Journal of Asian Scientific Research
ISSN(e): 2223-1331/ISSN(p): 2226-5724

journal homepage: http://www.aessweb.com/journals/5003

FORECASTING DETERMINANT OF CEMENT DEMAND IN INDONESIA WITH ARTIFICIAL NEURAL NETWORK

Edy Fradinata[1]† --- Sakesun Suthummanon[2] --- Wannarat Suntiamorntut[3]

[1]*Industrial Engineering and Management Dept. Serambi Mekkah University, Banda Aceh, Indonesia*

[2]*Industrial Engineering Dept. Prince of Songkla University, Hatyai, Songkhla, Thailand*

[3]*Computer Engineering Dept. Prince of Songkla University, Hatyai, Songkhla, Thailand*

ABSTRACT

This paper was presented Artificial Neural Network (ANN) as one of the predicting methods to obtain more accurate predicted data. Several methods have been applied to this purpose but still not gave a better accuracy. The method could be used in linear and nonlinear characteristic of data. Back propagation neural network was implemented in this experiment to solve the predicting problem. This research proposed to predict some future points to get the advantages from it. The data was demonstrated in generate from determinant of cement demand in Indonesia region. The data was used 6 variables which influenced the demand factors. The contribution of this experiment was an exploring the accuracy of predicted and the future points value of data. The result of this experiment was: data A, B, C, D, E and F data had the range of MSE 6.23e-9 until 1.34e-7. The MSE for the actual data was 2.39e-6 and the predicted was 1.99e-6. The predicting points has resulted on months 91 until 97 were 0.5854, 0.8448, 0.510, 0.6462, 0.8528, 0.516 and 0.5074 respectively. The delta between predicted and actual data were 0.0066, 0.1418, 0.069, 0.1492, 0.2038, 0.355, and 0.1046. The result of this experiment could be used to predict the future months on the time frame with neural network and measured the MSE of its performance.

Keywords: Artificial neural network (ANN), Determinant of cement demand, MSE, Cement industry, Predicting, Forecasting, Linear-nonlinear, Time series.

Contribution/ Originality

This study is one of very few studies which have investigated where it was specified in generated data from some variables of cement demand, time series demand characteristics of data, used neural network method with its parameters and in Indonesia region. Explanation of ANN step by step.

† Corresponding author
DOI: 10.18488/journal.2/2015.5.7/2.7.373.384
ISSN(e): 2223-1331/ISSN(p): 2226-5724

1. INTRODUCTION

Demands is an economic principle where the situation of the ability of customer to buy or pay some product in the condition of specific service of it. The price of a product or service increases if its demand increases and vice versa. Demand forecasting is the way to predict the data in the future based on the historical data determinant of demand to reach some locations of extrapolative in the future, [1]. The mainstream of statistical methods are practical for this field, such as moving average, to curve-fitting techniques, to time series analysis, and some other approaches with their improvement, [2].

The customer fill rate of demand can move in any conditions of demand behavior, [3]. Generally, some industries are using a qualitative method to predict demand need based on judgment, outlook, past experience or best guesses, to make accurate forecast, [4]. There are many forecasting methods that could be applied to predict the certainty and uncertainty conditions in the future, [5]. Time series regression data mining technique will be applied for this area, [6].

Forecasting is the method that usually used to predict the future condition which relevance to quantity, quality, time and the location to meet the customer need. Actually the forecasting have some approaches qualitative approach and quantitative approach, [7]. Other side the time series model for forecasting have 4 kinds of data behaviors: trend, seasonal, cycle and horizontal or stationary, [8].

Artificial Neural Network (ANN) is one of data mining in artificial intelligent methods. The system of network works based on the neurons look likes the biological system in the brain of nervous system. The key point of this paradigm is the information structural which is very highly interconnecting belong the neurons. The neuron works simulation to be partners belong them to solve the certain problems. ANNs, like human, learning by example or historical data. The ANN usually used for specific application in pattern recognition or data classification by process of learning system. ANN is able to solve linearity and nonlinearities, discontinues which capability of adaptively and learning process inside, [9] Application in Portland cement for forecast demand as well, [10]. The purpose of this research is to explore some objectives, such as predict some months in the future situation and its performance. The prediction is very useful to do by the business organization to know briefly the next situation to take some advantages for their profit. That was why the assumption of cement demand data was needed by the factory to starting the forecast demand. More specifically, the random data were been tried to variety of the customer demand data to predict the future situation.

Finally, this paper was mainly propose a neural network approach to get some conditions of the customer cement demand in the future. Some theories mention that better prediction should be produce the better result of prediction will contribute much opportunities and advantage of profit for the factory.

2. METHODS

2.1. Artificial Neural Network (ANN) Approach

ANNs, which is illustrated in Fig.1 has developed to the brain simulating cognitive learning process of animals. Nevertheless, lately in many areas like business, health, education, agriculture, robotic, engineering and environmental adopt the concept of neural network to solve the problems. It can contribute the exact significant solution with more accuracy to perform the complex modeling problems, [11] such as illustrate in Fig.1.

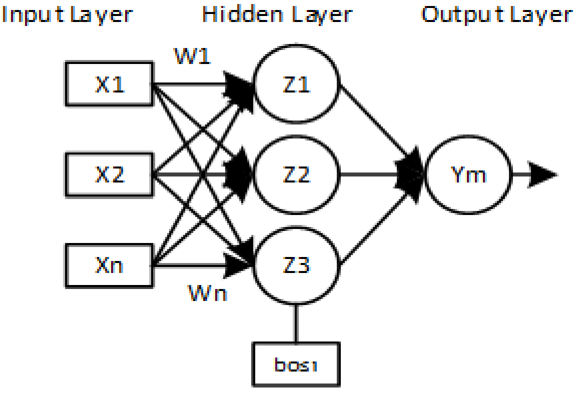

Fig-1. Perceptron with representations of neuron

The output y_o is shown in Eq 1.

$$y_0 = f(\sum_{i=1}^{n} w_i x_i + w_o) \tag{1}$$

And the representative of bias $x_o \leq 1$ show in Fig.1 and the weight from input should be shown in Eq.2.

$$w^T x + w_o \geq 0 \tag{2}$$

Meaning that the activated and produced is an output signal. The input layer could be used linear or nonlinear likes time series, [12]. This has been activated by its activation function with this matter and sigmoid activation function Eq 3 and Fig. 2.

$$f(x) = \frac{1}{1+\exp(-x)} \tag{3}$$

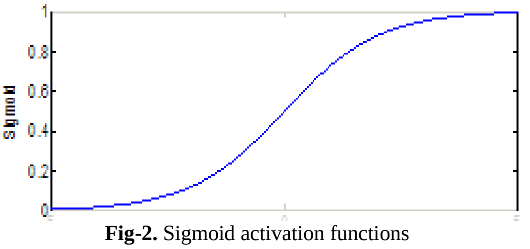

Fig-2. Sigmoid activation functions

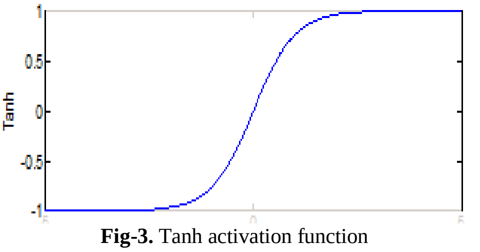

Fig-3. Tanh activation function

Fig. 2 is the sigmoid function s: R →(0,1) and in the case of hyperbolic tangent the mapping is tanh : R→(-1,1) in Fig.3. It is very Common used the activation function and shall also require a function that has continuous derivatived since this is a property required by the "networks" learning, [13]. And the hyperbolic tangent function, in Eq 4, Fig 3.

$$\tanh(z) = \frac{e^{s} - e^{-s}}{e^{s} + e^{-s}} \tag{4}$$

The recursive learning algorithm is *α-LMC Algorithm and the weight is automatically the weight value is w(k) and the advantage of* $\eta\varepsilon(k)x(k)$ for proposing the next weight value, that shown in Fig 1 and in Eq 5.

$$w(k+1) = w(k) + \eta\varepsilon(k)x(k) \tag{5}$$

Recently, most companies try to create the new model for forecasting to control the demand. It is important because companies can manage their quality of planning for their financial, [14]. The planning can make periodically as a real time, weekly, monthly, quarterly and yearly basis.

2.2. Demand

Small enterprises, the government, the individual and the household need the certain good, service or commodity in overall factors that are called determines of demand. Determinant of demand usually have some factors, such as: GDP growth, Population, Potential Customer, Price, Sales, Promotion, Quality the expectation future price and preference,

The demand forecasting development uses statistical methods for extrapolative historical data into the upcoming,. The practice selects the greatest potential method for forecasting future demand based on various user and classification inputs, [15]. The users to explanation for dissimilar types of demand characteristics, such as lumpy demand, seasonal demand, and so on, also present statistical parameters.

2.3. Mean Square Error (MSE)

Demand patterns are significant to continue tune the system to construct optimal forecasts, [16]. There are various measures the error in prediction method, some equations usually use to identify the error; *Mean Square Error* (MSE) is the estimator for measuring the Average of Squares Errors. Mean Square Error (MSE), of an Estimator measures the average of the squares of the "errors", that is difference between the estimator and what is estimated, [17, 18]. Eq. 6.

$$MSE = \frac{\sum_{i=1}^{n} (yt - Ft)^{\wedge 2}}{n} \tag{6}$$

Where,:

y_t is the actual value time period of t,

F_t is the forecast value time period of t and

n is the number of periods.

3. METHODOLOGY

Demand forecasting is needed by the business unit like manufactures and industries. This activity will give the impact to them for maximum profit to their business. This research use the backpropagation network to get the minimum error. This condition was taken to anticipate the more competition belong the competitors of cement industries in Indonesian region.

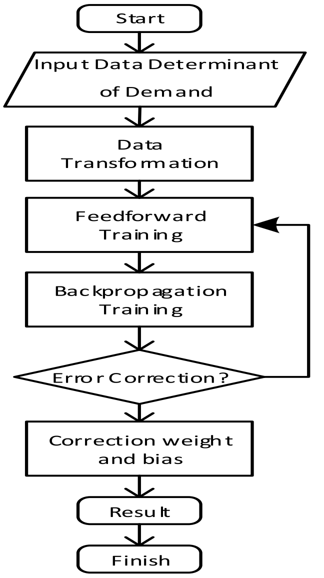

Fig-4. Flow chart of ANN step

The data of determinant of demands are transformed (0,1) before it will be trained with feed forward back propagation network, correction weighted and bias with trial and error, then get the result from the output. The network, training, and correction weight step explained as follow:

The steps of algorithm of backpropagation: using sigmoid as the activation function is very common, as follow:

- Step 1, Initialization the weight (determine the small number, usually 0.5).
- Step 2, if the error still need trial. (do the step 2-9).
- Step 3, for the training function when using feedforward (use the step3-8).
- Step 4, Every input unit (X_i, i= 1,…n). this input distribute to the next layer (hidden layer).
- Step 5, For every hidden layer, (Z_j , j = 1,….,p), the input multiply the weight and make the accumulative amount, and using activation function to calculate the out put (zj=f(z_in), and send this respond to next layer (output layer).
- Step 6, for every unit output (Y_k , k = 1,…,m) and using the weighted together to y_in =w_{oj}+Y_k).

Backpropagation from error

- Step 7, For every error (Y_k , k = 1, ….,m) receive the target value which relevance to the input, calculation of it error is ($\delta k = (t_k - y_k) f'(y - in_k)$ and calculate the weight correction ($\Delta w_{jk} = \propto \delta_k z_j$) and calculate the bias ($\Delta w_{ok} = \propto \delta_k$) and send the δ_k to the former layer unit.
- Step 8, the hidden (Z_j , j = 1,….,p), add with δ_{in} and with the activation function to calculate the error $(\delta\_in_j f\left(z_{in_j}\right)$ calculated with the its weight $(\Delta v_{ij} = \alpha \delta_j x) j$ and the correction of bias ($(\Delta v_{oj} = \alpha \delta)$.

- Step 9, For every output (Y_k , k = 1, ….,m) the bias and weight was updated (j=1,…,p)(w_{jk}(new) = w_{jk} (old) + Δ w_{jk}), for every hidden layer (Z_j , j = 1,….,p) the weight and bias were updated (i=1,…..,p)(v_{ij} (new) = w_{jk} (old) + Δ w_{ij}).

At last the process of the weight and bias result the output of the performance.

4. STATISTICAL ANALYSIS

This experiment was limitation in some variables determinant of demand, such as GDP growth, (D1); Population, (D2); Number of Customer, (D3); Price, (D4); Sales, (D5), Promotion,(D6); quality, (D7); Expectation Future price, (D8); Preference price, (D9),.

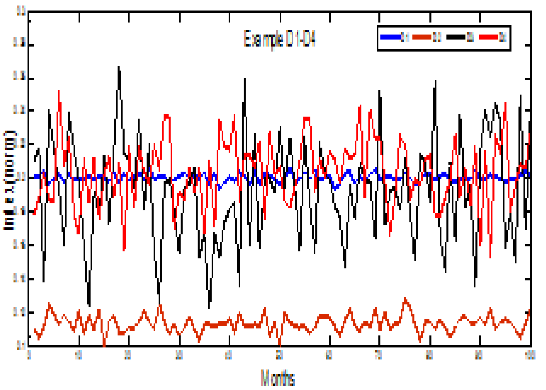

Fig-5. Data from D1 until D4

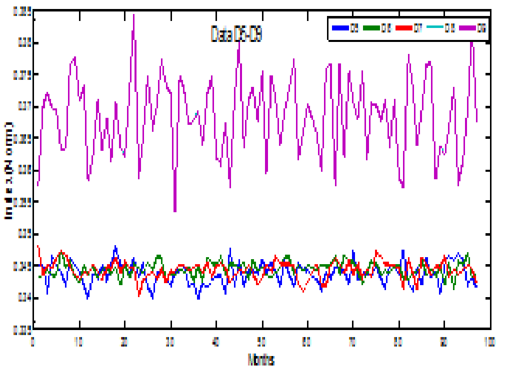

Fig-6. Data from D5 until D9

Fig 5 and 6 show the movement of the 9 variables before selected to be 6 variables caused of the correlation between the predictors where it were been selected to be used. The movement of every data shown very different movement form its time frame. The data was taken its characteristic and then generated to get the amount of data.

ANN is one of data mining methods, the way of the neural network process were the variable selection, data collection, data preprocessing, training and testing set, setting of paradigm of neural network, evaluation.

A. Test Determinant of Variables

This experiment will use one of the classification method in forecast assumption (classical test), select the variable with the certain correlation to demand data for entered/removed. SPSS software will be used to get the result from only six variables that can be used to the analysis of further step and do the autocorrelation test with Durbin Watson. The data eligible usage 97-time frame of data, (8 years).

The variation of the MSE in the different number of variables shown in Fig 5 and 6. The data from D1 until D9 show the fluctuation and different movement of data. Example of the movements data are as follow, see in Fig 7.

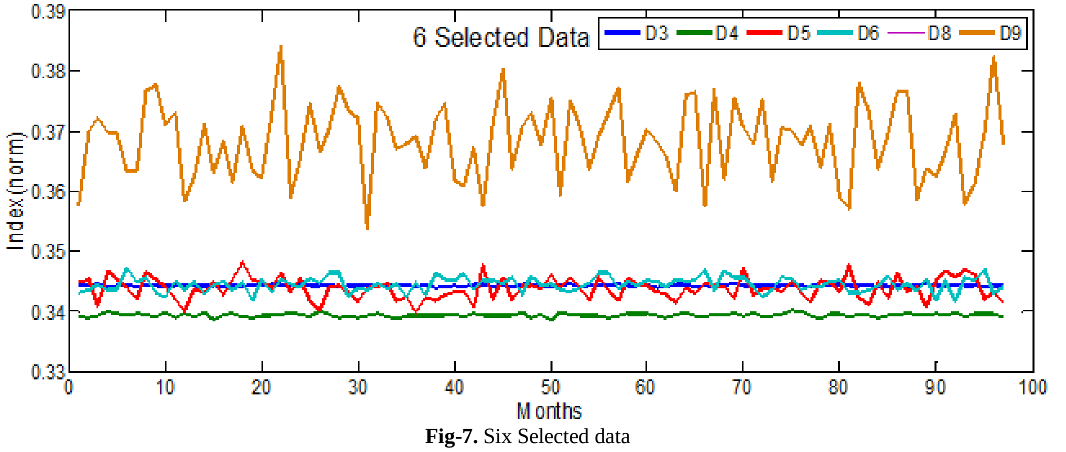

Fig-7. Six Selected data

B. Preprocessing

Preprocessing data has a purpose to arrange the data for more informative to produce the better result from the process. Some of treatments on this step usually using the transformation into more understandable to process such as making in the cross-tabulation standard. From the cross-tabulation we try to delate the missing value and outlier on the group of data if any.

C. Training and Testing Set

This research was using the parameters with variable input were 6, activation function was sigmoid, amount of data 97, learning rates were 150, hidden layer was 1 neuron 10 training function was trainLm, total layers were 3, and network type was feedforward backpropagation.

D. Exploratory Analysis

In this research we used the Durbin Watson test to know the correlation belong the variable predictors to independent variable such as demand variable. From the analysis of the data we got some variables could be used cause of the correlation reason as follow: D3, D4, D5, D6, D8, and D9. It could be seen in the Table 1 for the model summary.

Table-1. Model Summary[b]

Model	R	R Sqr	Adjusted R Sqr	Stdr Error	Durbin Watson
1	.283	.08	.019	.1670	1.741

a. Predictors(Constant), D9,D3,D5,D8,D6,D4
b. Dependent Variable: DEMAND

The value of calculation 1.741 was dropped between 1.489 and 2.150, (Accepted the assumption no correlated belong the predictor white noises), meaning that there was no autocorrelation between the noises belong error disturbing, and it was explained in Table 1.

For the validation, demand data was divided in to two groups, they were 90% for training and 10% for testing. The training data was used for the model and testing using for validating. The set up parameter for algorithm were: Training using Levenberg-marquate, network using feed forward backpropagation, training function was using trnlm, number of hidden layer was 1, total layers were 3, transfer function was logsig and number of neurons were 10. Set iteration was 150. The result from the process were as follow: test of best validation, Fig.9 show the performance of best validation from the third tests: training, validation, and testing set. There was an additional line to show the best validation performance point where the stop training point was caused by the validation started increased to protect the over fitting. See in Fig.9.

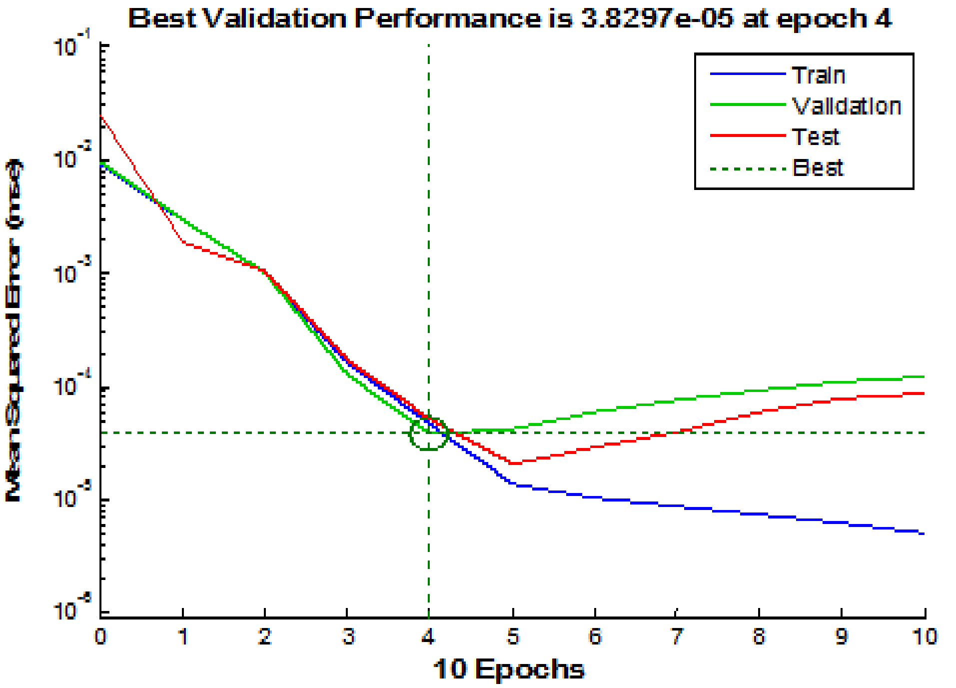

Fig-9. Best validation test for demand

The result view of the best validation performance and their MSE for every variables (6 variables) could be shown in Table 2, from this variable also could be analyzed that the MSE from data A (D1) to F (D9) have a tend to decreased and the best validation performance tend to increased.

Table-2. The best validation performance and MSE for each variables

Data	MSE	Best-Validation Performance
Data A (D3)	1.34e-7	5.023e-8
Data B (D4)	2.37e-7	1.927e-7
Data C (D5)	5.21e-8	1.373e-6
Data D (D6)	4.07e-7	1.535e-6
Data E (D8)	3.27e-8	1.251e-6
Data F (D9)	6.23e-9	2.553e-6

To check the validation network performance was still in best fit condition we could see the validation line with R value 0,99819, meaning that the best fit of R was still very good, because if the value nearest to 1 is the best condition of comparative between output and target. See Fig.10.

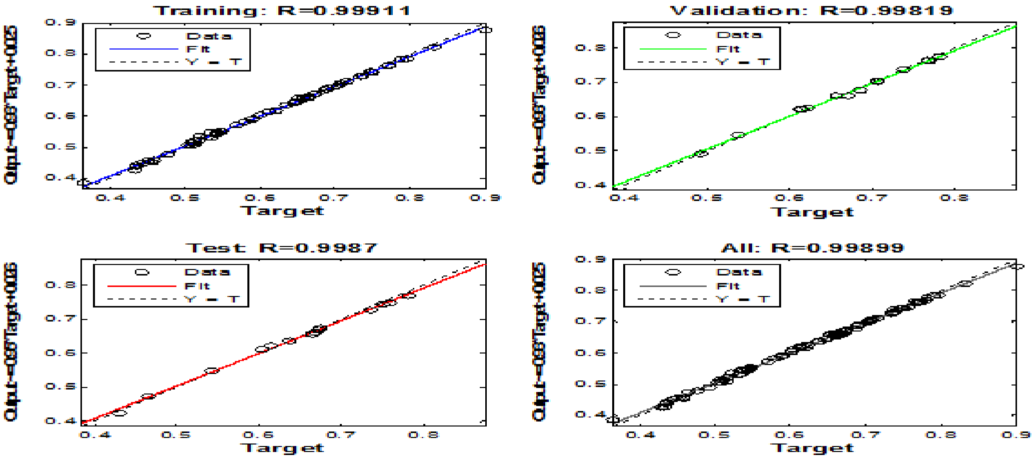

Fig-10. The best fit of Validation, training and testing set

E. Explore the Pattern

From the six data we already used random percent 90% data set (around 87 data from 97 data) was been used to be training process and then predicted from data 91 to 97.

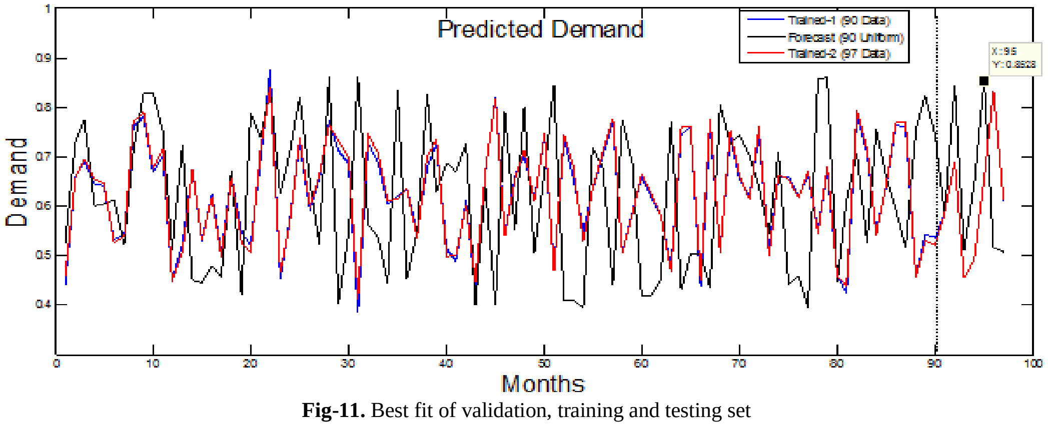

Fig-11. Best fit of validation, training and testing set

For more detail information could be explained under the Table.4 about the information the delta.

Table-3. The information of data, predicted and error.

Month	Data	Predicted	(δ)	Network Error
91	0.592	0.5854	0.0066	0.0001
92	0.703	0.8448	0.1418	0.0004
93	0.441	0.510	0.069	0.0058
94	0.497	0.6462	0.1492	0.0004
95	0.649	0.8528	0.2038	0.0003
96	0.871	0.516	0.355	0.0000
97	0.612	0.5074	0.1046	0.0004
Average			0.1471	0.0011
MSE	2.39e-6	1.99e-6		

From Table 3 was been explained some points of predicted data was much closed to the actual data (Data) and with very small performance, MSE 1.99e-6. From this research the method was very good enough to predict the future points in the next period of time because δ was been shown very small (closer to zero absolute), the δ network error was very small, too.

5. RESULTS

Finally, we conducted that the model from the predicted cement demand dataset give the view that the accuracy of ANN method and we got the result as in Table 3 and Fig.11. From that table we concluded that the very precise predicted data between actual data and predicted, also MSE from the ANN was very small 1.99e-6 as well. We concluded that this method had a high accuracy based on their MSE and the delta of predicted data. Our suggestion, next time it is better if we create the development of neural network with its constraints or hybrid to get more accuracy then now on.

6. DISCUSSION

Since our research was to explore the neural network as a forecasting method that could be applied to predict a certain or uncertain situation likes time series data in the future from cement customer demand. Some literatures had been used the neural networks as a tool but still very rare using cement generated data.

The topic is "Comparative ANN and SARIMA in Portland cement supply chain to forecast demand". From this research the researchers had the conclusion of ANN was better than SARIMA they took the single demand data from period *January 2004 to March 2005,* [10]. The title of "A decision support system to forecast cement demand". Their research was to determinant of variations to the relevant factors affecting cement demand and then to generate revised and updated estimates on a year to year basis, [19]. The other researcher with the title of "An improved demand forecasting method to reduce bullwhip effect in supply chains". In this research resulted the conclusion from comparative ANN-DWT and Arima. The demand of cement depends on various factors are establishment of new industrial projects, commercial, domestic, academic building, and construction of road, bus stops, schools or bridges, [20]. "Demand scenario analysis and planned capacity expansion". From this research resulted inputs: construction growth, GDP growth, and investment growth to specific business decisions such as planned capacity expansion policies that will improve the system performance, [21]. "ANN, ARIMA and MA timeseries model for forecasting in cement manufacturing industry: Case study at lafarge cement Indonesia—Aceh". This research resulted the ANN was better method than Arima and MA, [1].

From literatures above mention that ANN is very eligible and high capable to produced the model and was used the method for predicting data. In this study was contributed the more accuracy performance of ANN method when using in forecasting to predicted the future conditions of data, see in Table 3.

7. CONCLUSION

In conclusion, this study took the data from determinant of cement demand and was generated to be 8 years to identify the more accuracy when using to ANN method. ANN will work properly if data longer enough for training system. ANN method can be used for forecasting method to predict the future situation in linear or non-linear, as like time series dataset and gave more precision in predicted of data. This study will helpful for the other researchers and practitioners to explore the alternative forecasting methods.

8. ACKNOWLEDGEMENTS

This Project was financially under DIKTI or Kemristekdikti-Indonesia's scholarship 2012. I would like to respect and say thank you very much to the Higher Education, Research and Technology of Indonesia Government (DIKTI or Kemristekdikti) and Prince of Songkla University, Thailand as well.

Conflict of interest declaration: There is no conflict of interest among the authors.

Funding: This study received no specific grant from any funding agency.

Authors' contributions: Edy Fradinata- conception of study, data collection and analysis.

REFERENCES

[1] E. Fradinata, N. Sirivongpaisal, S. Suthummanon, and W. Suntiamorntuthq, "ANN, ARIMA and MA timeseries model for forecasting in cement manufacturing industry: Case study at lafarge cement Indonesia — Aceh," presented at the Advanced Informatics: Concept, Theory and Application (ICAICTA), 2014 International Conference, 2014.

[2] E. Kayacan, B. Ulutas, and O. Kaynak, "Grey system theory-based models in time series prediction," *Expert Systems with Applications,* vol. 37, pp. 1784-1789, 2010.

[3] Y. Lu, J. S. Song, and D. D. Yao, "Order fill rate, leadtime variability, and advance demand information in an assemble-to-order system," *Operations Research,* vol. 51, pp. 292-308, 2003.

[4] D. Waddell and A. S. Sohal, "Forecasting: The key to managerial decision making," *Management Decision,* vol. 32, pp. 41-49, 1994.

[5] D. Demeritt, H. Cloke, F. Pappenberger, J. Thielen, J. Bartholmes, and M. H. Ramos, "Ensemble predictions and perceptions of risk, uncertainty, and error in flood forecasting," *Environmental Hazards,* vol. 7, pp. 115-127, 2007.

[6] T. Hill, M. O'Connor, and W. Remus, "Neural network models for time series forecasts," *Management Science,* vol. 42, pp. 1082-1092, 1996.

[7] S. Makridakis, S. C. Wheelwright, and R. J. Hyndman, *Forecasting methods and applications*. New York: John Wiley & Sons, 2008.

[8] C. Petropoulos, K. Nikolopoulos, A. Patelis, and V. Assimakopoulos, "A technical analysis approach to tourism demand forecasting," *Applied Economics Letters,* vol. 12, pp. 327-333, 2005.

[9] S. M. Shi, L. Da Xu, and B. Liu, "Improving the accuracy of nonlinear combined forecasting using neural networks," *Expert Systems with Applications,* vol. 16, pp. 49-54, 1999.

[10] P. Liu, S. H. Chen, H. H. Yang, C. T. Hung, and M. R. Tsai, "Application of artificial neural network and SARIMA in portland cement supply chain to forecast demand," presented at the Natural Computation, 2008. ICNC'08. Fourth International Conference, 2008.

[11] C. Hemming, "Using neural networks in linguistic resources," Department of Languages, University College of Skövde, Swedish National Graduate School of Language Technology, 2003.

[12] B. Santosa, *Data mining Terapan dengan matlab*. Yogyakarta: Graha Ilmu, 2007.

[13] P. Balakrishna, S. Raman, T. B. Trafalis, and B. Santosa, "Support vector regression for determining the minimum zone sphericity," *International Journal of Advanced Manufacturing Technology,* vol. 35, pp. 916-923, 2008.

[14] H. Van Landeghem and H. Vanmaele, "Robust planning: A new paradigm for demand chain planning," *Journal of Operations Management,* vol. 20, pp. 769-778, 2002.

[15] M. L. Froukh, "Decision-support system for domestic water demand forecasting and management," *Water Resources Management,* vol. 15, pp. 363-382, 2001.

[16] R. Aggarwal and Y. Song, "Artificial neural networks in power systems. III. Examples of applications in power systems," *Power Engineering Journal,* vol. 12, pp. 279-287, 1998.

[17] L. Hong and W. Ping, "Bullwhip effect analysis in supply chain for demand forecasting technology," *Systems Engineering-Theory & Practice,* vol. 27, pp. 26-33, 2007.

[18] M. Rajopadhye, M. Ben Ghalia, P. P. Wang, T. Baker, and C. V. Eister, "Forecasting uncertain hotel room demand," *Information Sciences,* vol. 132, pp. 1-11, 2001.

[19] K. Ramani and B. H. Dholakia, "A decision support system to forecast cement demand," *Information Technology for Development,* vol. 8, pp. 169-182, 1999.

[20] S. Jaipuria and S. Mahapatra, "An improved demand forecasting method to reduce bullwhip effect in supply chains," *Expert Systems with Applications*, vol. 41, pp. 2395-2408, 2014.

[21] E. Suryani, S. Y. Chou, R. Hartono, and C. H. Chen, "Demand scenario analysis and planned capacity expansion: A system dynamics framework," *Simulation Modelling Practice and Theory,* vol. 18, pp. 732-751, 2010.

