane and Kengpol [12] apply the mathematic model in the form of a Linear Programming model for the production planning to get the maximum benefit and the limitation of production capacity and inventory. The improvement of production planning increases the profit of an organization.

3 Research Methodology

This research is to design the accurate forecasting model to predict fresh durian quantity and using the Linear Programming model to calculate optimal fresh durian production quantity for maximum profit of each area shown in Figure 4.

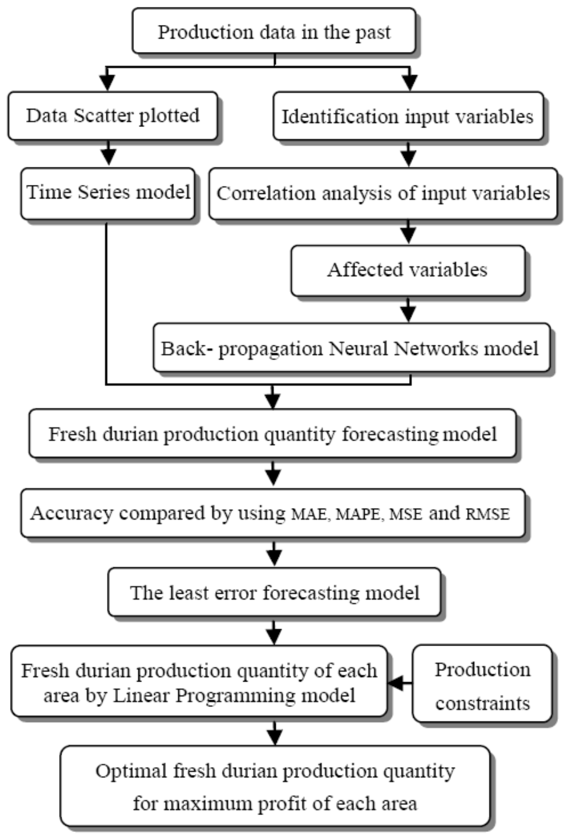

Figure 4: Research model

The data of this research is about the quantity of fresh durians grown in Thailand from the year 1996 to 2008 provided by the Office of Agricultural Economics, Ministry of Agriculture and Cooperatives. Figure 5 shows fresh durians quantity from 26 provinces along with plotted graphs. The data is the movement and the example of the fresh durian in each province as shown in Table 2.

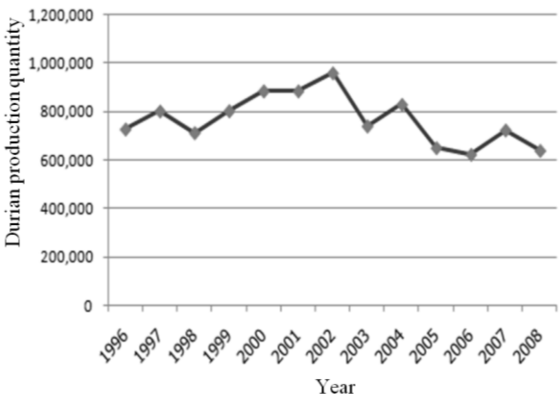

Figure 5: Data of the fresh durians of the whole country from the year 1996-2008 (tons)

Table 2: Example of fresh durian production quantity data in each province from 1996 to 2008 (tons)

Year / Province	1996	. . .	2008
Sukhothai	1,954	. . .	3,961
Utharadit	7,749	. . .	9,023
Chanthaburi	310,641	. . .	243,808
Trat	36,878	. . .	37,306
Rayoung	132,143	. . .	94,290
Chumphon	85,593	. . .	100,584
. . .	. . .	. . .	. . .
Ranong	25,807	. . .	7,514
Surat Thani	20,869	. . .	37,513
Nakhon Si	17,510	. . .	38,222
Yala	17,855	. . .	22,161
Narathiwat	18,154	. . .	9,472
Total	726,806	. . .	637,790

The methodologies of this research are as follow:

1. The information about fresh durian production quantity in the past from overall Thailand is studied.
2. Durian cultivating areas, areas providing yield and durian production quantity per acre in Thailand are investigated.
3. Domestic durian consumption quantity, fresh durian and processed durian product export quantity are studied.
4. Proportion of fresh durian consumption and processed durian product consumption are studied.
5. Variables affecting durian production quantity are investigated.
6. Models of durian production quantity forecast in advance are studied and developed in advance.
7. Time Series methods used as techniques of forecasting are as follows:
   1) Moving Average model
   2) Weighted Moving Average model
   3) Single Exponential Smoothing model
   4) Holt's Linear Exponential Smoothing model
8. The forecast model based on Back-propagation type of Artificial Neural Networks (ANNs) is constructed.
9. The models of durian production quantity forecast using the information in 1996 - 2008 are tried out.
10. The errors of forecast between Time Series models and Back-propagation Neural Networks model are compared to inspect the forecast accuracy. The items required to compare are as follows:
    1) Mean Absolute Error (MAE)
    2) Mean Square Error (MSE)
    3) Root Mean Square Error (RMSE)
    4) Mean Absolute Percentage Error (MAPE)
11. The information of fresh durian production quantity.
12. The data of production and the consumer demand for fresh durians from each cultivated area are applied for the farmer to make maximum profit by a Linear Programming model.

13. Summary of research result and recommendations.

4 Mathematical models used in this research

These research models consist of two models, the first is the Time Series model and the latter is the Artificial Neural Networks (ANNs).

4.1 *Time Series models*

The Time Series model is based on the assumption that the future is a function of the past by considering that what has happened in that period of time and the data series, are to be used as a forecast. The numerical data used can be divided into a week, a month, three months or a year from Bernard [13] and Makridakis *et al.* [14]. In this research, the data used to forecast is the yearly durian production quantity data from each of the 26 provinces containing durian cultivating area in Thailand (shown in Table 2). The four Time Series models used in this research are as follows:

4.1.1 Moving Average model

The Moving Average model is made to present a smooth forecasting using the average 1 series observation data made in the past to summarize the forecast data for the next period. The advance durian production quantity forecast is using retrospective durian production quantity data between 2 and 10 years. We can calculate by:

$$MA_nF_{t+1}^p = \frac{1}{n}\left[\sum_{t=i+1-n}^{i} A_t^p\right] \quad (1)$$

Where

$MA_nF_{t+1}^p$ = Moving Average of n forecasted durian production quantity in period t+1

$t+1$ = Period of forecast

i = The last year of the period used for calculating

t = The first year of the period at start for calculating

n = Number of periods in Moving Average as yearly start at n = 2, 3, …, 5 years

p = The provinces with durian cultivated areas

A_t^p = Actual durian production quantity at time period t

4.1.2 Weighted Moving Average model

The Weighted Moving Average model is the average of production quantity in the past consecutive years. The importance weight to produce quantity close to current then in descending order based on the past. The result is a forecast value of the next period. We can calculate by:

$$WMA_nF_{t+1}^p = \sum_{t=i+1-n}^{i} W_t A_t^p \quad (2)$$

Where

$WMA_nF_{t+1}^p$ = Weighted Moving Average of n forecasted durian production quantity in period t+1

$t+1$ = Period of forecast

i = The last year of the period used for calculating

t = The first year of the period at start for calculating

n = Number of periods in moving average as yearly start at $n \geq 2$

p = The provinces of durian cultivated areas

W_t = The weight for period t, between 0 to 100%

A_t^p = Actual durian production quantity at time period t

4.1.3 Single Exponential Smoothing model

A Single Exponential Smoothing model allows us to vary the importance of recent product quantity to the forecast. We can calculate by:

$$ESF_{t+1}^p = \alpha A_t^p + (1-\alpha)ESF_t^p \quad (3)$$

Where

ESF_{t+1}^{p} = Single Exponential Smoothing forecasted in Period t+1

ESF_{t}^{p} = Single Exponential Smoothing forecasted in period t

$t+1$ = Period of forecast

α = Smoothing constant when $0 \le \alpha \le 1$

T = Period before forecast

P = The provinces with durian cultivating areas

A_t^p = Actual of durian production quantity at time period t

4.1.4 Holt's Linear Exponential Smoothing model

This is an extension of Exponential Smoothing to take into account a possible linear trend. There are two smoothing constants α and β. We can calculate by:

$$LESF_{t+1}^{p} = L_t + b_t \quad (4)$$

Where

ESF_{t+1}^{p} = Holt's Linear Exponential Smoothing forecasted in period t+1

L_t, b_t = Respectively (Exponentially Smoothed) estimates each level and linear trend of the series at time t

We can calculate L_t and b_t by:

$$L_t = \alpha A_t^p + (1-\alpha)(L_{t-1} + b_{t-1}) \quad (5)$$

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta) + b_{t-1} \quad (6)$$

Where

α = Smoothing constant when $0 \le \alpha \le 1$

β = Smoothing constant for trend When $0 \le \beta \le 1$

T = Period before forecasting

p = The provinces of durian cultivating areas

A_t^p = Actual durian production quantity at time period t

4.2 *Artificial Neural Networks (ANNs) model*

Artificial Neural Networks (ANNs) are a simulation of the human brain working by computer programming from Fausett [15]. The Back-propagation Neural Networks (BPN) is the most representative learning model for the ANNs. The procedure of the BPN is the error at the output layer that propagates backward to the input layer through the hidden layer in the network to obtain the final desired outputs. The gradient descent method is utilized to calculate the weight of the network and adjusts the weight of interconnections to minimize the output error from Lee [16]. The BPN model has high or low efficiency, depending on the selection of network construction which are numbers of hidden layers, hidden units and parameters of learning. Network Architecture from Hagen *et al.* [17] is shown in Figure 6. The working principle of Artificial Neural Networks (ANNs) model is shown in Figure 7.

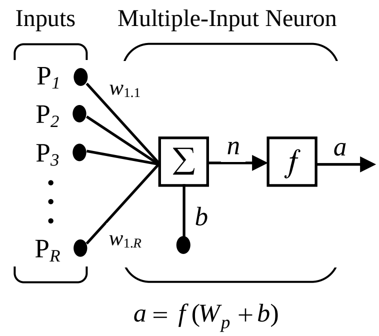

Figure 6: Network Architecture

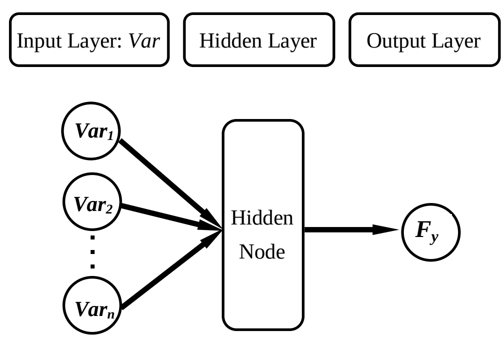

Figure 7: Working principle of Artificial Neural Networks (ANNs) model

The data is applied with the Artificial Neural Networks (ANNs) model. There are many variables that affect the fresh durian production; the variable inputs of this research are provided by the Office of Agriculture Economics and Department of Agriculture, Ministry of Agriculture and Cooperatives. Input variables of this research start from 10 input variables as follows:

1. Planted area
2. Harvested area
3. Yield per acre
4. Farm price
5. Export price
6. Cost of production per acre
7. Rainfall
8. Rain-day
9. Oil price
10. Consumer price index

After getting the input variables to reach the correlation it is found that the input variables are related to the quantity of durian and the correlation is in the strength level. There are 4 variables that affect the fresh durian production (harvested area, farm price, export price and rainfall). Data from the years 1996-2008 has been used for the calculation and the example data is shown in Table 3.

Table 3: Example of input variables in 1996

Province	Harvested area (Acre) Var_1	Farm price (USD/ ton) Var_2	Export price (USD/ ton) Var_3	Rain fall (mm) Var_4
Sukhothai	1,954	883	650	606
Utharadit	6,262	881	650	612
Si Sa Ket	157	733	650	637
Surat Thani	6,625	573	650	1,094
Phangnga	2,045	625	650	1,545
Nakhon Si	4,691	625	650	1,169
Phatthalung	1,287	625	650	1,012
Songkhla	4,606	625	650	1,071
Satun	1,640	625	650	1,429
Pattani	1,645	649	650	1,214
Yala	6,776	643	650	1,795
Narathiwat	4,906	625	650	1,630

Input variables for Artificial Neural Networks (ANNs) model are:

Var_1 = Harvested area (At the time t-1)

Var_2 = Farm price (At the time t-1)

Var_3 = Export price (At the time t-1)

Var_4 = Rainfall (At the time t-1)

Output variable for Back-propagation Neural Networks model is:

F_y = Forecast of durian production quantity (At the time t)

The structure of Back-propagation Neural Networks model used in the research is shown in Figure 8.

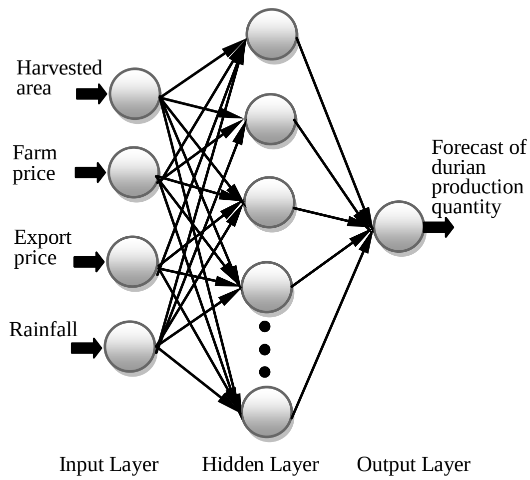

Figure 8: Structure of Back-propagation Neural Networks model

In this research, the data is divided into 2 series which are the training series containing 260 data sequences and the testing series containing 52 data sequences. The infrastructure consists of 4 input variables, 1 hidden layer, changing 1-10 hidden nodes and the parameter of learning. The error goals are 0.007, 0.009, 0.01 and 0.03. The results of Back-propagation Neural Networks model forecast testing are shown as MAPE (shown in Table 4).

Table 4: MAPE calculated by Back-propagation Neural Networks (BPN) model (%)

Hidden Node \ Error goal	**0.007**	**0.009**	**0.01**	**0.03**
1	31.47	39.49	43.00	56.01
2	26.01	28.29	29.58	67.74
3	22.41	21.59	26.15	28.71
4	24.73	25.22	28.96	91.66
5	21.93	30.85	33.53	49.24
6	62.75	78.49	84.41	96.20
7	65.70	79.40	83.45	47.32
8	24.12	12.95	**11.63**	48.80
9	36.38	29.06	24.79	15.83
10	28.37	27.52	27.38	41.58

4.3 *Comparison of model efficiency*

The general accuracy of forecasting is measured Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE) and Root Mean Square Error (RMSE). MAE is the easiest to understand and compute. The use of absolute values or squared values prevents positive and negative errors from offsetting each other. It measures the overall accuracy and provides an indication of the overall spread, where all error are given equal weights. The forecast model efficiency compares the forecast errors by comparing MAE, MSE, RMSE and MAPE resulting from forecast models from Co and Boosarawongse [4]. The forecast model efficiency compares the forecast error by comparing the Mean Absolute Percentage Error (MAPE) resulting from Zhang and Qi [18]. In this research, accuracy measurement of the five different forecasting models is based on MAPE. The Mean Absolute Percentage Error (MAPE) can be calculated by using the following equation.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \times 100 \qquad (7)$$

Where

F_t = Actual durian production quantity in period t

A_t = Forecast of durian production quantity in period t

t = Period considered

n = Total number of periods

In general, the selected models are not very accurate in most of the measuring dimensions. The classified forecasts with MAPE values are less than 10% as highly accurate forecasting, between 10% and 20% as good forecasting, between 20% and 50% as reasonable, and forecasting, larger than 50% as inaccurate forecasting from Frechtling [19].

Table 5: Error comparison of forecasting

Forecast model	**MAE**	**MSE**	**RMSE**	**MAPE**
1. Moving Average 2 years	91,230	1.09×10^{10}	104,499	12.36
2. Weighted Moving Average 2 years	89,694	1.10×10^{10}	104,691	12.22
3. Single Exponential Smoothing $\alpha = 0.7$	92,612	1.14×10^{10}	106,879	12.61
4. Holt's Linear Exponential Smoothing $\alpha = 0.9$, $\beta = 0.05$	93,441	1.28×10^{10}	113,296	12.77
5. Back-propagation Neural Networks 4-8-1	**82,391**	**1.01×10^{10}**	**100,424**	**11.63**

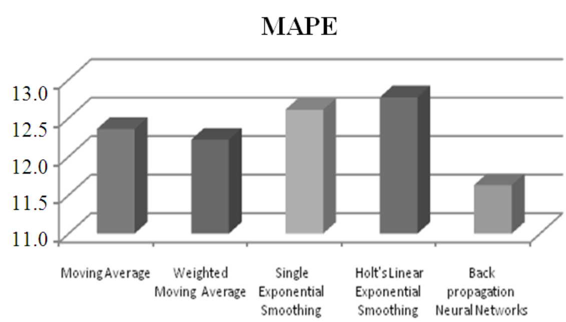

Figure 9: Error comparison of Mean Absolute Percentage Error (%)

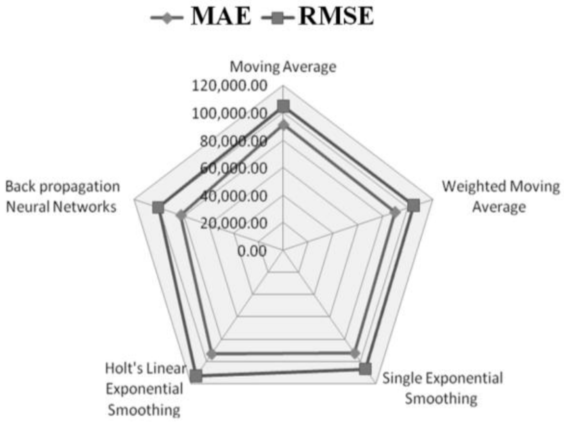

Figure 10: Error comparison of Mean Absolute Error and Root Mean Square Error (tons)

5 Results

The comparison error of the forecasting model between the Time Series model and the model of Back-propagation Neural Networks are to forecast the durian production quantity one year in advance. The error of the forecasting of every aspect with the structure of 4-8-1 is less than the other forecasting model. From Table 5, the value of MSE is equal to 10,085,058,740.14. MAE is equal to 82,391.28. RMSE is equal to 100,424.39. The last MAPE is equal to 11.63%. It can be seen that the result of the forecasting is accurate at the good forecasting level by MAPE [19]. The comparison error of the forecasting and the comparable graph in Figures 9 and 10, the Back-propagation Neural Networks (BPN) model gets the effectively good level forecasting.

After getting the appropriate forecasting model to predict the quantity of fresh durian, we can apply the result of forecasting by a Linear Programming model to calculate a suitable production quantity in each region of Thailand so the farmers can acquire maximum profit.

The Linear Programming is the technique for solving the problems of factor and resource allocation. The relationships of various variables are all linear relationships. The LP objective is to solve the problem and make decisions to, for example, maximize profit and cut down on expenses to acquire benefits from Taha [20].

Optimisation problem comprises of 3 parts such as:

1. Decision variables are the value of the alternative to make a decision. They are written as $X_1, X_2, ..., X_n$.
2. Constraints are the regulation.
3. Objective function is the mathematics function to show the relationship of the decision making variables to reach a purpose such as to maximize or minimize in the form of Max or Min: $f(X_1, X_2, ..., X_n)$ from Ragsdale [21].

This research shows the related factors and the mathematics model by target equations to maximize profit as follows:

X_1 = The export demand of fresh durian quantity in the Northern part

X_2 = The export demand of fresh durian quantity in the North-eastern part

X_3 = The export demand of fresh durian quantity in the Central part

X_4 = The export demand of fresh durian quantity in the Southern part

X_5 = The domestic demand of fresh durian quantity in the Northern part

X_6 = The domestic demand of fresh durian quantity in North-eastern part

X_7 = The domestic demand of fresh durian quantity in the Central part

X_8 = The domestic demand of fresh durian quantity in the Southern part

a_j = Profit coefficient for each types of fresh durian quantity

Maximize Profit

$$MAX = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8$$

Subject To

$$X_1 + X_2 + X_3 + X_4 \leq \text{ Exports Demand}$$
$$X_5 + X_6 + X_7 + X_8 \leq \text{ Domestic Demand}$$

$X_1 + X_5 \leq$ The forecasting fresh durian quantity in the North

$X_2 + X_6 \leq$ The forecasting of fresh durian quantity in the North-Eastern

$X_3 + X_7 \leq$ The forecasting of fresh durian quantity in the Central

$X_4 + X_8 \leq$ The forecasting of fresh durian quantity in the Southern

$X_j \geq 0 \qquad j = 1, 2, 3, ..., 8$

The Linear Programming model is the mathematic model that is applied to survey the fresh durian production quantity in tons, in each part of Thailand; such as the Northern part, the North-eastern part, the Central part and the Southern part of Thailand by using the forecasting data for demand and supply of durians in domestic and foreign markets 2008.

The purpose of the Linear Programming model is to find the appropriate quantity by each part in order to achieve a suitable price for the durians. The maximized profit cannot be less than the production cost, a forecasting of the fresh durian quantity on the supply-side and the result of the fresh durian demand should show a net profit of 200 USD per ton which is a good price for the farmers. The total of fresh durian supply of the country should not exceed 595,000 tons. The quantity of fresh durians in each part of Thailand should be as follows:

The Northern of Thailand	=	15,000	tons
The North-eastern of Thailand	=	5,000	tons
The Central of Thailand	=	405,000	tons
The Southern of Thailand	=	170,000	tons

The net profit should be equal to 119 million USD related to the real value of 2008 profit which is 100 million USD [3], an increase of 19 million USD. The Office of Agricultural Economics or Department of Agriculture Ministry of Agriculture and Cooperatives apply the research result to forecast the fresh durian quantity in advance and calculate the appropriate production in each region for the following year. The Department of Agriculture can inform the Office of Agricultural Research and Development Region 1-10 in Thailand of the growing durian data then send the information to the provinces which have durian growing areas. Then, through the provincial agriculture office and district agriculture office for production, distribute the fresh durian production quantity in the next year to ensure maximum profit to the farmers in the area and make recommendations for processing durians if it is over quantity.

6 Conclusions and Recommendations

The purpose of this research is to design and develop the models which can effectively forecast the quantity of fresh durians production for the following year. This study is to obtain the most accurate forecasting model to be able to foresee Thailand's fresh durian quantity by comparing the errors between a Time Series model and a Back-propagation Neural Networks (BPN) model. This study forecasts fresh durian production quantity in advance by a quantitative forecasting that uses Time Series models, one of the forecasting methods using retrospective data of fresh durian production quantity to be input variables, compared with a forecasting of Back-propagation Neural Networks model, using many input variables influencing the durian production quantity of each year; harvested areas, farm price, rainfall and export price. The study results are found in the Back-propagation Neural Networks (BPN) model that has the most accurate forecast with the least errors, i.e. MAE is equal to 82,391 tons and MAPE is equal to 11.63%, which are in the range of good forecasting according to Frechtling [18]. The model giving the second accurate forecast is Weighted Moving Average model with MAE of 89,694 tons and MAPE of 12.22% because fresh durians and other fruits production yields depend on several unpredictable factors. The result is that some years more or less have the same durian production quantity. Therefore, the Time Series model is not suitable for prediction of data characteristics with side-way fluctuations. The Back-propagation Neural Networks (BPN) model has the abilities of generalization and adaptability, which could take data of input variables to make a forecast accurate. This complies with Co and Boosarawongse [4] and Shabi *et al*. [10]. The forecasting outcome should be utilized by taking data of predictive durian production quantity and of consumer demand to calculate and plan for future fresh durian yield by applying the Linear Programming model. The result of this calculation can be used as information to make a suitable plan of fresh durian production for farmers from each cultivated area in Thailand and to appropriately plan advanced processed durian production quantity, e.g. durian paste, durian chips, which can solve problems of excessive durians and the durian price decline. These are active solutions for farmers in the long run and thus sustainable.

The result from the forecasting model can be applied to other fruits in Thailand and foreign countries in the same aspect.

Further, the next step of the research should design a computer software package for calculating the production quantity under the export price, farm price, exchange rate and other factors of production quantity for each area.

References

[1] Agricultural Information Center, Office of Agricultural Economics, 2008. *Fundamental Information of Agricultural Economics*. Bangkok, Thailand.

[2] Office of Agricultural Economics, 2008. *Durian Survey Report in 2008*. Bangkok, Thailand.

[3] Agricultural Information Center, Office of Agricultural Economics, 2008. *Agricultural Statistics of Thailand in 2008*. Bangkok, Thailand.

[4] Co H.C. and Boosarawongse R., 2007. *Forecasting Thailand's Rice Export: Statistical Techniques vs. Artificial Neural Networks*. Computer & Industrial Engineering, 53: 610-627.

[5] Prybutok V.R., Yi J. and Mitchell D., 2000. *Comparison of Neural Network Models with ARIMA and Regression Models for Prediction of Houston's Daily Maximum Ozone Concentrations.* European Journal of Operational Research, 122: 31-40.

[6] Law R. and Au N., 1999. *A Network Model to Forecast Japanese Demand for Travel to Hong Kong.* Tourism Management, 20: 89-97.

[7] Mukhopadhyay S., Solis A.O. and Gutierrez R.S., 2008. *Lumpy Demand Forecasting Using Neural Networks.* International Journal of Production Economics, 2: 409-420.

[8] Baroutian S., Aroua M.K., Raman A.A. and Sulaiman N.M., 2008. *Prediction of Palm Oil-Based Methyl Ester Biodiesel Density Using Artificial Neural Networks.* Journal of Applied Sciences, 8: 1938-1943.

[9] Kaastra I. and Boyd M.S., 1996. *Designing a Neural Network for Forecasting Financial and Economic Time Series*. Neurocomputing, 10: 215-236.

[10] Shabri A., Samsudin R. and Ismail Z., 2009. *Forecasting of the Rice Yields Time Series Forecasting using Artificial Neural Network and Statistical Model*. Journal of Applied Sciences, 9: 4168-4173.

[11] Law R., 2000. *Back-propagation Learning in Improving the Accuracy of Neural Network-Based Tourism Demand Forecasting*. Tourism Management, 21: 331-340.

[12] Chachiamjane T. and Kengpol A., 2007. *Suitable Production Quantity Evaluation Using Mathematical Models: A Company Case Study of Production Planning in Paper Industry*. The Journal of King Mongkut's Institute of Technology North Bangkok, Thailand.

[13] Bernard W.T., 2006. *Introduction to Management Science.* 9th Edition, Prentice Hall, Upper Saddle River, New Jersey.

[14] Makridakis S., Steven C.W. and Victor *E.M.*, 1983. *Forecasting: Methods and Applications.* 2nd Edition. John Wiley& Sons. New York.

[15] Fausett L., 1994. *Fundamentals of Neural Networks: Architectures, Algorithms, and Applications*. Prentice-Hall, Englewood Cliffs, New Jersey.

[16] Lee T.L., 2007. *Back-propagation Neural Network for the prediction of the short-term storm surge in Taichung harbor, Taiwan*. Engineering Applications of Artificial Intelligence, 21: 63-72.

[17] Hagan M.T., Demuth H.B. and Beale M., 2008. *Neural Network Design*, India Edition, Cengage Learning India.

[18] Zhang, G.P. and Qi M., 2005. *Neural network forecasting for seasonal and trend time series.* European Journal of Operational Research, 160: 501-514.

[19] Frechtling D.C., 2001. *Forecasting Tourism Demand: Methods and Strategies.* Butterworth-Heinemann, Oxford.

[20] *Taha* H.A., 2007. *Operations Research An Introduction*, 8th Edition, Prentice Hall of India.

[21] Ragsdale C.T., 2004. *Spreadsheet Modelling & Decision Analysis*, 4th Edition, Mason, Thomson South-Western.