Applying Backpropagation Neural Network to Predict the Price of Sticky Rice in Thailand

Srayut Tongnoy and Deng-Neng Chen

***Abstract*—** The sticky rice is the stable food to achieve the sustainability of Thailand country. The price of rice is fluctuated in domestic and global markets because the imbalance between supply and demand needed to be redressed. Therefore, the findings highlight the essential role of modern techniques to forecast the prices in the domestic transaction market. Such price forecast can support farmers understanding the direction of the prices in market and the development of agricultural sectors. In this research, the back propagation neutral network (BPNN) was applied to develop a month time-series prediction model. The model was used to predict the forecasting domestic price of sticky rice type and evaluation of the forecasting techniques. The collected data covered the months from January 2007–December 2017. Training data consisted 70% of total observations and were randomized before model executing. The remaining data 30% were used to test the model for model fitting. The results show that the models have high accuracy rate, thereby implicating that BPNN can be used to predict the Thailand's rice price in the domestic market.

***Keywords*—**neural network, back propagation, sticky rice, time series, price prediction.

I. Introduction

Rice is the most important product of Thailand. Thai rice exporters association showed that rice exports in the previous year of 2017 (Jan-Aug) totaled 7,395,579 tons, valued at 3,200 million US dollars. The export volume increased by 21.5%, and the value by 14.0% compared to the previous year with the export volume of 6,084,575 tons, valued at 2,735 million US dollars. The highest export categories were 3,344,683 tons of white rice(9.1% increased), follow by 1,628,745 tons of jasmine rice(7.1% increased), 1,879,320 tons of parboiled rice (56.9% increased), 301,696 tons of sticky rice (40.1% increased), respectively.

The world's top three rice exporters are Thailand, India, and Vietnam, respectively. Thailand, with a market share of around 25%, has been the world's top rice exporter for decades. The majority of Thailand's population is in the agricultural sector. Over 50% of the country's farmland is devoted to rice. About 55% of rice is produced for domestic consumption, and the remaining 45% is for export.

Srayut Tongnoy, Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, Taiwan,

Deng-Neng Chen, Department of Management Information Systems, National Pingtung University of Science and Technology, Taiwan,

Sticky rice is a type of rice grown mainly in southeast and the eastern parts of south Asia, which is especially sticky when cooked. While it is widely consumed across Asia, it is not only a stable food in northeastern Thailand and Laos but also for various countries the global world. However, the price fluctuations are a matter of concern among consumers, farmers and officer. Therefore, how to make a precise prediction is very important for efficient monitoring and planning the transaction of rice domestic market. Several attempts have been conducted in the past to develop price forecasting models for various commodities [1].

A number of studies have described the creation of agricultural commodities by using data mining and artificial neural network. For improving the accuracy of prediction, data mining techniques have been rising analysis field [2]. Data mining techniques that allow extracting unidentified relationships among the data items from large data collection that are useful for decision making [3]. The results showed that the information analysis technologies and algorithms are useful in agricultural prediction research. There are some price prediction systems that were designed based artificial neural networks (ANNs). The system was trained by backpropagation technique. The experimental results show the systems were effective [4]. Data mining in agriculture field is a relatively novel research field. Yield prediction was concern in agricultural problem. The large data sets process were extracted for useful information and important knowledge from large sets of data. In the past, yield prediction was performed by considering farmer's experience, especially field and crop. Currently, the insight data is to be filtered from big data and the gathered data is used to classifying that is the latest technology of yield predictions [5]. Artificial neural network (ANN) model was to applied to predict the environmental influents of potato production. A back-propagation (BP) learning algorithm was chosen to conduct the experiment. Data mining were applied to agricultural sector. In the area of investigation research was examined to find appropriate data processing models to realize high accuracy and new forecasting capabilities. In additional techniques and algorithms like k-means, k-nearest nneighbor (KNN), support vector machine (SVM) and artificial neural network (ANN) were used in agriculture. These showed that several data processing techniques were utilized in agriculture study areas [6]. Agricultural yield data has been made to review the research studies on application of data mining techniques. Some of the techniques such as the k-means and

linear regression (MLR) were used in experimentation. There were concern the problem of predicting yield. The difference between datamining techniques were evaluated on different data sets [7]. In the other, moving average (MA) and artificial neural network (ANN) techniques were used to enhance the transaction of agricultural price based on agricultural products. This developed model can be applied to forecast agricultural product price accurately [5].

The back-propagation neural network (BPNN) have been investigated in vegetable price prediction [8]. Because of the rapidly changing dimensions for vegetable price and unstable which makes impact in daily life. Artificial neural network techniques can be used to develop an innovative model to predict the market. Price prediction was highly useful for farmers to plan their crop cultivation activities. It can be profit more prices in their crop cultivation and forecasting the future price in the advance market. A prediction model was designed based on neural network. Back propagation neural network (BPNN) algorithm is the most common model that has been used in the present research.

In our research, we applied back-propagation neutral network (BPNN) to develop month time-series models to predict the prices of sticky rice in domestic market in Thailand. Sticky rice is one of the crops that are always exposed the unstable price due to the current price is fluctuation all the time. Another problem is one of the delay purchasing. The suspended stock of rice is until its deal with a high cost of purchasing which cannot be distributed to the market. In most cases, the farmers are uncertain about their future production and income. The matter is to affect the imbalance between supply and demand in the market. Thus, modelling and forecasting the annual and monthly price is important in practice. We have collected the dataset from 2007 to 2017, and month time-series models has been developed. The dataset were used to train and evaluate with BPNN models. The remainder sections of this paper are arranged as followings. The BPNN model is introduced in section two. Our research design and modelling method are described in section three. The data analysis and prediction results are shown in section four, and conclusions are discussed in section five.

II. Backpropagation Neural Network

In the big data era, an artificial neural networks (ANNs) are computational models are capable for machine learning and deep learning recognition. They are displayed as frameworks of interrelated "neurons" that can specify values from inputs by providing data through the system. Neural networks have been utilized to solve a wide range of tasks that are difficult to solve utilizing Computational mathematics. The most used kind of ANNs is the multilayer perception, in which neurons are organized in layers. All input layer are normalization range 0 to 1 or -1 to 1, then neurons receive the input signal to feed in the network. There are some hidden layers between the input and output layer. Each neuron can receive input signal from the neuron belongs to previous layer after passing threshold function and it can send its output to the successive layer. The neurons on the output layers are active and the result they provide is considered as the output provided by the network. Back-propagation neural network (BPNN) is the most representative learning model for ANNs. BPNN is based on the error back propagation to the multi-layer neural network [9].

The back-propagation is one of the most popular ANNs algorithms. In back-propagation training algorithm, the first step is to initialize all weight and threshold to a random. After that, the network must activate its backpropagation by using the activation function. Then, the weight for each neuron is updated accordingly based on the number of neurons for each layer. Finally, all of the above processes will be repeated until the sum square error is a least [9]. Basically, the errors are back propagated from the output layers towards the input layer during training phase. This algorithm is important as the hidden layers do not have target values and these layers should be trained based on errors from the previous layers. The weight value continuously get update as the errors are back-propagated. Training phase continue until the errors in the weights are minimized [10]. The process involves in the back-propagation algorithms is shown in the following steps: *Step 1)* Provide the input datasets and normalization *Step 2*) Compute the error between the actual and predicted outcomes *Step 3)* modification of the weights related with hidden and input layer *Step 4)* Compare the error and weight updates *Step 5*) The algorithm is stopped when the value of the error function has become sufficiently slight [9].

This section presents a very brief review of the related and recent studies. BPNN is one of variety for data mining techniques. BPNN have been employed in the past to study price fluctuations of crops. For improving the accuracy of prediction, BPNN have been rising analysis field [7]. There are lots of data mining and machine learning technologies were used in agricultural research, such as k-means, k-nearest neighbor (KNN), support vector machine (SVM) and artificial neural network (ANN). This show the information analysis technologies and algorithms are useful in agricultural prediction research [2]. A prediction model was applied by the neural network. The study observed factors affecting the Thai rice export in the global market. The method were achieved a more stable and accurate prediction, neural network techniques were combined for developing and predicts the rice export price and demand based on ensemble model [11]. BPNN were combined with the statistical techniques to predict the agricultural product prices. It reveals that the stability and accuracy of the entirety method was better than the ones of each base model alone. Moreover, BPNN used to help the automatic system. It can be used for rice grain type to handle the identification and classification with digital image. It was recognized as an efficient technique to extract the features from rice grains in a non-contact manner. This effort has been proposed to categorize and identify the specified rice sample based on its morphological features[12]. Due to the rapidly changing dimensions for milk price and unstable this makes impact in daily life. ARIMA

and artificial neural networks (ANN) were applied to predict price of farm gate milk. Price prediction is highly useful for farmers to plan their farm activities. They could be obtained more price in their farm and knowing the future price in the advance market. These methods can help farmers and government policy makers to obtain more efficient monitoring and planning.

III. Research Design

All dataset of sticky rice were collected from 2007 to 2017 from the publicly available records of Thai government to train our BPNN prediction models. There are 131 records of month time-series which divided the data 70% for training and 30% for testing models.

A. Data Collection and Modelling

Sticky rice price is affected by several economic factors such as exchange rates, money supply, demand, and volume rice export. Therefore, the precise prediction is more difficult than ordinary price products. The price of sticky rice has fluctuated frequently since 2007. It is very difficult to collect along with factors. In this paper, the factors are crucial to sticky rice price, which were collected as input parameters to train with artificial intelligence (AI), back-propagation neural network model (BPNN). The factors are the gross domestic product (GDP), money supply, interest rate, US currency baht per dollar (THB/USD), exchange rate dong per dollar (DONG/USD), Consumer price index(CPI), sticky rice yield (metric ton) and rice export price(million USD). On the other hand, the Stick rice price is designed as the output parameter in the model.

In the month time-series prediction model, the data were divided into twelve by monthly. We used the monthly data were random of 70% for training data. And the 30% of remaining data used for testing model.

The parameters of BPNN model is set as followings:

Nodes of input layer: 7
Nodes of hidden layer: 2-12
Nodes of output layer: 1
Iterations: 1000
Learning rate: 0.2
Momentum: 0.1-0.5

The input parameters are the seven variables of the related rice prices and the output one is the monthly price of sticky rice. These parameters were normalized into -1 to 1 for data transformation, preparing the data to be appropriate for BPNN algorithm. It can use statistics to adjust new values.

B. Min-Max Normalization:

This method transforms the dataset from one range of values to a new range of values. Then, the features are rescaled to put within a range of 0 to 1 or from -1 to 1. There are some researcher uses this linear interpretation formula such as equation (1)

$$X' = (x_{\max} - x_{\min}) \times \frac{(x_i - x_{\min})}{(x_{\max} - x_{\min})} + x_{\min} \quad (1)$$

where $(x_{\max} - x_{\min}) \neq 0$, when $(x_{\max} - x_{\min}) = 0$ for a feature, it indicates a constant value for that feature in the data. When a feature value is found in the data with a constant value, it should be removed because it does not provide any information to the neural network. When the min-max normalization is applied, each feature will replace within the new range of values will remain the same. Min-max normalization has the advantage of preserving exactly all relationships in the data [10].

The forecasting ability of different models is measured with the mean squared error (MSE). The MSE can be calculated by using the equation (2):

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_t - \hat{y}_t)^2 \quad (2)$$

y = actual sticky rice prices
$\hat{y}$ = predicted sticky rice prices

We defines accuracy rate to measure the prediction result. The use of absolute values prevents positive and negative errors from offsetting each other. In this research, accuracy measurement forecasting models is based on MSE.

IV. Results and Discussion

We used WEKA software to develop our prediction system. The dataset were used to train and evaluate our model. The analysis results of month time-series are shown in table 1.

TABLE I: Comparison of MSE Error

	Comparison MSE Error				
Network modes	**Momentums**				
	0.1	**0.2**	**0.3**	**0.4**	**0.5**
7-2-1	0.0507	0.0506	0.0505	0.0502	0.0500
7-4-1	0.0443	0.0405	0.0454	0.0503	0.0537
7-6-1	0.0241	0.0229	0.0276	0.0267	0.0305
7-8-1	0.0271	0.0299	0.0329	0.0338	0.0312
7-10-1	0.0289	0.0307	0.0305	0.0277	0.0253
7-12-1	0.0294	0.0292	0.0293	0.0322	0.0294

The error comparison for different networks models show that the network model of 7-6-1, 0.2 of learning rate value and 0.2 of momentum. That was successful rate of neural network algorithm to predict the sticky rice price. Because the total error measure is lower than the other. From table 1, the network model of 7-6-1 had MSE value of 0.0229 which was a minimum error. It can be seen that the result was accurate by using network model of 7-6-1. The forecast error comparison can effectively obtain a high precision of forecasting model.

TABLE II: ACCURACY RATE OF PREDICTION RESULTS
(MOMENTUM=0.1- 0.5)

	Accuracy Rates				
Network models	**Momentums**				
	0.1	**0.2**	**0.3**	**0.4**	**0.5**
7-2-1	0.8752	0.8751	0.8751	0.8752	0.8754
7-4-1	0.9043	0.9074	0.9064	0.8851	0.8791
7-6-1	0.945	0.9487	0.9405	0.9461	0.93
7-8-1	0.936	0.9318	0.9386	0.9381	0.9317
7-10-1	0.9332	0.9293	0.9314	0.9458	0.9476
7-12-1	0.9319	0.9324	0.9328	0.9348	0.9332

The results show that the accuracy rates are 94.87%, 94.76%, and 94.61%, follow by 7-6-1 (momentum 0.2), 7-10-1 (momentum 0.5), and 7-6-1(momentum 0.4) of network model, respectively. As can be seen from the table 2, along with the forecasting model that can reach to high performances, the results 7-6-1 of network model is better than other models. In the past, the forecasting techniques were considered insufficient to properly resolve the interactions of the factors and outcomes due to the complexity of the large dataset and input variables. Therefore, ANN is considered one alternative to be a modern technique for predicting in agricultural areas. This paper showed around 94% of accuracy rate and then the total error was only 0.0229. It can be seen that the result of the forecasting was accurate to provide a good forecasting level. Moreover, the error comparison can show the effect of prediction accuracy. That is also said BPNN with monthly time-series prediction model can be able to estimate nearby the actual price. It is good in month by month prediction.

V. CONCLUSION

This study used the key factors to predict the prices of the sticky rice in the domestic market. The month time-series prediction models were developed and evaluated. BPNN can be utilized an insight that how to use BPNN to develop a prediction model for rice price and production. Our method is contributive to monitor the fluctuated price in market and it is helpful to make an effective cultivating plan for the farmers.

Although our research has achieved our objectives, there are still some limitations. First, we only collected the month time-series data. By obtained a precise of prediction model, if we can get more deep data to train our model, the prediction outcome will be enhanced. Second, we only used the economic factors to be the input parameters, although we have get good prediction accuracy rate, there are lots of another influential factors might be considered to train the model, such as climates, soil, and government policy factors.

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