APPLICATION OF ARTIFICIAL NEURAL NETWORK FOR DEMAND FORECASTING IN SUPPLY CHAIN OF THAI FROZEN CHICKEN PRODUCTS EXPORT INDUSTRY

Pongsak Holimchayachotikul[(a)] , Teresa Murino[(b)], Pachinee Payongyam[(c)], Apichat Sopadang[(d)] , Matteo Savino[(e)], Romano Elpidio[(f)]

[(a)]College of Arts, Media and Technology Chiang Mai University, Chiang Mai, 50200, THAILAND

[(b)] ,[(f)]Department of Materials Engineering and Operations Management
University of Naples "Federico II" P.le Tecchio – 80125 Napoli ITALY

[(c)] ,[(d)]Department of Industrial Engineering Faculty of Engineering
Chiang Mai University, Chiang Mai 50200, THAILAND

[(e)]Department of Engineering, University of Sannio
Piazza Roma, 21 Benevento 82100, ITALY

[(a)]holimchayachotikul@hotmail.com, [(b)]teresa.murino@unina.it, [(c)]karagenan@hotmail.com,
[(d)] apichat@chiangmai.ac.th, [(e)] matteo.savino@unisannio.it , [(f)]elromano@unina.it.

ABSTRACT

Owing to the U.S Hamburger crisis effect since the middle of 2007, frozen food products export industry sector, especially cooked chicken products export to Japan of Thai industry, endeavor has been spent in the supply chain management (SCM) of internal efficiency, merely aiming at competitiveness survival in terms of better quality and cost reduction. To reach the customer satisfaction, the company must work towards a right time and volume of his demand delivery. Therefore, forecasting technique is the crucial element of SCM operation. The more reducing inventory and capacity planning cost increase their company competitiveness; the more understanding how their company use the right forecasting based on information sharing in their SCM context. Currently, most of the companies, in this sector, do not have a right knowledge to implement the suitable forecasting system to sustain their business; furthermore, they only use top management judgment and some of the economical data for production. On the ground of the complex, stochastic, dynamic nature and multi-criteria of the logistics operations along the food products exporting to Japan of the Thai industry supply chain, the existing time series forecasting approaches cannot provide the information to operate demand from upstream to downstream effectively. The aim of the paper is to develop an innovative and simplified forecasting system and then implement for this industry based on data mining including time series factors and causal factors. This research methodology was designed with the case study company managers and engineers. Artificial neural network (ANN) theory was used to develop time series forecasting model for case study product. The type of ANN implemented was Multilayer Perceptron with the Quick-propagation training algorithm by using time series factor and causal factor such as Thai- Japan, EU-Thai and USA-Thai exchange rate, customer demand forecast and the other economic factors, from the case study company as input. The accuracy of the neural network model was compared with traditional customer demand forecast. The experimental results suggested that the ANN was capable of high accuracy modeling and resulted in much smaller error in comparison with the results from the present forecasting method of the company case study.

Keywords: supply chain collaboration, artificial neural network, frozen food

1. INTRODUCTION

Supply chain management strategies are mostly focused on improvement of customer support service levels as well as the operational cost reduction in order to sustain their profit margins. It is extensively admitted many various forecasting techniques by global firms that is one of the outstanding nub competencies for an organization to reach the right quality and time to deploy their goods in the markets. Therefore, the forecasting system performance in supply chain has attracted firm and researcher s' attention. The more complicated in supply chain system according to various demand patterns, the more forecasting methods are developed and augmented to handle with it. No matter what the dramatic change in quantity from each unit in supply chain, an inaccurate forecast in one place of the supply chain can affect the whole supply chain due to the bullwhip effect, which also affects the manufacturing plans and any plans to conform to

customer demands in terms of time and quantity - a significantly difficult problem in business.

This research is appointed to apply the novel back-propagation artificial neural networks, namely Quickprop in the demand forecasting of the supply chain to be able to realize the true demand of customers even more accurately by the special input preparation. The forecasting techniques used in supply chain management are categorized into three groups, which are 1) Traditional techniques such as moving average, exponential smoothing and ARIMA such as Co and Boonsarawondse (2007) have forecasted the rice export of Thailand using artificial neural networks that imports time series, smoothing exponential time series and ARIMA. The imported data was dated from January 1996 to December 2004 and January 2005 to December 2005. The results of the trial were that artificial neural networks were rated best with ARIMA in second.
2) Computational intelligence techniques such as artificial neural network and support vector regression. For instance, Leung (1995) has introduced an approach to applying artificial neural networks to various aspects of the supply chain management for instance, forecasting, optimum parameter achievement, model and simulation creation, and decision support. Chiu and Lin (2004) has also applied multilayer perceptron to forecast collaborative supply Chain planning of an alliance of small firms.

3) Hybrid methods such as applying traditional techniques such as ARIMA with artificial neural networks or support vector regression, or applying fuzzy system techniques with ARIMA which presents us with techniques more complex but of higher accuracy. Most of application in this field has also use the traditional input type to form forecasting model; hence, this research use the combination of input factors from time series and economical factors from the industry of interest while traditional techniques can only use time series data. For incident, Vahidinasab (2008) introduced a price forecasting system for electronic appliance repair and maintenance in the Pennsylvania-New Jersey-Maryland using artificial neural networks trained

This paper is organized as follows. In section 2, the Quickprop algorithm was briefly described. In section 3, the problem statement of the frozen chicken products exports to Japan of Thai industry sector. In section 4, the methodology of the proposed approach was shown. Results and discussion of the proposed framework were shown in section 5. This section has the proposed model performance comparison with the present forecasting method of company case study. Finally, conclusions were provided in section 6.

2. BACKGROUND

ARTIFICIAL NEURAL NETWORK

Multilayer perceptron (MLP) was wildly used in many researches. It comprises of processing elements called neuron located in layers. Some or all of the outputs in each layer are connected to one or more inputs in the next layer. The input layer is the first layer, where the MLP receives input parameters. The output layer is the final layer, where the outputs are provided to the user. The hidden layers are located between input and output layer. The task of the individual neuron is to take inputs from the outside, or from other neurons connected to it, and sum these inputs according to their weight or the strength of the connection of each input. A transfer function is then adopted to produce the output. Back propagation (BP) is the most extensively adopted learning algorithm C.A.O. Nascimento *et.al* (2000). The output layer provides a response depending on training history of the network. The trained network should be able to correctly predict outputs for unseen input conditions. The Quickprop can be described as follows: Quickprop uses the concept of second order error derivative information instead of only the usual first order gradients algorithm S. Kuman (2005). This is based on two assumptions. First, the error function ε is a parabolic function of any weight w_{ij}, and second the change in the slope of the error curve is independent of other concurrent weight changes. To compute the weight, the previous value of the gradient $\partial\varepsilon/\partial w_{ij}^{[s-1]}$ and the previous weight change $w_{ij}^{[s-1]}$ are required. Then

$$w_{ij}^{[s]} = \frac{\dfrac{\partial\varepsilon}{\partial w_{ij}^{[s]}}}{\dfrac{\partial\varepsilon}{\partial w_{ij}^{[s-1]}} - \dfrac{\partial\varepsilon}{\partial w_{ij}^{[s]}}} w_{ij}^{[s-1]} = \alpha_{ij}^{[s]} w_{ij}^{[s-1]} \qquad (1)$$

3. PROBLEM STATEMENT AND CASE STUDY

The stated problem has taken place the case study factory which is a frozen chicken products export to Japan of Thai industry sector. From this case study supply chain diagram in Figure 1, the research area was focused on the planning division of case study company, who forecasts and plans the finished frozen chicken product, exported following Japanese customer demand.

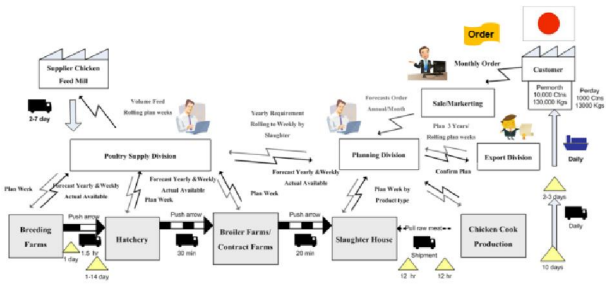

Figure 1: Supply chain of the Thai frozen chicken export to Japan

The customer demands are highly uncertain, causing current forecasting methods not being accurate enough and can lead to various problems in production plans such as over purchasing clutch food and planning clutch

production, which results in high costs on reserved goods. Moreover, the material in this company case study is not able to storage much more time because it is the fresh chicken meat. Other effects are excess overtime for employees and increased costs in bringing chick up. Purchasing insufficient materials can also result in production holds, leading to loss in sales opportunities. This is why demand forecasting is very important in management of the supply chain. Leading companies have agreed that customer demand can be managed only to a certain degree. Demand fluctuation is an important reason that causes conflicts in demand and supply chain which in ideal conditions; everyone desires to know the demand and the value chain to be constant.

4. METHODOLOGY

From documents and related researches, we can define the processing methodology. A schematic diagram of the proposed conceptual framework is shown in Figure. 2. This comprises of the combination of feature selection, ANN applied to build the innovative and simplified forecasting system implementation for supply chain of frozen chicken products export to Japan of Thai industry based on data mining including time series factors and causal factors such as gold price, oil price, dollar-bath and yen-bath exchange rate. According to the normal planning production of this case study company, the proposed framework is developed to provide the potential forecasting value of production plan when they do not receive the final confirmation of demand within the period.

The phases are as follows :

4.1. Exploring and selection of data

Current demand in case study company of cooked chicken products export to Japan of Thai industry supply chain Primary data analysis, following the concept of demand forecasting in SCM based on collaborative planning forecasting and replenishment (CPFR), of the case study factory are conducted by means of basic demand and supply data of the supply chain to measure the efficiency of customer conformance and production and resource management to define the direction of solving the problems.

4.2. Data Preparation and Sufficiency

Data cleaning process was performed to eliminate noise data. Next, the cleaned data was rearranged following input and output format for each method. Data sufficiency was employed to indicate the suitable quantity of data for data mining learning process. Moreover, monte carlo simulation will generate the data in case of insufficiency of data

4.3. Learning data preparation

The data from 4.2 can used for forecast modeling by randomly dividing the data sets into three groups for training and test set were 80 and 20 percentage of all data, respectively.

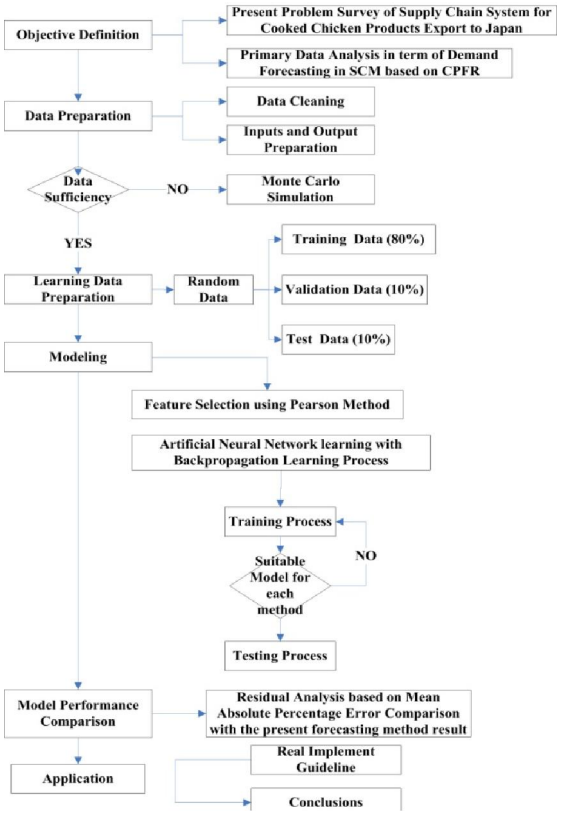

Figure 2: Schematic diagram of the proposed

4.4. Artificial Neural Network Learning Process

4.4.1. Input Feature Selection process

Pearson's chi-square was used for indicating significant input factors related with the next week customer demand at the 95 percentage of confident interval.

4.4.2. Develop the Suitable Structure of Artificial Neural Network Model

Artificial neural network learning with Quickprop was constructed based on the appropriated component from grid search. The data from 4.3 can be used for forecast modeling development. In addition, MAPE of test set was used as the threshold for indicating the appropriated model based on over fitting checking with residual analysis for each data mining technique. If the MAPE of test set was less than or equal five percentage, it can imply that the structure of this method will be the suitable structure.

4.4.3. Model Performance Analysis and Comparison

MAPE of artificial neural network employed for comparison with the traditional forecasting (case study company's present forecasting) to find the best technique for demand forecasting of case study company.

5. RESULT AND DISCUSSION

5.1. Input Feature Selection process

The result of Pearson's chi-square was used indicate the significant degree of each input factor ,related with the next week customer demand at the 95 percentage of confident interval. 22 of the interested factors are chosen as the inputs of this feature selection process. Last but not least, the result Pearson's feature selection was shown in the Figure 3. It is certainly true that the next plan load is the most significant factor with 0.999 of importance value. In the research, the factors ,which have the important value greater than 0.75, were used as the input factor for the neural network model as follows the next plan load, Thai-Japan exchange rate, fish scrap, broken-milled rice, gold price, 4 moving average and 3 moving average. We also found that the other exchange rates and the fuel price are not effect to the customer demand.

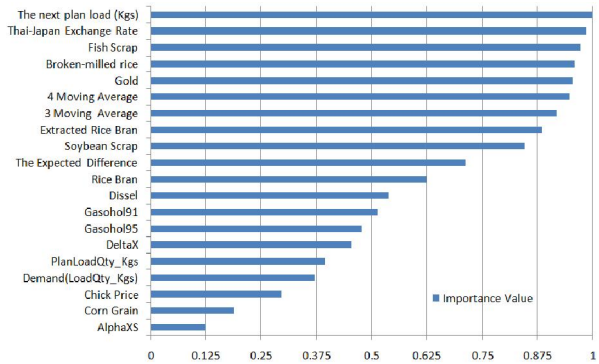

Figure 3: The importance value of each factor

5.2. Artificial Neural Network learning process

In this study, all computational experiments are performed on Intel Centrino Core 2 Duo, 2.4 GHz CPU and 4 GB of memory. A total of 80 actual results obtained from actual customer demand collection. The period of data collection is 2 year and 7 month. It is enough to perform the forecasting model because its period can capture the changing and movement of the customer demand in this supply chain. After data cleaning (remove the abnormal values) process, these data were divided into two sets. The first 80% of data (approximately 64 samples) were used for training, while the rest 20% (approximately 16 samples) were used in the testing process. Accuracy of the network was measured by mean square error. Exhaustive search was used to identify network parameters to achieve the best setting with minimum error. The search was conducted with 10,000 iterations and two retrain in each combination. Testing error fitness criterion was used. The smaller the error on the test set the better the accuracy of the network. Space search of two hidden layers started from 1 to 50 hidden nodes in each layer with search step one by one. The best topology obtained from the search was 7-20-20-1 network, as depicted in Figure. 4. The Quickprop algorithm was used in training process. The network was trained with sigmoid transfer function for hidden and output layers. The coefficient term of 1.75 was used for fast convergence. Consequently, the number of training iterations was 500,000 epochs and the initial values of weights and biases are random.

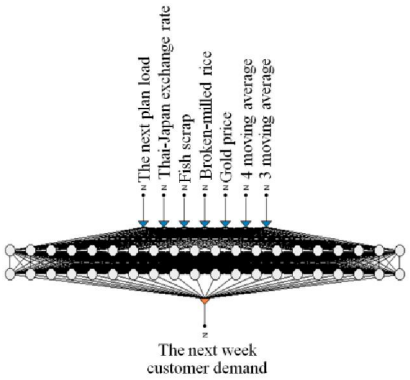

Figure 4: The Quickprop network topology

5.3. Model Performance Comparison

The results from the traditional method and neural network based on time series and economical data. The test set data are shown in Figure 5. The performance of each model was compared by using MAPE of the overall data set, training data set and testing data set.

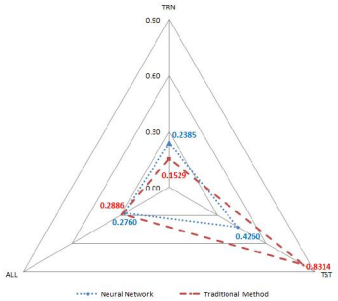

Figure 5: The MAPE comparison of desired output and the output from approaches.

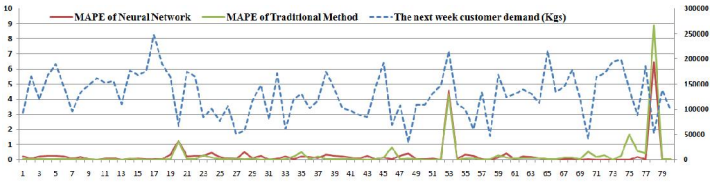

Figure. 6 The MAPE comparison of desired output and the output from approaches.

Figure. 6 shows the MAPE comparison of the desired output of the next week customer demand compared with the results obtained from two approaches. The training data were cases 1-64 and the testing data were cases 65-80. This chart has also provided some of the real next week customer demand from January 2007 – July 2009. According to the overall data set error, it was found that neural network is lower error than the traditional method. It is clearly seen that neural network provides a good results and suitable to deal with the real problem. As a result, it

was used for the forecasting demand model for this case study supply chain.

6. CONCLUSIONS

This paper has described the application of neural network, trained with the time series factor, the causal and the other economic factors, to construct the innovative and simplified forecasting model for the Thai frozen chicken product export to Japan supply chain. After performing test set forecasting (16 weeks), it can be efficiently employed to reduce the waste production of frozen chicken approximately from 16,500 kgs to 3,800 kgs. As a result, the direct cost of company cuts has been cut down around €5,800 of this period, from the enchanting forecasting system of this supply chain planning system based on the information sharing between customer and company. Further research in each step of this research will develop the complicated forecasting system based on qualitative factor with some data to see the real effect should be done. Moreover, we might conduct the other data mining tools such as support vector regression, recurrent neural network and ANFIS to compare their performance with this work.

ACKNOWLEDGEMENT

The financial is supported by three main organization as follows Department of materials engineering and operations management of University of Naples "Federico II", Erasmus Mundus, External Cooperative Window Project, The Logistics Research Center, The Thailand Research Fund (TRF Master Research) and College of Arts, Media and Technology Chiang Mai University, THAILAND.

REFERENCES

C.A.O. Nascimento, R. Giudici, R. Guardani, 2000. Neural network based approach for optimization of industrial chemical processes, *Computers and Chemical Engineering*, 24 (9-10), 2303-2314.

CHIU, M. & LIN, G., 2004. Collaborative supply chain planning using the artificial neural network approach. *Journal of Manufacturing Technology Management*, 15, 787-796.

CO, H. C. & BOOSARAWONGSE, R., 2007 Forecasting Thailand's rice export: Statistical techniques vs. artificial neural networks. *Computers and Industrial Engineering*, 53, 610-627.

LEUNG, H. C.,1995 Neural networks in supply chain management. *IEEE International Engineering Management Conference* , 347-352.

VAHIDINASAB, V., JADID, S. & KAZEMI, A. ,2008 Day-ahead price forecasting in restructured power systems using artificial neural networks. *Electric Power Systems Research*, 78, 1332-1342.

S. Kuman,2005. Neural networks a classroom approach, *International Ed. Mc Graw Hill*, 198-199

AUTHORS BIOGRAPHY

Pongsak Holimchayachotikul is a Eramus Mundus Doctoral student at Department of Engineering, University of Sannio, Italy. He also do research at Department of Materials Engineering and Operations Management University of Naples "Federico II" , Italy. He received M.Eng in Industrial Engineering and B.Eng in Computer Engineering at Chiang Mai University, Thailand in 2008 and 2006 respectively. His research interests include supply chain and logistics management, data mining, optimization, decision making for management and applied operations research.

Teresa Murino is researcher in Department of Materials Engineering and Operations Management University of Naples "Federico II". She teaches "Industrial Logistics" at the University for students in Logistics & Production Engineering (3rd year) and "Manufacturing System Management" for students in Mechanical Engineering (4th year) degree courses. The research interests include Advanced Models and Applications of Logistics & Manufacturing, simulation with system dynamics and optimization problems , data analysis

Pachinee Payongyam is a Researcher in Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University, Thailand. She is going to study in Master Program of Industrial Engineering at Chiang Mai University. She has received the scholarship from Her research interests include supply chain management, simulation and lean manufacturing

Apichat Sopadang is an Assistant professor in Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University, Thailand. He received a Doctoral of philosophy degree from Clemsom University, USA in 2001. His research interests include lean manufacturing, supply chain and logistics management.

Matteo Mario Savino is Professor of Industrial Operations and Industrial Management at the University of Sannio. He got a PhD in Industrial plants in 1999 at the University Federico II of Naples, Department of Design and Industrial Engineering. His research interests are mainly related to Supply Chain and ERP management, Quality aspects related to industrial production and scheduling of production systems. He has managed several National and EU Funded research and educational projects. From 2008 he is Delegate of the Rector for Quality Assurance and is the President of the University Quality Centre.

Romano Elpidio is a Doctoral student at Department of Materials Engineering and Operations Management University of Naples "Federico II" The research interests include Advanced Models and Applications of Logistics & Manufacturing, simulation with system dynamics and optimization problems , data analysis