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IMPROVEMENT OF DEMAND FORECASTING SYSTEM : CASE STUDY IN PVC LEATHER AND PLASTIC COMPANY

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A Thesis Submitted in Partial Fulfillment of the Requirements
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ณัฐกมล จินตโกวิท : การปรับปรุงระบบการพยากรณ์ความต้องการกรณีศึกษา บริษัท พลาสติกพีวีซี และหนังเทียม (IMPROVEMENT OF DEMAND FORECASTING SYSTEM : CASE STUDY IN PVC LEATHER AND PLASTIC COMPANY) อาจารย์ที่ปรึกษา : รศ. ดร. ปารเมศ ชุติมา, 140 หน้า.

ในวิทยานิพนธ์นี้ได้แสดงให้เห็นถึงการใช้การพยากรณ์โดยใช้โครงข่ายประสาทเทียมเพื่อพยากรณ์ยอดขายของสินค้าตัวอย่าง โดยในการพยากรณ์นี้จะใช้ อัตราดอกเบี้ย อัตราว่างงาน ดัชนีราคาผู้บริโภค ราคาน้ำมัน ดัชนีมวลรวมประชาชาติ อัตราการบริโภคภายในครัวเรือน อัตราการผลิตไยสังเคราะห์ อัตราการนำเข้า และอัตราการส่งออก เพื่อเป็นข้อมูลนำเข้าเพื่อใช้ในการพยากรณ์กับข้อมูลยอดขายในอดีตของบริษัท ผลลับที่ได้จากการพยากรณ์คือยอดขาย ในการพยากรณ์นี้จะใช้วิธีการเรียนรู้แบบการกระจายย้อนกลับ ในโครงข่ายนี้จะถูกฝึกเพื่อใช้พยากรณ์ยอดขายของสินค้าตัวอย่าง

สำหรับการพยากรณ์ยอดขายของเดือนกรกฎาคม 2548 ถึงเดือนมิถุนายน 2549 ผลที่ได้จากโครงข่ายประสาทเทียมมีความแม่นยำมากกว่าแบบวิธีเดิม โดยมีค่าร้อยละของความผิดพลาดที่ร้อยละ -1.09 โดยมีค่าเฉลี่ยผิดพลาดยกกำลังสองเท่ากับ 18.78 โดยที่วิธีการพยากรณ์แบบเก่าแบบวิธีค่าเฉลี่ย ซึ่งมีร้อยละของความผิดพลาดเท่ากับร้อยละ -5.163 และมีค่าเฉลี่ยผิดพลาดยกกำลังสองเท่ากับ 29.165

เพื่อที่จะแสดงให้เห็นถึงประโยชน์ของการพยากรณ์โดยใช้วิธีโครงข่ายประสาทเทียม บริษัทจะทำการปรับแต่งการวางแผนการผลิตโดยใช้การพยากรณ์โดยโครงข่ายประสาทเทียมแทนที่วิธีค่าเฉลี่ยของการเคลื่อนที่

ภายหลังจากการปรับแต่งการวางแผนการผลิตให้คล้องกับการพยากรณ์ยอดขายโดยโครงข่ายประสาทเทียม บริษัทสามารถลดปัญหาสินค้าคงคลังทำให้สามารถลดค่าใช้จ่ายได้ถึง 2,254,000 บาทหรือประมาณ 28 เปอร์เซ็นต์

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต.....ลายมือชื่อ.....

สาขาวิชา...การจัดการทางวิศวกรรม.....ลายมือชื่ออาจารย์ที่ปรึกษา.....

ปีการศึกษา..2550.....

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THESIS ADVISOR : ASSOC. PROF. PARAMES CHUTIMA, Ph.D., 140 pp.

This research presents the application of neural network to forecast the demand of the sample product. Interest rate, unemployment rate, consumer price index, oil Price, GDP, in House Garment Consumer Rate, synthetic Fiber Production, export Rate and import Rate are the input of the network which is properly train with historical sale data. The result of the forecasting is the sale volume. The learning process that we used in this thesis is backpropagation. This network is trained to be able to forecast the sale volume of sample product.

For sale volume forecasting of Jul 48 – Jun 49, the result from artificial neural network provides more accuracy by having the percentages of error at -1.09 percent with MSE at 18.78 while the result from moving average technique has the percentage of error at -5.163 percent with MSE at 29.165

In order to simulated the benefits of the neural network forecasting technique, the company will adjusted the production planning by using neural network forecasting instead of moving average technique.

After the company adjusted the production planning according to the neural network forecasting technique, the company is successfully reducing the inventory problem. The total cost of the sample product is reducing around 2,254,000 baht which is 28 percent.

The regional Centre for Manufacturing Systems ..... Student's signature.....
Field of study Engineering Management ..... Advisor's signature.....
Academic year 2007

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This Thesis would not be completed without lots of supports from many people.

I would like to give my thankfulness to Assoc.Prof. Parames Chutima, my advisor who always guides and supports me with precious suggestion and understanding.

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CHAPTER I

INTRODUCTION

1.1. Introduction

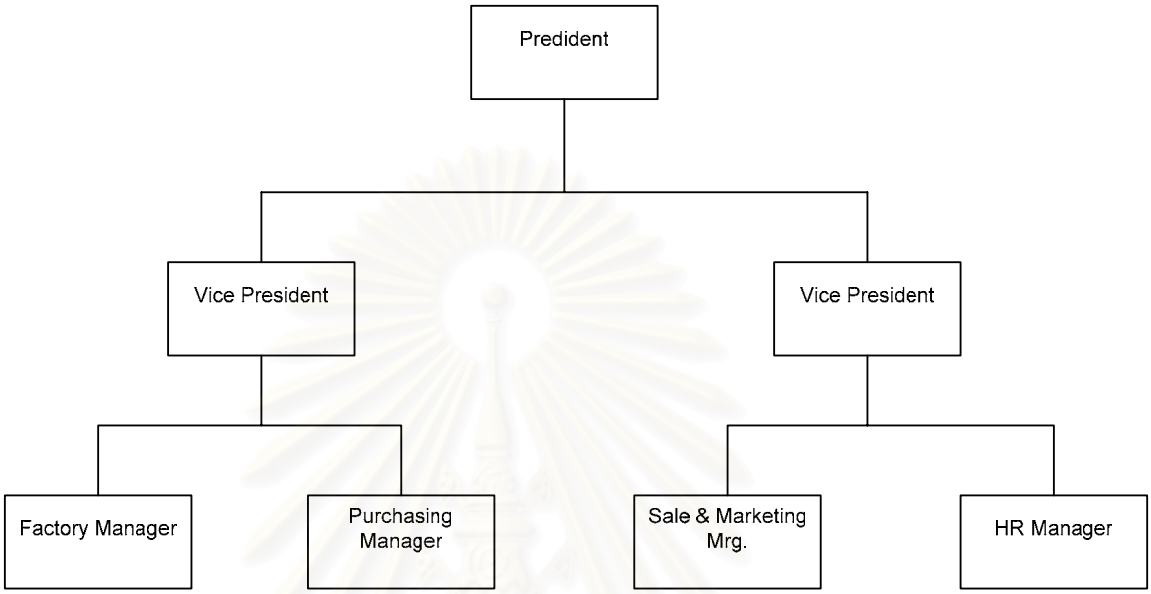
The case study company was established in August, 1983 by the foresighted founders. A wholly Thai-owned company with an initial registered capital of 25 million baht. The 17 rai factory is located on Mean Uri Province Bangkok. The company currently employs over 50 people at its factory and office. The management have their plastic business background for more than 20 years, have hired foreign engineers to train technicians and workers deploying incentive measures to boost the morale and performance of its employees. These efforts warrant that each and every products by the company will meet the strict quality standard required by customers. The factory contains modern and sophisticated machinery mainly imported from Taiwan and Japan for the production of PVC Sheets, PVC Leather Cloth , PVC Floor Matting. The products are widely used, such ad bags, luggage and shoes, motor vehicles' head lining and door panels, furniture, stationery , raincoats, children's toys, and premiums. In the field of agriculture and engineering, PVC Sheets have been used for green houses, pool linings, reservoirs, tunnel drainage, shoreline protection against water corrosion and sinking of ground and pits. The company's products are sold to both domestic and overseas markets. The company has present capacity of 550 metric tons per month, a complete range of colors and designs in thickness from 0.05 mm to 3.00 mm and 36-37 inches width. The company intend to boost its production capacity to 15,000 metric tons a year and will continue investment, not only in its manufacturing scope, but also in diversification to related fields in the near future. This is the picture of the case study products.

Figure 1.1: A product example from case study company

The organization structure of the case study company can be divided into four division which are as follows:

1. Factory : it in clued a lot of activity which are :
   1.1 Engineering and Maintenance department
   1.2 The manufacturing department. It include engineering, maintenance and quality control.
   1.3 Inventory control department both raw material and finished product inventory
   1.4 R&D
2. Purchasing : procure a raw material
3. Sale & Marketing
4. Human Resource

Figure 1.2: The picture of organization charts



1.2. Statement of Problem

The inventory level of this case study company is in trouble because some finished product is stocked very high and some product is shortage, so the company will lose a lot of money for inventory cost. For the product shortage, the company must produced the product very hurry in order to send the finished product to the customer on time , so it will caused a lot of money for the extra production.

A lot of finished product is now faced with the out-of-date situation, but it still has a planning to manufacture. This problem is occurred because of poor demand forecasting method. Currently, This case study company forecasting method is Qualitative forecasting and some of quantitative method (moving average), so it will depend on employee experience. Therefore, it will caused a lot of variance and a lot of mistake in the demand forecasting result. Moreover, this method is suitable for a long term forecasting, but for production planning it need short term planning which are the Quantitative forecasting is suitable.

All above problem is occurred from the not effective demand forecasting of the case study company. Because the company does not have a demand forecasting method, so it will resulted to the

The writer will conclude the statement of problem of the case study company which are as follows :

1. The inventory level in the case study company is in trouble, because some product is stocked too much, but some product is shortage (not enough to supply to the customer). This problem is caused by the unsuitable forecasting method
2. The demand forecasting method is base on employee experience (Qualitative forecasting) and inaccurate forecasting technique which was unsuitable for company.
3. The company faced with the out-of-date problem because of poor demand forecasting method.

Demand forecasting system is become important role in solving this problem. For the capacity of the PVC leather products.

To maximize the efficiency of the company and reducing cost of inventory in the case study company, the writer will come to improved the forecasting problems, and adjust the production planning according to the demand forecasting.

1.3. The Objective

In order to formulate efficient and effective plans, it is necessary to undertake this research study as following:

1. To forecast the plastic PVC products demand.
2. To adjust the production planning according to the demand forecasting.
3. To reduced the inventory problem by using forecasting demand method.

1.4. Scope of the study

This thesis is study and improves the forecasting method of the sample. The scopes of this study are as follows:

1. The research study considering only one product that make a high profits to the company
2. Forecast only demand for example product for one year.
3. Adjust the production planning (only master production) according to the demand forecasting.
4. Measured the result of demand forecasting only 1 or 2 month.

1.5. Methodology

The methodology can be divided into 7 step which are as follows :

1. Study the relevant literature
2. Investigate a case study company, to observe the current situation of the case study company.
3. Collect the data which was relevant to the problem
4. Design a forecasting model using the theory and relevant research
5. Conclusion and Suggestion
6. Make a final report

1.6. The Expected Benefits

1. The case study company can reduce the fluctuation of demand forecasting.
2. To gain better accuracy on forecasting the Plastic PVC products demand.
3. The study can help the company in term production planning by demand forecasting
4. The case study company is finally reduced the inventory.

1.7 The Measurement

1. The inventory shortage must be reducing.
2. The value of inventory must be reducing.

CHAPTER II

THEORY OF THE FORECASTING

2.1. Theory of the forecasting

The demand forecasting is started because the management need to know figure of demand in the future. Normally, it can be told that the future ts come from the present, and the present is come from the future. Then, the future demand can be forecasted by using the information that happened in the past. The forecasting can be done by using past information, then the important factor for the demand forecasting are as follows:

2.1.1 Forecasting Time Horizons

This forecasting c an be classified by considering a period of time that occurred in the future. It can be classified into three type which are:

2.1.1.1 Short-range forecasting

This type of forecasting are normally consume 1 year. This forecasting type is suitable to the planning purchasing, job scheduling and job assignments.

2.1.1.2 Medium-range forecasting

This type of forecasting are normally consume 3 month to 3 year. This forecasting type is suitable to the Production planning, sale planning and cash budgeting.

2.1.1.3 Long-range forecasting

This type of forecasting are normally consume 3 year or more than 3 years. This forecasting type is suitable to New product introduction, Capital expenditure and Location expansion.

2.1.2 The influence of product life cycle

Due to the product cannot be sale in the same level throughout the life cycle, then the product life cycle can be classified into 4 Stage.

1. Introduction Stage
2. Growth Stage
3. Maturity Stage
4. Decline Stage

The forecaster should put an emphasis on forecasting in introduction stage and growth stage.

2.2 The factor that the forecaster should be concern when forecasted

2.2.1 The accuracy of the data

The more precisely data, the more time consume. The forecaster should collect the data with the suitable level of accuracy.

2.2.2 The frequency of data collection

The frequency of data collection can be resulted to the accuracy of the data. It can be conclude that if the forecaster collect the data more frequency, and used the update data, the outcome resulted would be more accurate.

2.2.3 The level of accuracy

The accuracy of the input data can affect to the time and cost to gathering the data. In order to get an accuracy data the company have to pay a lot of money, so the company have consider the important to acquire an accuracy data.

2.3 Type of Data

The important factor that the company should consider is a source of the data. The source of data can be divided into two type.

2.3.1 Primary Data

This data was collected by the forecaster. The forecaster can collect the data by interviewing, survey report and focus group interview.

2.3.2 Secondary Data

This type of data can be collected from both inside and outside company. Internally data such as sale volume and inventory, but forecasting are also need some external data such as economic data, social data and so on.

The external data can be easily collected at the government burial. For instance, The industrial burial can provide the number of factory. The bank of Thailand can provide the data of GDP and interest rate.

2.4 The forecasting steps

The forecasting steps are shown:

1. The company should determine the use of forecast by focus on objective of the company.
2. The forecaster should detect the item to be forecasted.
3. Determine the time horizontal of the forecast. To consider the time of forecasting, for example, short term forecast, middle term forecast or long term forecast.
4. Gather the needed data which was important to forecast. The company should to have database to monitor a selling demand.
5. Make a forecast

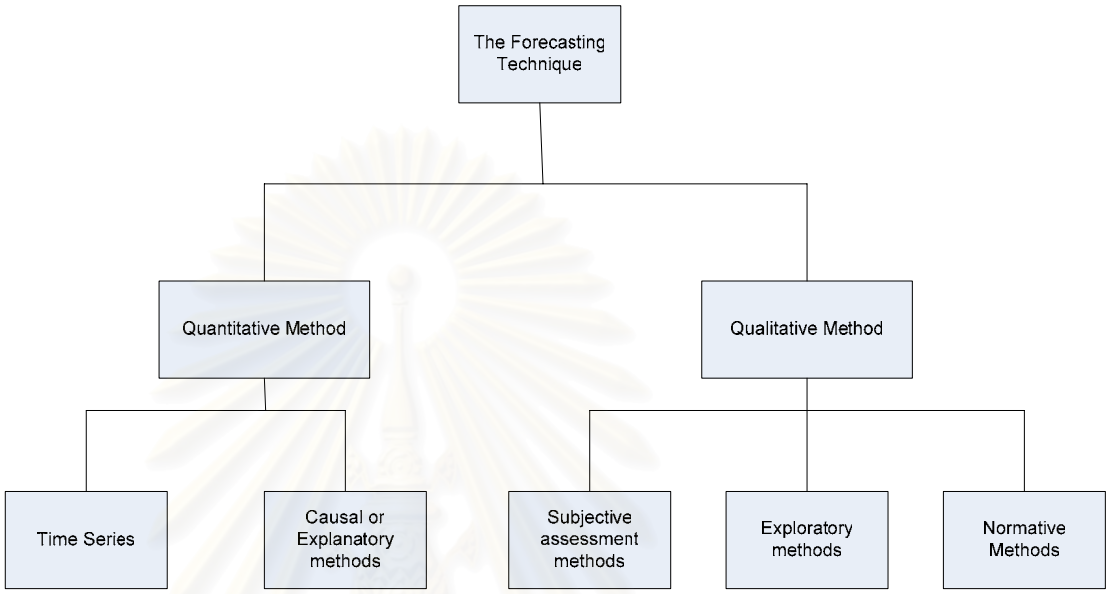
2.5 Type of forecasting

Forecasting can be divided into two which are :

1. Quantitative forecasting method
2. Qualitative forecasting method

Then, both two technique has many sub technique which was shown in the following picture.

Figure 2.1: Illustrate the forecasting method trees



2.5.1 Quantitative Forecasting Method

Quantitative method is a forecasting which was used one or more mathematical model which depend on the data. It use past data to forecast the future trend of the demand. The quantitative method that are popular is Time-series models.

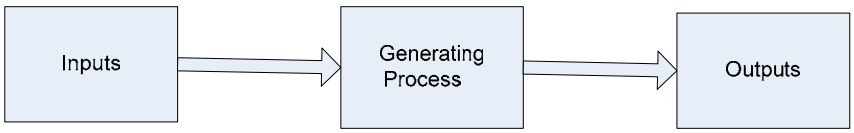
The quantitative method can be used under three conditions which are as follows

1. Data Availability: The data must be sufficiency enough to make a forecasting in the future.
2. The data must be quantifiable
3. The forecaster must be able to assume the continuity of the demand.

The quantitative method can be divided into two main model which are Time-Series model and Causal model.

Time-series model is a model which forecast the future trend based on the historical data. Picture 2.1 will show the format of Time Series model

Figure: 2.2 illustrate the format of time-series model



Form the Figure 2.2, It is obviously illustrate that the historical data is the most important data. The forecaster need to find a historical data pattern which was base on time period.

The type of sale pattern was interested by the forecaster because they believe that the historical sale volume will continue if the environment circumstance not change.

2.5.1.1 Time Series Model

This method uses a time series analysis which was use a historical data. The forecaster will use the technique call Smoothing technique. The technique of this method is also same with time series model, but the forecaster will weight the data differently. The Smoothing technique can be categorize into four type which are asa follows:

2.5.1.1.1 Single moving average technique

This method is weight the value equally. The model can be shown as

Figure 2.3: Illustrate the single moving average technique formula

$$\hat{Y}_{t+1} = \frac{Y_t + \ldots + y_{T-K+1}}{k}$$

The problem of this problem is the determination of K value. The more k value, the more poor results.

2.5.1.1.2 Single Exponential Smoothing Method

This method is improving from a single moving average technique by weight the value base on exponential curve. Therefore, the recent value will be weight more that the old value.

Figure 2.4: Illustrate the single exponential smoothing method formula

$$\hat{Y}_{t+1} = \alpha Y_t + (1-\alpha)\hat{Y}_t$$

2.5.1.1.3 Double Moving Average Technique

This technique is improved from a single moving average technique by weight the value base on straight line.

Figure 2.5: Illustrate the Double moving average method formula

$$\hat{Y}_{t+p}(t) = \hat{T}_t(t) + p\hat{\beta}(t)$$

Where p=1,2,.....

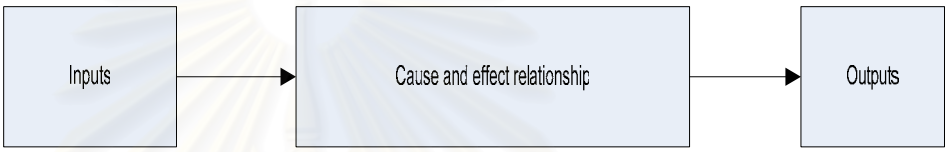
2.5.1.1.4 Double exponential Smoothing Technique

This technique is similar to the double moving average technique, but this method is weight between 0 to 1.

2.5.1.2 Causal Model

This model is base on reason. This model is focus on the relationship between variable. In case, Analyze only two variables called simple regression. If analyze more than two variable, it will call multiple regression.

Figure 2.6: Illustrate the Causal relationship



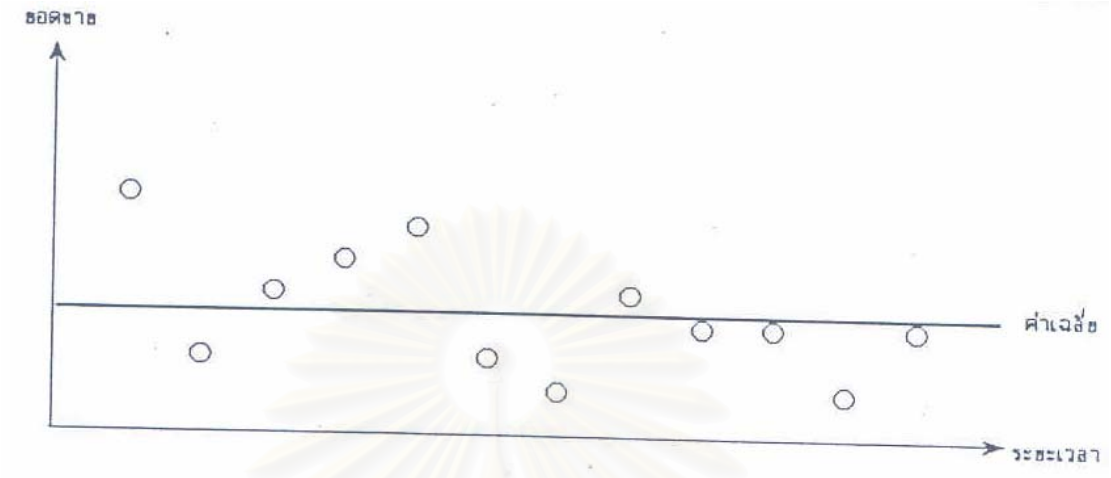
2.6 Forecasting Technique Selection

The forecaster should select the forecasting technique base on characteristic. The characteristic of data can specify the selection of the quantitative forecasting method. Normally, it can be classified into four type.

2.6.1 Horizontal data pattern

This type of data is constant, not often change. The horizontal data pattern is suitable with a single moving average technique and single exponential smoothing moving average technique.

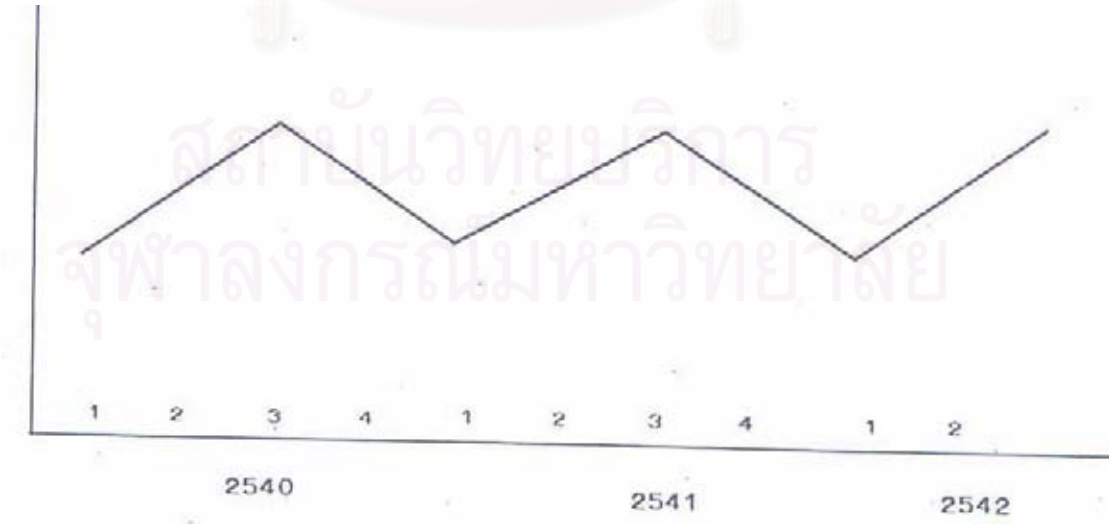
Figure: 2.7 Horizontal Data Pattern



2.6.2 Seasonal Data Pattern

This type of sale volume is base on seasonal such as the sale volume of umbrellas will be peak at raining season. The sale volume of the department store will be peak during December. The seasonal data pattern will be suitable to the decomposition, Box-Jenkins, and regression with dummy variable technique.

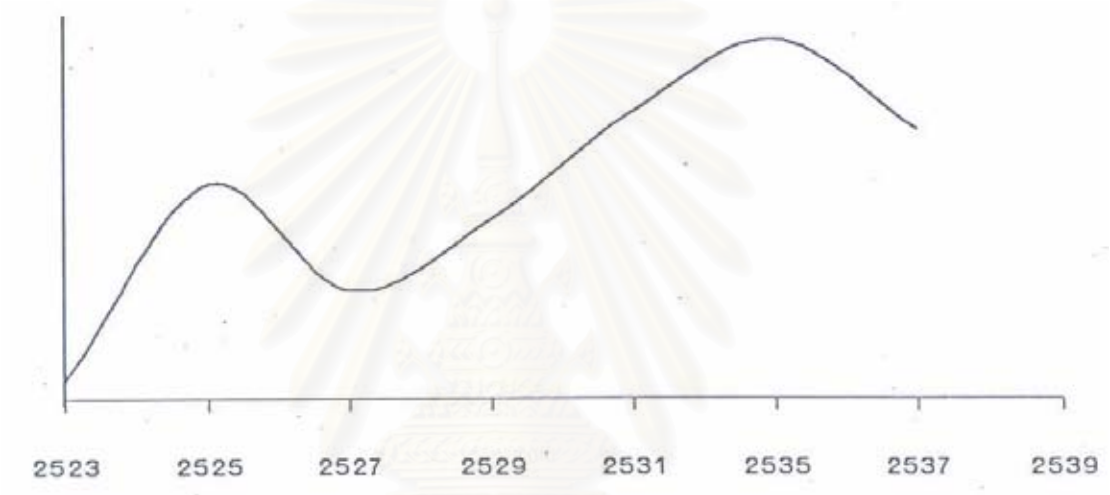
Figure: 2.8 Seasonal Data Pattern



2.6.3 Cyclical Data Pattern

This type of data must be long term collection. This technique is suitable to decomposition and box Jenkins technique.

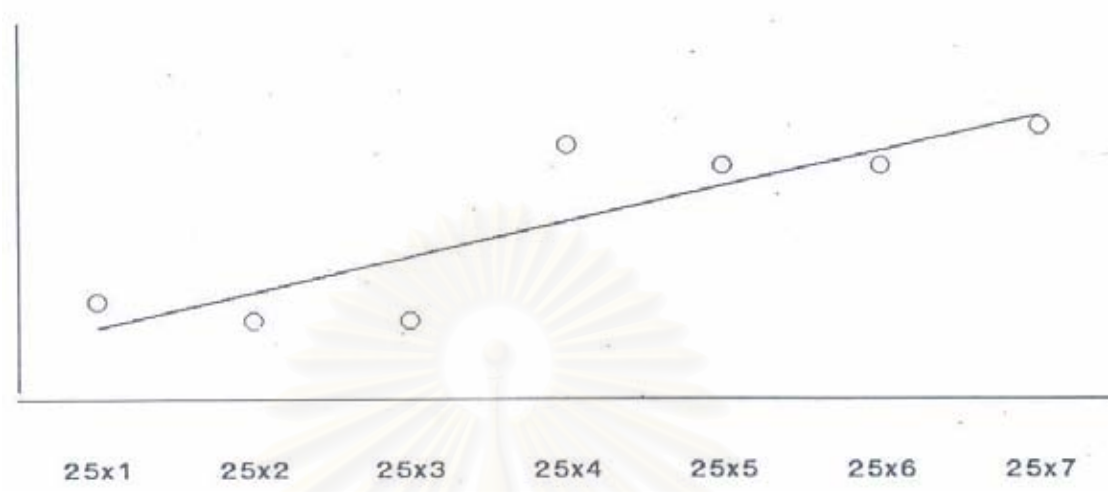
Figure: 2.9 Cyclical data pattern



2.6.4 Trend Data Pattern

The trend of this type of data is increasing or decreasing constantly. The figure 2.10 will show the trend of this data. The trend data pattern is suitable to the Box-Jenkins, regression technique, Linear moving average technique and linear exponential smoothing technique.

Figure 2.10: Trend Data Pattern



2.7 The Error Measurement

The accuracy of the forecasting is the differential between real sale volume and forecasting sale volume, therefore the less forecasting error, the more forecasting accuracy.

2.8 The different between Time-series models and Causal models

Both time-series and causal model are use in the different situation. Time series analysis is less complicate than causal model, but causal can use to persue the management to created a policy. Therefore, the forecasting model selection is based on the objective.

Eventhouhg, both time-series and causal model is a qualitative method, but its has some issue is different. The different between time-series and casual model are shown below:

1. Time series model use a historical data and observe the pattern of data. Forecasting the sale volume base on that pattern.

2. Time-series model do not need the reason where the data come from.

3. In time-series model, the forecaster will forecast the demand by using a data pattern.

4. In time-series model, The forecaster will focus on the historical sale volume, then assume the continuous of the data.

5. In casual model, the forecaster needs to know the relationship between the primary variable and sale volume.

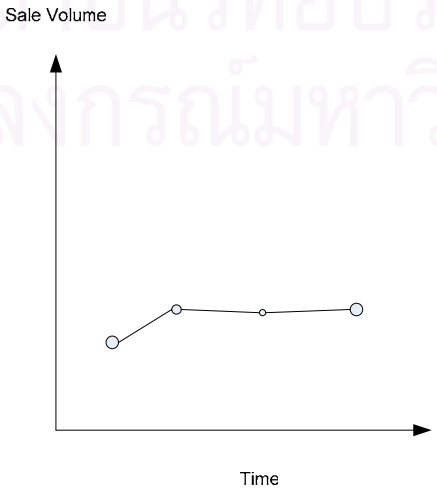
6. In casual model, the forecaster will use the form of relationship in the forecasting.

The key decision making of choosing forecasting method is depend on historical data and historical data pattern. The type of historical data pattern can be divided into 4 type which are as follows:

1. Horizontal Pattern

This type of data pattern is begin when the data pattern is not too much swing which mean the value of the sale volume of the historical data would be constant. Therefore, when the forecaster forecast the sale volume base on historical data, the forecasting result would be accurate due to the historical data is not swing.

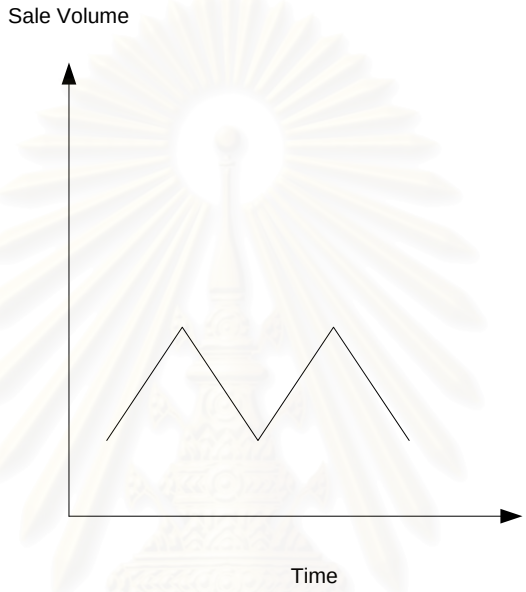
Figure 2.11: illustrate the horizontal Pattern



2. Seasonal Pattern

This type of data pattern is beginning when the data pattern was affected from timing factor. The sale volume of the product is not constant.

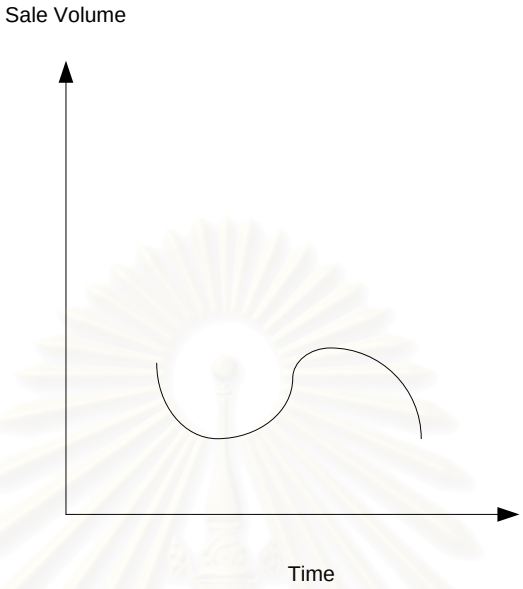
Figure 2.12: illustrate the Seasonal Pattern



3. Cyclical Pattern

This type of data pattern is beginning when the data pattern was affected by the economical factor such as sale volume of automobile. The different between a cyclical pattern and seasonal pattern is that the season pattern will limited the time period and it will repeat at the same period of time.

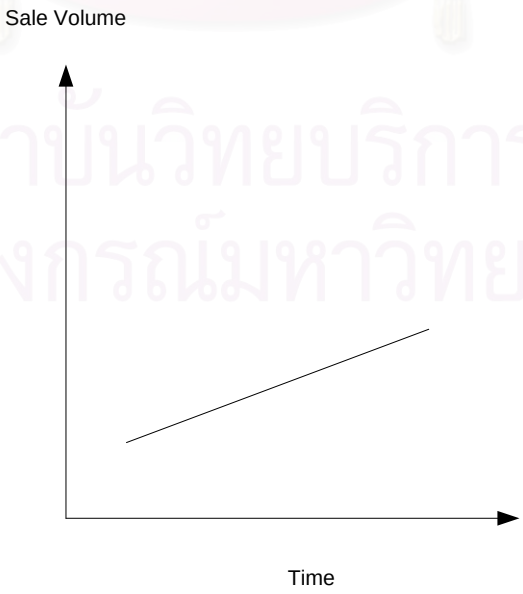
Figure 2.13: illustrate the Cyclical Pattern



4. Trend Pattern

This type of data pattern is beginning when the volume is continuous increase or decrease. This type of data pattern is obvious illustrate by the growth state in the life cycle of the product.

Figure 2.14: illustrate the Trend Pattern



2.9 Qualitative Forecasting Method

The qualitative forecasting method is one of the popular in term of practical method because it not complicate as much as the quantitative method. Especially, the top level management always used the qualitative method to forecast because the qualitative method is base on experience of the management. The qualitative method can be divided into three main method which are Subjective assessment method, Exploratory method ,and Normative method.

2.9.1 Subjective Assessment Method

2.9.1.1 Sales force estimate

This type of management is a bottom-up approach. The company will let the sale officers forecast the sale volume by themselves. Then, sum up every sale officers forecasting result, and propose as a sale volume of the company.

Advantage

1. The sale office will relate to the customer, so they will know the customer demand.
2. This type of forecast is suitable for the short-term forecasting.

2.9.1.2 A jury of executive opinion

This type of forecasting will use the opinion from the top level management. This type of management is a top-down approach.

Advantage

1. Wide range of idea
2. Easy and low cost

2.9.1.3 Market Survey

This type of forecasting can forecasted the demand by survey the need of the market. The market survey can survey the need of the specific user.

Advantage

1. This forecasting method studies the requirement from the direct user. This type of data can be use as an decision making data to prepare a strategy and marketing plan.

2.9.1.4 Test Market

This method is similar to the market survey method but this method will used when launch a new product to the market.

Advantage

1. The forecaster will receive a direct feedback from the user.
2. The technique is suitable for a new product introduction.

2.9.2 Exploratory Method

This technique try to predict the future trend by assume that what will happen and how it happen in the future. This method will use the technique call scenario analysis.

This technique will predict in the future, and this technique will not forecast by using historical data.

2.9.3 Normative Method

This technique will force the company to achieve the target on the future with the specific time. This method can be divided into two technique which are relevance trees and system dynamics.

2.9.3.1 Relevance Trees

This technique is similar to a decision trees. This technique will determine the future target, then find the way to achieve the target.

2.9.3.2 System Dynamic

This technique is a system analysis. The target of this technique is to find the relationship between every party in the system. This technique has many target to achieve which are as follows:

- To show the relationship between every party in the system
- To forecast the result of the system, and improve the future results

2.10 The factor which use to selects the forecasting technique

Now a day, it has many forecasting technique both time-series analysis or casual model and qualitative technique. In order to choose a forecasting technique, it not only concern the ability of the forecaster, but also concern with many factore which are shown below:

1. Time Horizon
2. Pattern of data
3. Accuracy
4. Cost
5. Ease of use
6. Ability of computer soft ware

2.10.1 Time horizon

The forecasting can be divided base on a time period from short-term to long-term forecasting.

- Very Short-term forecast not over than 1 month
- Short-term forecast not over than 1-3 month

- Medium-term forecast not over than 3-24 month
- Long-term forecast more than 24 month

The time horizon is affect to the forecasting technique decision making. Normally, The short-term and medium-term forecasting can use time-series technique or subjective assessment model technique base on the objective of the forecasting. For the long-term forecasting, the forecaster should apply the time-series technique or casual model technique. For the qualitative forecasting method, it can be implement in the very long-term forecasting.

2.10.2 Pattern of data

Pattern of data is one of the important decision making factor which use to choose the forecasting technique. The historical data must be plot in order to see the data pattern. The data pattern can be classified into four type which are as follows:

2.10.2.1 Horizontal data pattern

After plot the graph, the graph will show the horizontal line, therefore the appropriate technique is a moving average or exponential smoothing method.

2.10.2.2 Seasonal Data Pattern

This type of data pattern is base on season. The trend of this data in the same period will be same in next year.

2.10.2.3 Cyclical Data Pattern

The decomposition method or Box-Jenkins method is suitable for the cyclical data pattern.

2.10.2.4 Trend Data Pattern

The characteristic of the data is a positive trend and a negative trend. The forecasting technique which suitable to the trend data pattern is regression analysis or econometric.

2.10.3 Accuracy

The accuracy is mean how much a result from forecasting is close to the actual sale volume. Therefore, the forecaster should choose the forecasting method which was provide the best accuracy.

$$\text{Error} = \text{Actual} - \text{Forecast}$$

The error of the forecasting is much or less is base on many factors such as the quality of data, and selecting wrong forecasting method.

Normally, The forecasting method which give the best accuracy result will give the less MSE or MAD, comparing with another forecasting method.

2.10.4 Cost

Cost is mean the cost that pay for achieving the forecasting result. The main cost normally pay for data collection especially primary data because the forecaster must buy some tools for collecting the data, or buy some information from the provider. In reality cost is not the main factor that use to select the forecasting method because the forecaster may have to pay for a high price data that is useful for the forecaster.

2.10.5 Ease of use

Normally, the forecaster and the person who use the forecasting result is not the same person, so the forecaster need to aware of easiness of understanding the results. The forecasting method that use a very complicate mathematic model will

confuse the other people. Therefore, the selection of forecasting method should be well known and easy understanding.

2.10.6 Ability of computer software

Now a day, many computer software has been develop to help the forecaster to forecast the sale volume demand such as SPSS (Statistical Package for Social Science), SPSSX ISP (Interactive Statistical Program), MINITAB FORECAST. The forecaster should select the program according to the forecasting technique in order to get the accuracy forecasting result.

2.11 The Accuracy Measurement

The appropriate accuracy measurement model can be shown as following:

2.11.1 Mean Error

$$ME = \frac{\sum_{i=1}^{n} e_i}{n}$$

2.11.2 Mean Absolute Error (MAE) or Mean Absolute Deviation (MAD)

$$MAD = \frac{\sum_{i=1}^{n} |e_i|}{n}$$

2.11.3 Sum of Squared Error

$$SSE = \sum_{i=1}^{n} e_i^2$$

2.11.4 Mean Squared Error

$$MSE = \frac{\sum_{i=1}^{n} e_i^2}{n}$$

2.11.5 Standard Deviation of Error

$$SDE = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n-1}}$$

2.11.6 Root Mean Square Error

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n}}$$

2.11.7 Percentage Error

$$PE_t = \left(\frac{X_t - F_t}{X_t} \right) 100$$

2.11.8 Mean Percentage Error

$$MSE = \frac{\sum_{i=1}^{n} PE_i}{n}$$

2.11.9 Mean Absolute Percentage Error

$$MAPE = \frac{\sum_{i=1}^{n} |PE_i|}{n}$$

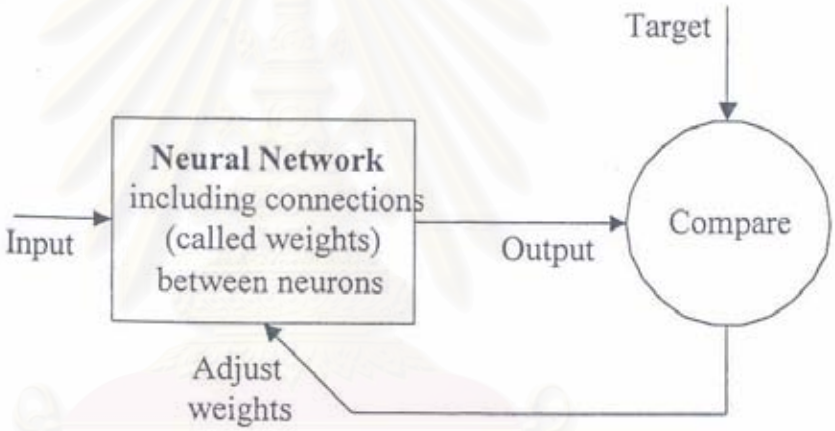
2.12 The Artificial Neural Network

Artificial neural network is one branch of the artificial intelligence (AI). Now it is widely used for solving problems that are difficult for computing with conventional computer or human. Artificial neural network is inspired by biological systems so it will imitate the human brain. An artificial neural network is comprised of

nodes or elements and their connections. We can train an artificial neural network to perform a particular function by adjusting the values of the connection or the weight between elements.

The network will be adjusted based on comparison of output and target until the output meet the target. Learning process of the artificial neural network is shown in figure 2.16

Figure 2.16: Learning Process of the Artificial Neural Network



2.12.1 Definition

Since the artificial neural network has been developed for a many decades, many people have defined it.

Medsker, Turban and Trippi (1993) defined artificial neural network as an information-process system that imitates biological neural network.

Skapura (1995) described that a neural network is collection of simple, analog signal processor, connected through links called connection.

2.12.2 Application of neural network

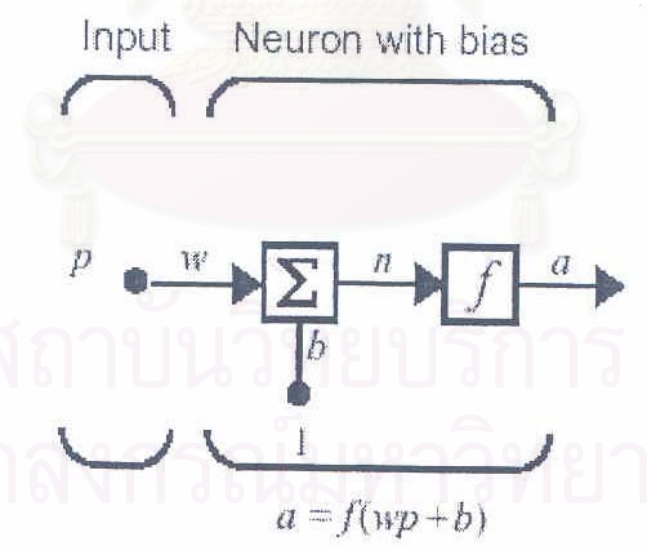
Neural network have been found that it is widely used in many fields such as Aerospace, Automotive, Banking, Defense, Electronics, Entertainment, Financial, Industrial, Insurance, Manufacturing, Medical, Oil & Gas, Robotics, Speech Recognition, Securities, Telecommunication and Transportation.

2.12.3 Neuron Model

2.12.3.1 A simple neural

One neural network is comprised of several neurons. A model of a simple neuron that explains the computation of a neuron is illustrated in Figure 2.17

Figure 2.17: A simple neuron model



The scalar output “a” of a neuron is demonstrated by the equation

$$a = f(Wp+b) \qquad (2.1)$$

Where “p” is a scalar input,

“w” is a weight,

“b” is a bias,

“f” is a transfer function

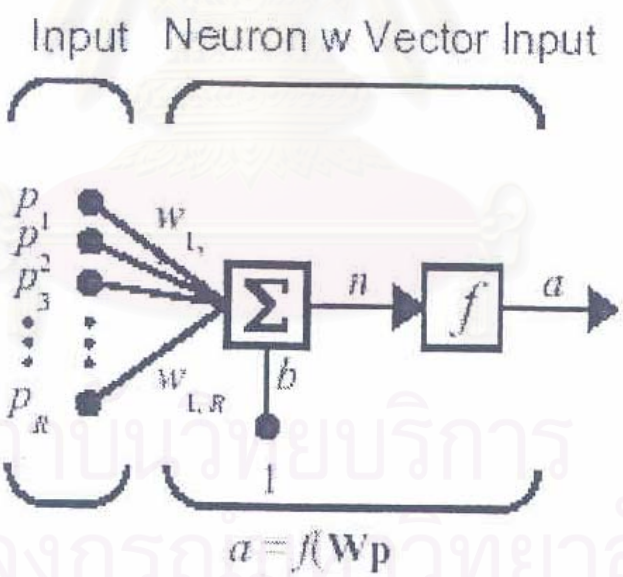
And “a” is an output of the network.

The sum of weighted input and bias will be compared with the threshold activation value by the transfer function. If the sum meets the threshold value, this neuron will transfer an output to its neighbor.

2.12.3.2 A neuron with vector input

A model of a neuron with vector input is shown in Figure 2.18

Figure 2.18: A neuron with vector input



The scalar output “a” of a neuron is demonstrated by the equation

a = f(n) (2.2)

n = W1P1 + W2P2 + …. + WrPr + b (2.3)

Where “P” is vector input,

"W" is a matrix of weight of each input,

"b" is a bias,

"n" is a sum of weighted input added with bias,

And "f" is a transfer function

A neuron with vector input, like a simple neuron, the sum of weighted input and bias will be compared with the threshold activation value by the transfer function. When the sum meets the threshold value, this neuron will transfer an output to its neighbors.

2.12.4 Characterization

An artificial neural network is characterized by three characteristics, which are as follows: Network Architecture, Transfer Function, and Learning Process. The details of network architecture, transfer function and learning process are described in sections 2.12.5, 2.12.6 and 2.12.7 respectively.

2.12.5 Network Architecture

The architecture of a network concerns with the number of layers in the network, layer's transfer function and number of neurons per layer.

2.12.5.1 A layer of neurons

A layer of neurons is comprised of several neurons positioned in parallel. Its model can be described as shown in Figure 2.14.5.1. Note that now the output "a" is a vector output.

2.12.5.2 Multiple-layer network

A neural network can contain many layer of neurons. A network shown in Figure 2.19 is an example of multilayer network. Figure 2.20 presents a network with two layers of neurons. The first layer of neurons is called the hidden layer because its

position is between the input layer and the output layer so that it has no connections to the outside.

Figure 2.19: A layer of neurons

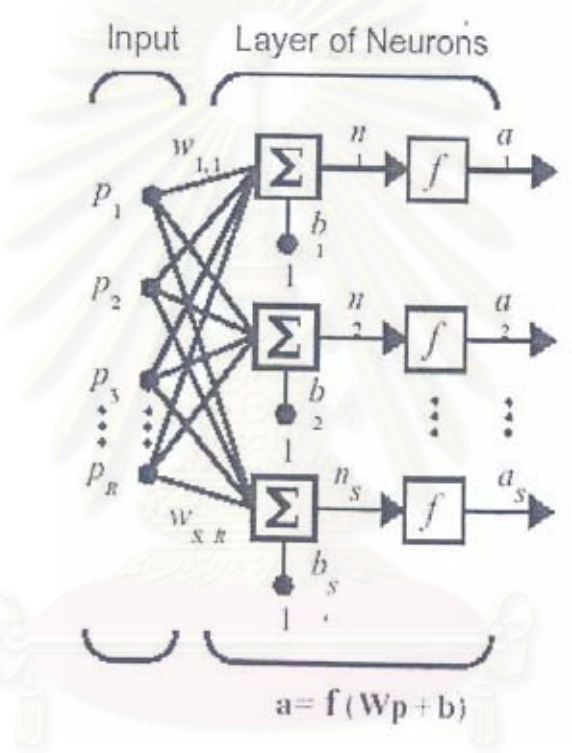
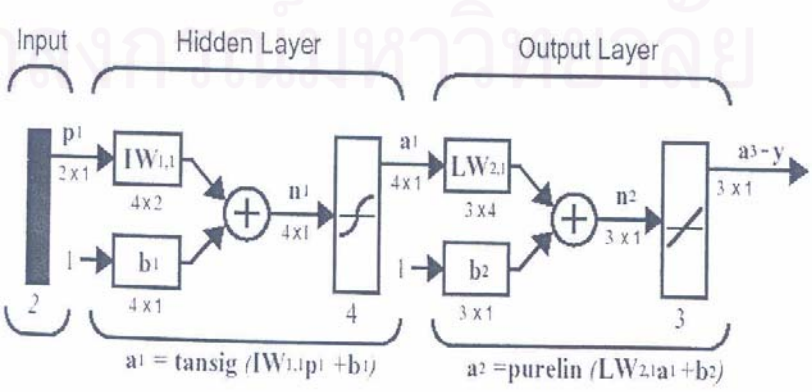


Figure 2.20: An example of a two-layer network



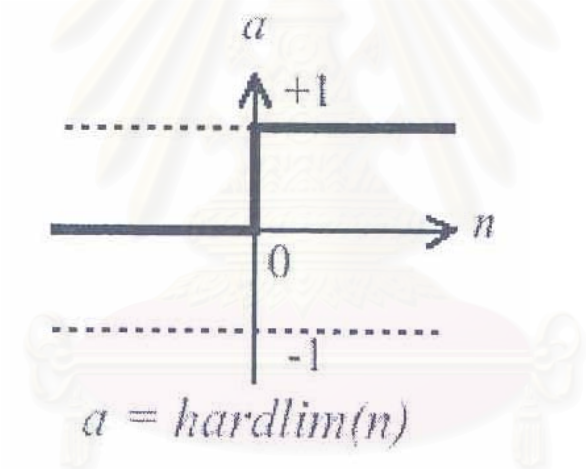
2.12.6 Transfer function

There are many transfer functions or activated function. Mathematics functions that are commonly used as transfer function are described as follows:

2.12.6.1 Hard-Limit Transfer Function

The hard limit transfer function as shown in Figure 2.21 takes the input and limits the output to be either 0 if the value of “n” is less than 0; or 1 when “n” is more than or equal to 0

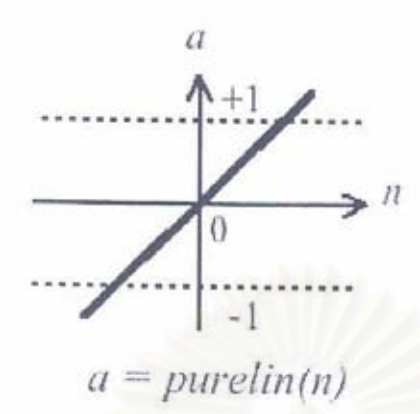
Figure 2.21: Hard Limit Transfer Function



2.12.6.2 Linear Transfer Function

Linear Transfer Function as shown in Figure 2.22 takes the input and produces output as its input. The range of input is any value from minus of infinity to infinity and the range of output also can be any value.

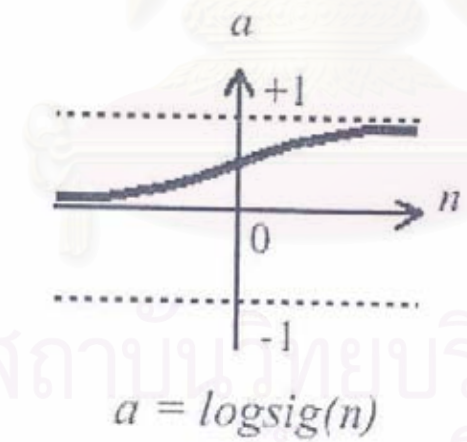
Figure 2.22: Linear Transfer Function



2.12.6.3 Log-Sigmoid Transfer Function

Log-Sigmoid Transfer Function as shown in Figure 2.23 takes the input that can be any value and generates the output that range from 0 to 1

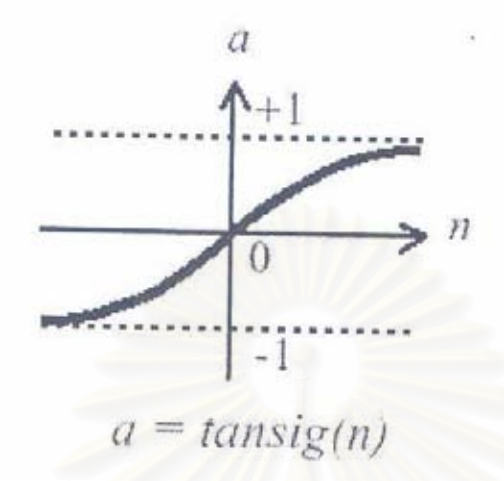
Figure 2.23: Log-Sigmoid Transfer Function



2.12.6.4 Tan-Sigmoid Transfer Function

Tan-Sigmoid Transfer Function as shown in Figure 2.24 takes the input that can be any value and generates the output that range from -1 to 1

Figure 2.24: Tan-Sigmoid Transfer Function



2.12.7 Learning Process

Learning process of the neural network can be divided into two styles, which are batch training and incremental training. In batch training the weights and biases are adjusted for the entire set of inputs and targets. In incremental training, training the weights and biases are adjusted for each input that is presented to the network.

2.12.8 Backpropagation

It can be said backpropagation is the most commonly used network for problems solving in the fields of artificial neural network. Its ability to learn the complicated relationships between the training input and its targets makes it become a standard network for forecasting.

2.12.8.1 Principle

The operation principle of backpropagation is gradient descent that is used to update the weights and biases. Demuth and Beale (2000) have described gradient descent as the process of making change to weights and biases where the

changes are proportional to the derivatives of network error with respect to those weight and biases.

2.12.8.2 Architecture

Backpropagation network is a multi-layer network that mostly consists of the input layer, hidden layer and the output layer. The number of inputs to the network is the number of variables that is considered to be the input of the problem needed to be solved. The number of neurons in the output layer is determined by the number of outputs desired by the problem. The number of hidden layers and the number of neurons in the hidden layer are up to network designer.

2.12.8.3 Transfer Function

Log-Sigmoid, Tan-Sigmoid and Linear Transfer Functions are most commonly used in backpropagation network. The selection of transfer function depends on the desired output of the problems.

2.12.8.4 Algorithm

For the algorithm of backpropagation, weights and biases are updated in the directions of the negative gradient, which can be demonstrated by the equation

$$Xk+1 = Xk-LkGk \quad (2.4)$$

Where Xk = a vector of current weights and biases

Gk = the current gradient and

Lk = learning rate

Learning algorithms that will be used in this experiment are batch gradient descent and batch gradient descent with momentum.

1. Batch gradient descent

Batch means that weights and biases will be updated when all of the inputs are applied to the network. So in batch gradient descent learning style, the update of weights and biases based on negative gradient will be made when all entire set of inputs are presented to the network.

2. Batch gradient descent with momentum

Batch Gradient Descent with Momentum is the addition of batch gradient descent. Momentum helps a network to response to the recent trend in the error surface not just to the local gradient. The important benefit of momentum is to prevent network from settling in the local minimum that is one major problem of backpropagation algorithm. Batch gradient descent with momentum also provides faster than training that gradient descent does.

Momentum constant ranges from 0 to 1 where O represents the update of weights based on just the gradient and 1 represents the update of weights based on just the recent trend. Universally, the momentum constant is set to 0.9.

2.12.8.5 Problems

Although the backpropagation is the general-purpose network for many problems, users could find some problems on its use. Problems that should be mentioned to network designer are:

1. Overfitting

Overfitting occurs when there are too many neurons in the hidden layers that can result in high fluctuations at the fitting curves. In contrasts, if there are too few neurons in the hidden layer, underfitting can occur.

2. Local Minimum

Some networks can generate wrong results because of local minimum. Since there can be more than one error surface, in some cases, a network is struck at local minimum not the global minimum, users have to initialize and train network many times to be assured that the global minimum is found.

2.12.9 Development Process of Neural Network Model

Development process of neural network model concerns data selection and preparation, network design, training and testing the network.

2.12.9.1 Data selection and preparation

1. Consider variables to be input and output
2. Collect Data and divide it into two groups, which are training data and testing data.
3. Transform all data to appropriate format

2.12.9.2 Network Design

1. Specify the number of input to the network and the number of outputs requires from the network.
2. Specify the number of hidden layers, number of neurons and transfer function of each hidden layer.

2.12.9.3 Training and testing

1. Specify training parameters and then train the network.
2. Test the network.

Because users cannot know which neural network model will be the best for given problems, development process of neural network model should be repeated

by adjusting parameters in order to obtain the model that gives the minimum error of the testing data.

2.13 Literature survey

Related studies on water demand forecasting and the application of Artificial neural network are summarized as follows:

Rurkhamet (1997) developed neural network model for forecasting the requirement of new issued banknotes. Widrow-Hoff and backpropagation techniques are used to forecast new issued banknote of year 1993-1996 using the historical data around 12–15 years. In this study, the backpropagation neural network technique can give the best forecasting results. In comparison with the tradition regression technique used by the Bank of Thailand, Backpropagation technique can give with best result with the most accurately.

Vasinpongvanit (1999) examines the variables that have effects on water demand to find out how they are related. From Multiple regression analysis, three independent variables that have important effects on water demand are Gross Provincial Product (GPP), water price and population per household.

Supradish Na Ayudhya (2001) developed neural network models for water demand forecasting. They compared the forecasting by traditional regression technique call Accrual Moving Average with the backpropagation neural network technique. Backpropagation can give more accurately forecasting results than the accrual moving average gives.

Kannim (2004) developed neural network models for sale volume of motorcycle. The neural network analyses relationships among independent variables that effect motorcycle sales. The standard backpropagation neural network are used in

this study. The result show that the designed neural networks can learn sale volume of motorcycle accurately.

Sangarerun (2002) develop a production scheduling using the heuristic methods for the "press parts" shop in the compressor assembly company. The developed program can be used to record the daily production in order to monitor the production result so that the production scheduling can be properly adjusted. The program can be used interactively to produce schedule. Finally, the company can reduce the mean flow time around 11.5 percent, and the proposed production scheduling using the developed computer program increase in the machine utilization by 23% compared to the present scheduling method.

Laichutai (2002) was set up the production scheduling system and reduce the delay in delivery by study the conditions and problems of the lack of efficient production planning in printing industry. The significant factors affecting the ineffectiveness of the production planning are the deprivation of the factory study on its actual production capacity the absence of the production planning team, and the inaccessibility of the supply management proficiency. The researcher, therefore, has presented the pavements in solving those problems as follows: 1. Applying various technical knowledge of work study in order to set up standard time and machine capacity. 2. Applying production planning and control and production scheduling technique in order to increase efficient production scheduling and reduce the delay of delivery 3. Applying Borland Delphi 5 in order to set up database which is necessary for production scheduling and promote production scheduling system. From this research it can be conclude that the percentage of overtime-working hour is decreased from 4601.10 man-hour/month to 2332.33 man-hour/month (50.69%) and delay of product delivery is reduced form 134 jobs/180 jobs (74.36%) to 119 jobs/216 jobs (55.18%)

CHAPTER III

DEMAND FORECASTING USING MOVING AVERAGE

3.1. Introduction

This chapter will cover the method of forecasting that the company is currently used. This method is moving average method and qualitative method. In the company, It is easily to say that the forecaster will forecast the demand by using moving average, then they will correct the forecasting result by using their experience (qualitative method).

3.2. Moving Average Technique Theory

The moving average technique is now primary used by the company to forecast the demand of sale volume. The moving average is also one of time series analysis. Moving average is a method that average the sale volume over three month of the last years. The moving average technique can be calculated by using following equation:

$$MA_n = (\Sigma A_i)/n$$

Where i = refers to the most recent period,

n = number of periods in the moving average,

A_i = actual value with age i

MA_n = Forecast

3.3. Demand Forecasting Using Moving Average

As mention above, a person who has responsible to forecasting will collect the historical data and then calculated the demand forecasting by using moving average technique. The table 3.1 will illustrated the calculation of the moving average

technique. Table 3.2 will show the comparison between actual demand and demand forecasting by Moving Average technique.

Table 3.1: Calculation of demand forecasting by using Moving Average

Month/Year	Month Year use in Calculation	Calculation	Result
Jul-48	Jun 2547, Jul 2547, Aug 2547	(31.518018 + 35.685508 + 38.743687)/3	35.315737
Aug-48	Jul 2547, Aug 2547, Sep 2547	(35.685508 + 38.743687 + 27.347072)/3	33.925422
Sep-48	Aug 2547, Sep 2547, Oct 2547	(38.743687 + 27.347072 + 27.205732)/3	31.09883
Oct-48	Sep 2547, Oct 2547, Nov 2547	(27.347072 + 27.205732 + 37.122111)/3	30.558305
Nov-48	Oct 2547, Nov 2547, Dec 2547	(27.205732 + 37.122111 + 28.574297)/3	30.96738
Dec-48	Nov 2547, Dec 2547, Jan 2548	(37.122111 + 28.574297 + 23.266693)/3	29.654367
Jan-49	Dec2547, Jan 2548, Feb 2548	(28.574297 + 23.266693 + 24.604271)/3	25.481753
Feb-49	Jan 2548,Feb 2548, Mar 2548	(23.266693 + 24.604271 + 47.516536)/3	31.795833
Mar-49	Feb 2548, Mar 2548, Apr 2548	(24.604271 + 47.516536 + 27.639179)/3	33.253328
Apr-49	Mar 2548, Apr 2548, May 2548	(47.516536 + 27.639179 + 34.627786)/3	36.5945
May-49	Apr 2548, May 2548, Jun 2548	(27.639179 + 34.627786 + 30.629519)/3	30.965494
Jun-49	May 2548, Jun 2548, Jul 2548	(34.627786 + 30.629519 + 33.168504)/3	32.808603

After finished forecasting by using moving average technique, the forecaster will compare with the actual demand in order to find the forecasting error. The result of an error of forecasting are shown in table 3.3.2

Table 3.2: Comparison between Actual and demand forecasting by Moving Average technique

Month/Year	Actual	Forecast	Error
Jul-48	34.168504	35.315737	2.147233
Aug-48	36.981905	33.925422	-3.056483
Sep-48	35.771983	31.09883	-4.673153
Oct-48	32.665378	30.558305	-2.107073
Nov-48	31.650556	30.96738	-0.683176
Dec-48	29.703663	29.654367	-0.049296
Jan-49	32.703767	25.481753	-7.222014
Feb-49	30.834193	31.795833	0.96164
Mar-49	44.549969	33.253328	-11.296641
Apr-49	27.031401	36.5945	9.563099
May-49	36.882315	30.965494	-5.916821
Jun-49	31.349847	32.808603	1.458756
	404.293481	382.419552	-20.873929
Error = -5.163 percent			
MSE = 29.165			

3.4. Conclusion

As you can see from the table 3.2, the error rate is obviously high and negative which is – 5.163 percent. The result of forecasting from Moving Average technique is unsatisfactory. Therefore, a new and powerful technique should be introduced and test whether they can provide a better forecasting result or not.

Moreover, The moving average technique does not use economical factor to calculate, so the result of the forecasting will not be according to the economic situation.

3.5 The affect by using moving average technique

The result of forecasting which was come from the moving average technique is obviously high rate of error and MSE, therefore it cause a problem. Which are as follows:

3.5.1 The production planning department receives the inaccurate demand forecasting, then they will produced a sample product with the inaccurate quantity. Therefore it will cause an inventory problem.

3.5.2 The supplier can not supply the raw material on time because the demand forecasting of the sample product was not accurate.

CHAPTER IV

FORECASTING OF DEMAND USING BACK PROPAGATION

4.1 Introduction

This study is used for creating a forecasting model to forecast the demand of sample product. This model will use the factor that may affect to the sale volume. The suitable forecasting model can be use to forecast a future demand, and the forecasting data can be used in the marketing planning or production planning in the future. The forecasting model will be suitable or not is depend on the input factor.

This chapter covers the experiment of demand forecasting using back propagation method. The writer groups data into 14 groups in order to find the least MSE. The detail of each group will be explained in more detail later.

4.2. Data Selection and Preparation

The neural network needed some input factor because a neural network used an input factor to forecast an output by comparing with original output.

It has many factors that may affect to the demand forecasting of sample product. First the writer will interview the forecaster of the company to find the possible factor. From the interviewing, It can be divided into two category which are computable factor and incomputable factor. The computable factors are as follows:

- Interest rate
- Unemployment rate
- Consumer price index
- Oil Price
- GDP
- In House Garment Consumer Rate
- Synthetic Fiber Production
- Export Rate

In term of incomputable factor, the forecaster will use this factor to adjust the computable factor. The incomputable factors are as follows:

- Festival period
- Promotion Campaign
- Marketing Plan
- Natural Disaster

4.2.1 Interest Rate

The interest rate that used in this study is an interest rate that issued from the commercial bank. This factor can be collect from the commercial bank web site especially from the bank where subsidized money to the company.

4.2.2 Unemployment Rate

An unemployment rate can be collected at the Ministry of labour, or web site www.mol.go.th. This type of factor may affect to the sale volume because An employment person can have a power to purchase the sample product.

4.2.3 Consumer Price Index

The consumer price index is one of the factors that may affect to the sale volume of the sample product. This index can show the ability of the customer to consume the sample product.

4.2.4 Oil price

This factor can be collected by request from PTT Public Company Limited. The forecaster will use Diesel oil price as a input factor of this study.

4.2.5 Gross Domestic Product (GDP)

GDP is a value of final product or final service that was produce in Thailand by not include the value of raw material. This data cab be collected from the website www.eppo.go.th.

4.2.6 In House Garment Consumer Rate

The In house garment consumer rate is represent a consuming rate of in house garment product. The In house garment rate may affect to the sale volume of the sample product.

4.2.7 Synthetic Fiber Production

The synthetic fiber production represents the production rate of the synthetic fiber in Thailand. Because the sample product is one kind of synthetic fiber product, therefore this data may be related to the sample product.

4.2.8 Export Rate

This sample product is the top product of the company that can sale both inside and outside Thailand, so the exported data may affect to the sale volume of the sample product.

The raw data which was use as an input factor will be show in the appendix B.

4.3 Correlation

After gathering the data that cause an effect to the demand of the sample products, the forecaster has to analyze the data. In order to find which environmental data is correlate to the demand of the sample product.

The writer will use the technique called Correlation efficiency. In order to find the correlation between the environmental data and demand of the sample product, the writer will use the program called neural solution version 5 to calculate the Correlation efficiency. The output of input data after the calculation is shown in the table 4.1.

Table 4.1: The correlation analysis

	Syntetic Fiber Production	Export	Interest Rate	Unemployment	Consumer rate	Oil Price	garment consumer index	GDP	Sale
Syntetic Fiber Production	1								
Export	0.10520834	1							
Interest Rate	-0.047513264	-0.697885589	1						
Unemployment	0.187315557	-0.342069571	0.134354157	1					
Consumer rate	-0.073927521	0.727300219	-0.840635231	-0.25515989	1				
Oil Price	0.070725098	0.27770416	-0.550421813	0.327841796	0.418214918	1			
garment consumer index	0.103690369	0.732567513	-0.93930514	-0.07260956	0.849459284	0.556409756	1		
GDP	0.144785119	0.724461959	-0.923845328	-0.04750165	0.71318199	0.709373143	0.899545237	1	
Sale	0.211408576	-0.610736731	0.820255449	0.184200557	-0.719444523	-0.398199659	-0.768525088	-0.72361433	1

From the table 4.2, it can show that unemployment person, oil price, export, and synthetic fiber production is under MEAN (0.6), which mean that it not correlate enough to the sale volume of the sample product, so it will not be used in this calculation.

4.4. Demand forecasting by using Back propagation

It can be classified into two main methods which are as follows

4.4.1 Parameter Selection

In order to forecast the demand of sample product, the forecaster will use the program call Neural Solution version 5. In the program, it has many parameter that needed to fill in.

The writer will use default parameters which was set in the program in this calculation. Which are as follows:

Learning rate in Hidden layer is 1
Learning rate in Output Layer is 0.0001
Momentum is 0.7
Epoch is 5000
Transfer function is TranhAxon Function

After the forecaster can find a test set that provide least MSE, and then the forecaster will use sensitivity analysis to find the suitable parameter.

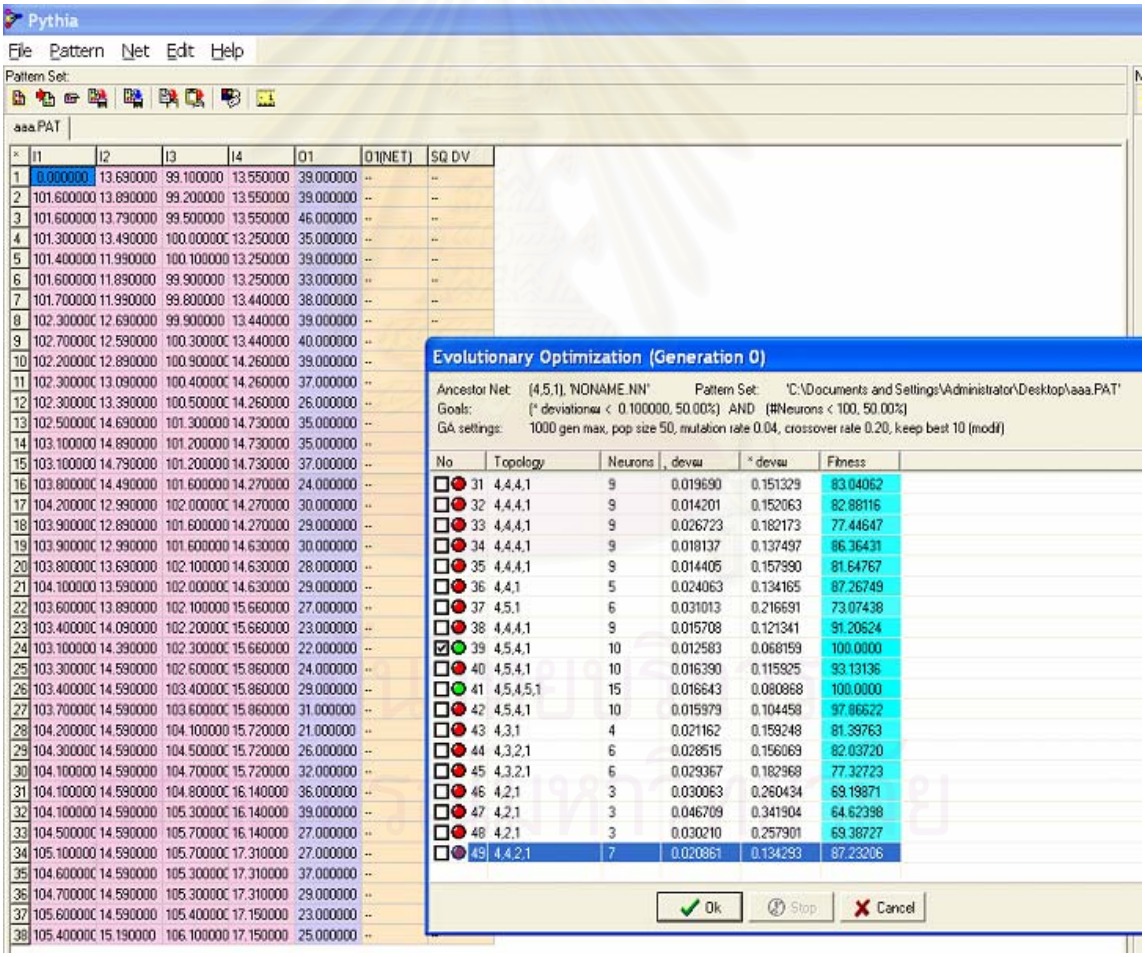
The last parameter that the writer must find is the number of neuron in the hidden layer. The number of neuron can be calculated from two methods.

1. The forecaster will use program call PHYTHIA to find the suitable number of neurons. The PHYTHIA program will find the deviation between the output from calculation and the original output in order to find the least deviation.

2. If the forecaster do not use a program package (PYTHIA), the forecaster will try to forecast with a different number of neurons, then selected the least MSE.

In this thesis, the writer will used the program call PHYTHIA to find the suitable number of neurons. The following picture will illustrate the calculation of program PHYTHIA. Form the result of the calculation of the program PHYTHIA, the 10 neurons can give a 100 percent fitness and least MSE.

Figure 4.1: Illustrate the calculation of the program PYTHIA

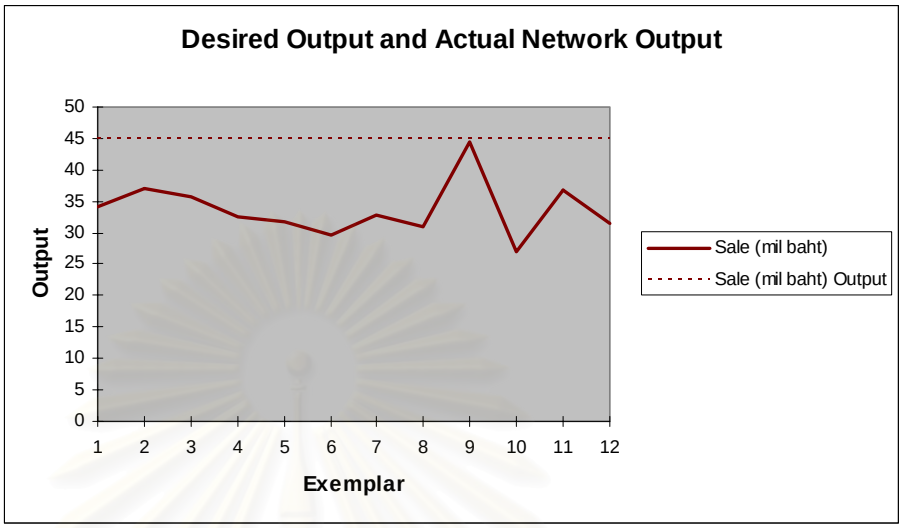


4.4.2 Input Factor Testing

After the forecaster chose the right input factor, the forecaster will calculate every possible input factor. Therefore, the test set can be divided into 14 TESTSET which are as follows:

1. Index customer price and sale volume
2. Index customer price, interest rate and sale volume
3. Index customer price, interest rate, garment customer index and sale volume
4. Index customer price, interest rate, garment customer index, GDP and sale volume
5. Interest rate and sale volume
6. Interest rate, garment customer index and sale volume
7. Interest rate, garment customer index, GDP and sale volume
8. Garment consumer index and sale volume
9. Garment customer index, index customer price and sale volume
10. Garment customer index, GDP and sale volume
11. GDP and sale volume
12. GDP, index customer price, interest rate and sale volume
13. GDP, index customer price and sale volume
14. GDP, interest rate and sale volume

1. Index customer price and Sale volume

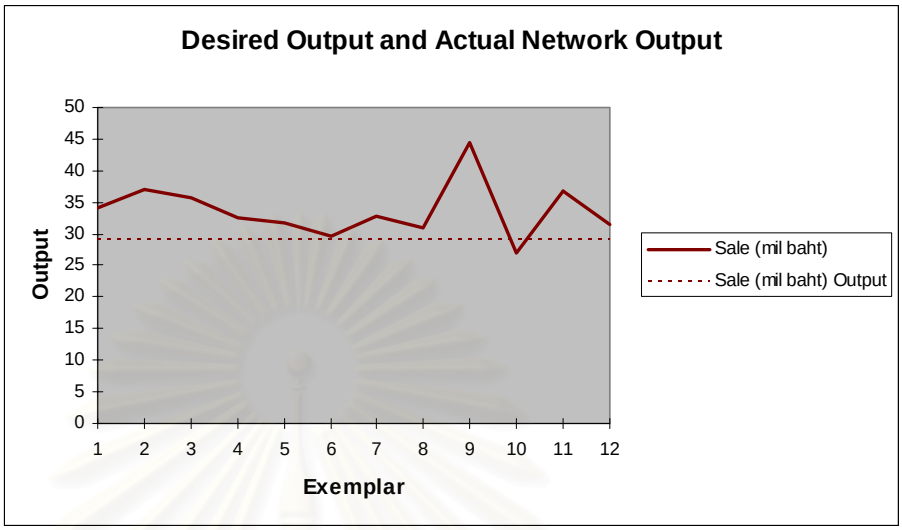


Index Customer Price	Sale (mil baht)	Sale (mil baht) Output
105.9	34.168504	44.8957367
106.4	36.981905	44.8958309
106.3	35.771983	44.8958113
106.4	32.665378	44.8958309
106.5	31.650556	44.895851
106.6	29.703663	44.8958714
106.9	32.703767	44.8959354
107.7	30.834193	44.8961269
107.9	44.549969	44.89618
108.5	27.031401	44.8963537
108.9	36.882315	44.8964825
109.1	31.349847	44.8965512

Error = 33.25 percent

MSE = 144.18

2. Index customer price, Interest rate and Sale volume

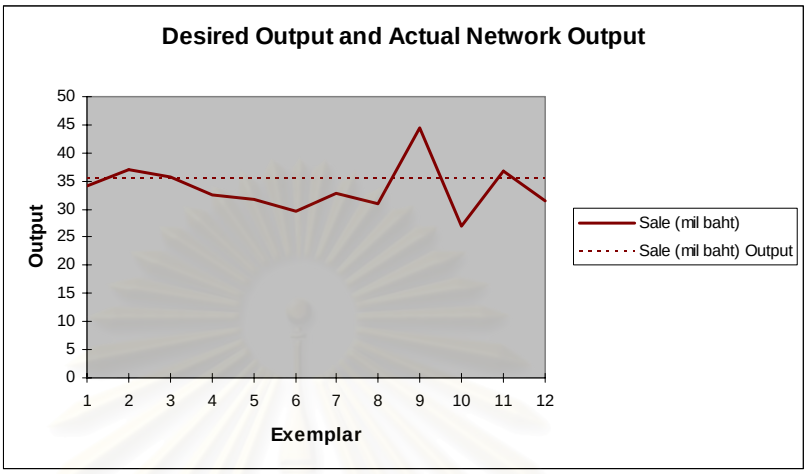


Index Customer Price	Interest Rate	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	34.168504	29.082548
106.4	1.18	36.981905	29.0824029
106.3	1.18	35.771983	29.0824323
106.4	1.59	32.665378	29.083733
106.5	1.59	31.650556	29.0837123
106.6	1.59	29.703663	29.0836914
106.9	2.09	32.703767	29.0846889
107.7	2.09	30.834193	29.0845745
107.9	2.09	44.549969	29.0845447
108.5	2.63	27.031401	29.0852109
108.9	2.63	36.882315	29.0851696
109.1	2.63	31.349847	29.0851484

Error = - 13.67 percent

MSE = 39.86

3. Index customer price, Interest rate, Garment customer index and Sale volume

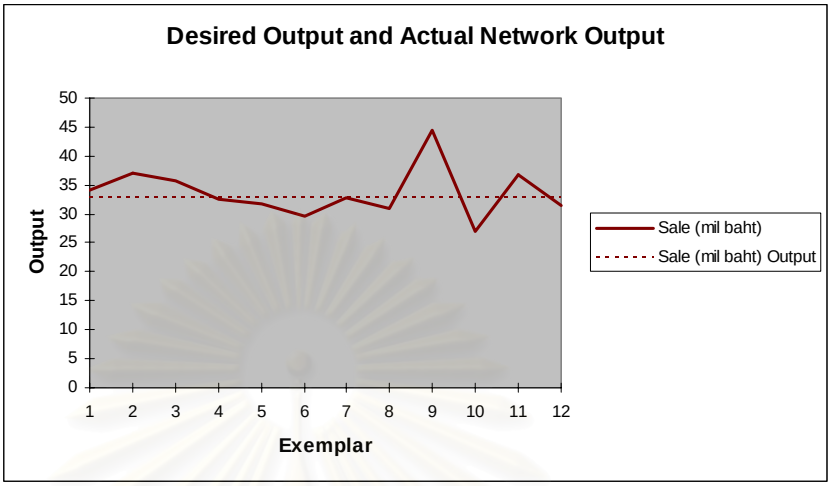


Index Customer Price	Interest Rate	Garment Customer Index	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	110.4	34.168504	35.5514711
106.4	1.18	111.2	36.981905	35.551395
106.3	1.18	112.1	35.771983	35.551385
106.4	1.59	112.3	32.665378	35.5529454
106.5	1.59	111.5	31.650556	35.552952
106.6	1.59	111.4	29.703663	35.5529343
106.9	2.09	111.6	32.703767	35.5565111
107.7	2.09	111.9	30.834193	35.5560387
107.9	2.09	113.1	44.549969	35.5558043
108.5	2.63	114.3	27.031401	35.5607275
108.9	2.63	115.1	36.882315	35.5601503
109.1	2.63	115.1	31.349847	35.5599636

Error = 5.53

MSE = 22.1

4. Index customer price, Interest rate, Garment customer index, GDP and Sale volume

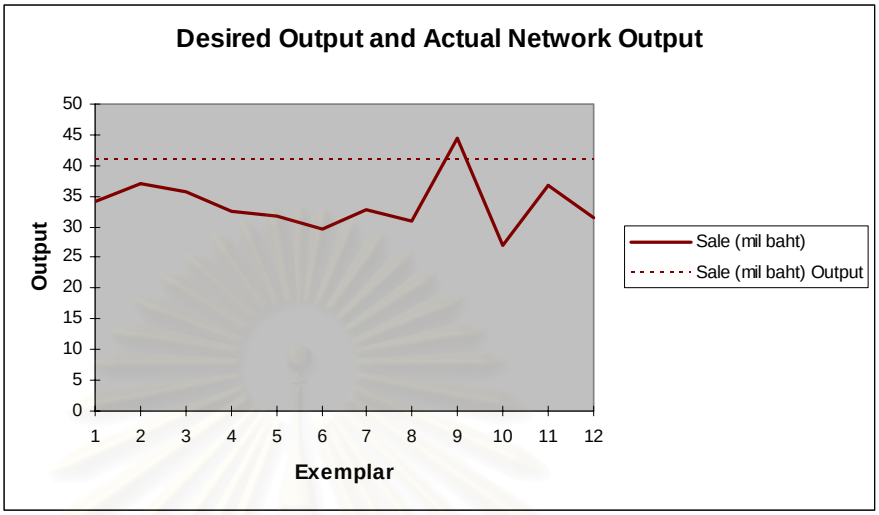


Index Customer Price	Interest Rate	Garment Customer Index	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	110.4	17.9094	34.168504	32.880073
106.4	1.18	111.2	17.9094	36.981905	32.8800914
106.3	1.18	112.1	17.9094	35.771983	32.8800866
106.4	1.59	112.3	19.2428	32.665378	32.8803884
106.5	1.59	111.5	19.2428	31.650556	32.8803953
106.6	1.59	111.4	19.2428	29.703663	32.8804086
106.9	2.09	111.6	19.30065	32.703767	32.8827982
107.7	2.09	111.9	19.30065	30.834193	32.8831412
107.9	2.09	113.1	19.30065	44.549969	32.8832777
108.5	2.63	114.3	18.89458	27.031401	32.888817
108.9	2.63	115.1	18.89458	36.882315	32.8886938
109.1	2.63	115.1	18.89458	31.349847	32.8886448

Error = -2.4 percent

MSE = 19.29

5. Interest rate and Sale volume

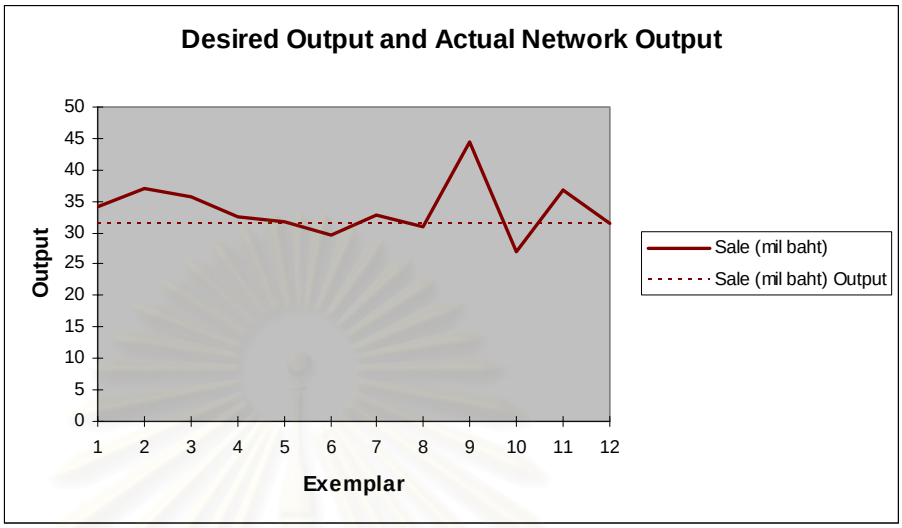


Interest Rate	Sale (mil baht)	Sale (mil baht) Output
1.18	34.168504	41.0871776
1.18	36.981905	41.0871776
1.18	35.771983	41.0871776
1.59	32.665378	41.0876345
1.59	31.650556	41.0876345
1.59	29.703663	41.0876345
2.09	32.703767	41.0889508
2.09	30.834193	41.0889508
2.09	44.549969	41.0889508
2.63	27.031401	41.0919678
2.63	36.882315	41.0919678
2.63	31.349847	41.0919678

Error = 21.95

MSE = 73.36

6. Interest rate, Garment customer index and Sale volume

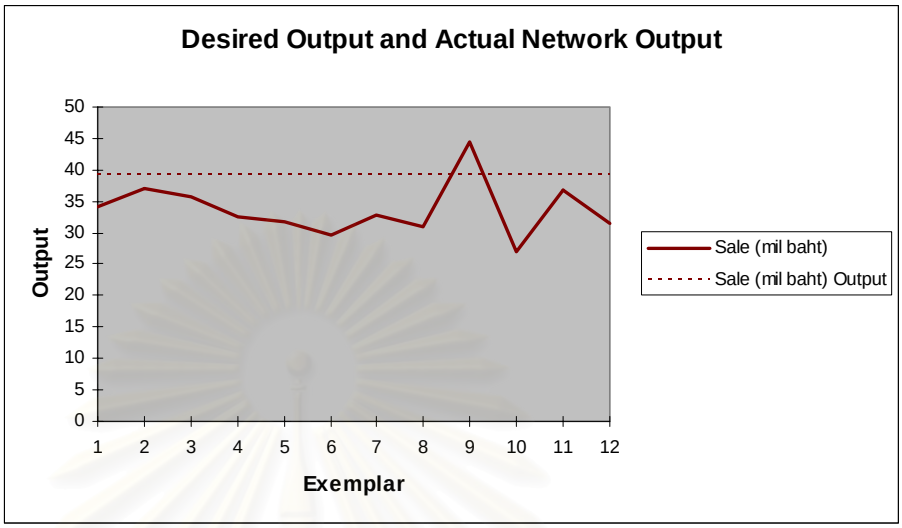


Interest Rate	Garment Customer Index	Sale (mil baht)	Sale (mil baht) Output
1.18	110.4	34.168504	31.4623876
1.18	111.2	36.981905	31.4623279
1.18	112.1	35.771983	31.462277
1.59	112.3	32.665378	31.4661251
1.59	111.5	31.650556	31.4662551
1.59	111.4	29.703663	31.4662725
2.09	111.6	32.703767	31.4708612
2.09	111.9	30.834193	31.4707879
2.09	113.1	44.549969	31.4705104
2.63	114.3	27.031401	31.4730911
2.63	115.1	36.882315	31.4729104
2.63	115.1	31.349847	31.4729104

Error = -6.6 percent

MSE = 23.58

7. Interest rate, Garment customer index, GDP and Sale volume

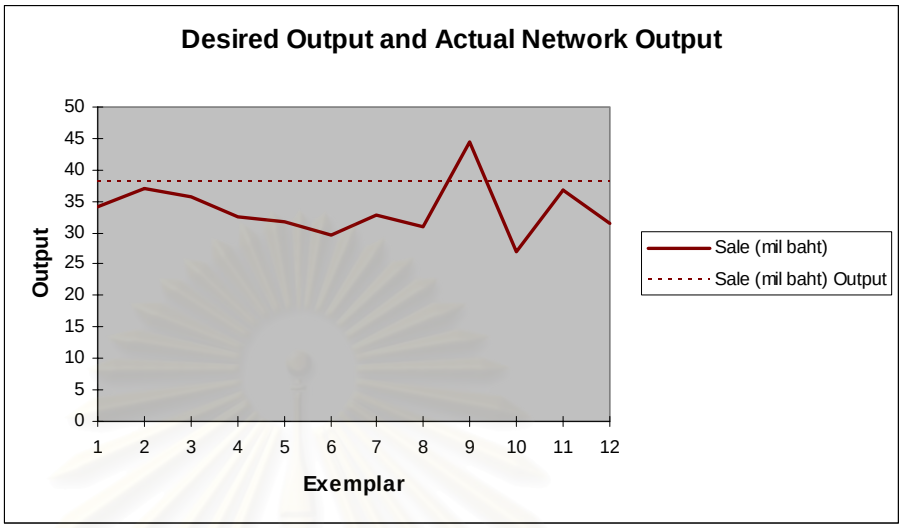


Interest Rate	Garment Customer Index	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
1.18	110.4	17.9094	34.168504	39.122667
1.18	111.2	17.9094	36.981905	39.1227463
1.18	112.1	17.9094	35.771983	39.122845
1.59	112.3	19.2428	32.665378	39.1235684
1.59	111.5	19.2428	31.650556	39.123445
1.59	111.4	19.2428	29.703663	39.1234303
2.09	111.6	19.30065	32.703767	39.1262232
2.09	111.9	19.30065	30.834193	39.1263353
2.09	113.1	19.30065	44.549969	39.1268186
2.63	114.3	18.89458	27.031401	39.1392797
2.63	115.1	18.89458	36.882315	39.1402893
2.63	115.1	18.89458	31.349847	39.1402893

Error = 16.14 percent

MSE = 48.2

8. Garment customer index and Sale volume

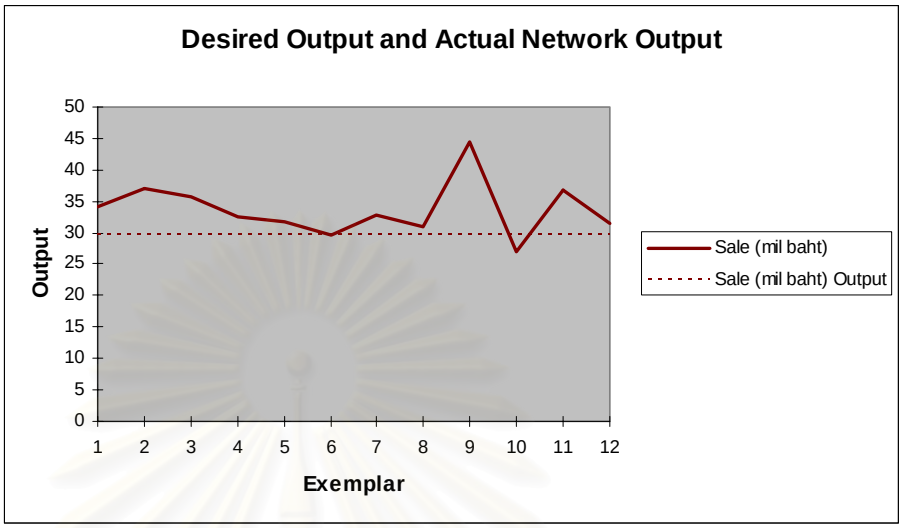


Garment Customer Index	Sale (mil baht)	Sale (mil baht) Output
110.4	34.168504	38.0369665
111.2	36.981905	38.0369312
112.1	35.771983	38.0368949
112.3	32.665378	38.0368873
111.5	31.650556	38.0369187
111.4	29.703663	38.0369228
111.6	32.703767	38.0369146
111.9	30.834193	38.0369027
113.1	44.549969	38.0368585
114.3	27.031401	38.0368199
115.1	36.882315	38.0367969
115.1	31.349847	38.0367969

Error = 12.9

MSE = 37.51

9. Garment customer index, Index customer price and Sale volume

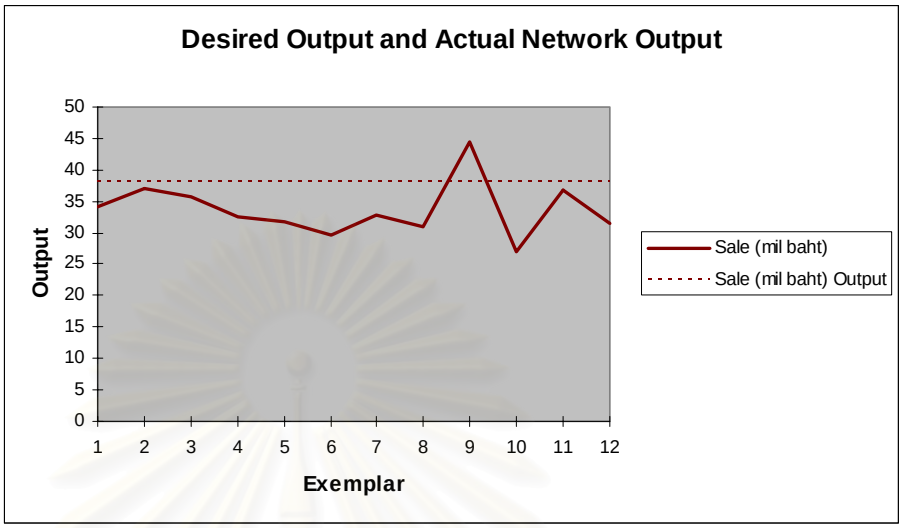


Index Customer Price	Garment Customer Index	Sale (mil baht)	Sale (mil baht) Output
105.9	110.4	34.168504	29.6655941
106.4	111.2	36.981905	29.6634504
106.3	112.1	35.771983	29.661873
106.4	112.3	32.665378	29.6614782
106.5	111.5	31.650556	29.6628049
106.6	111.4	29.703663	29.6629185
106.9	111.6	32.703767	29.6623493
107.7	111.9	30.834193	29.6613674
107.9	113.1	44.549969	29.6596039
108.5	114.3	27.031401	29.6580858
108.9	115.1	36.882315	29.6572726
109.1	115.1	31.349847	29.6572301

Error = -11.96

MSE = 34.87

10. Garment customer index, GDP and Sale volume

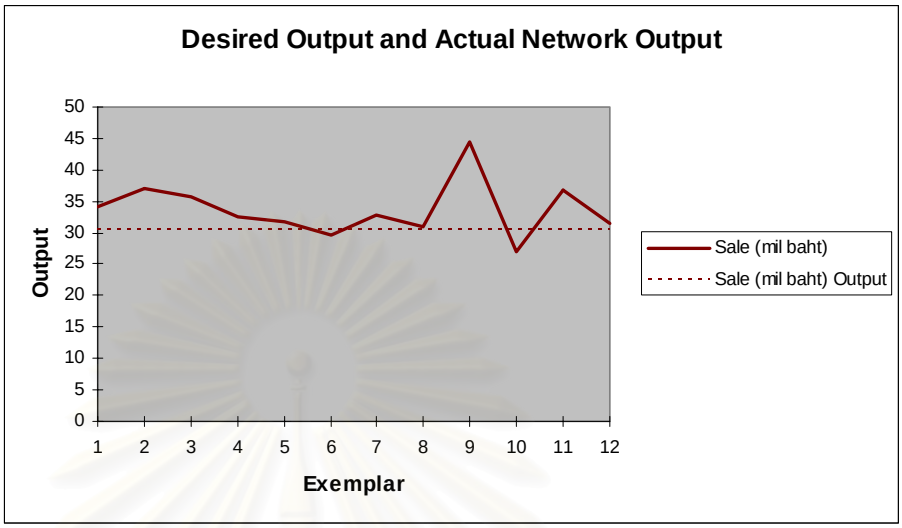


Garment Customer Index	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
110.4	17.9094	34.168504	38.1762064
111.2	17.9094	36.981905	38.1762004
112.1	17.9094	35.771983	38.176195
112.3	19.2428	32.665378	38.1761776
111.5	19.2428	31.650556	38.1761855
111.4	19.2428	29.703663	38.1761866
111.6	19.30065	32.703767	38.176185
111.9	19.30065	30.834193	38.1761819
113.1	19.30065	44.549969	38.1761711
114.3	18.89458	27.031401	38.1761636
115.1	18.89458	36.882315	38.17616
115.1	18.89458	31.349847	38.17616

Error = 13.31

MSE = 38.75

11. GDP and Sale volume

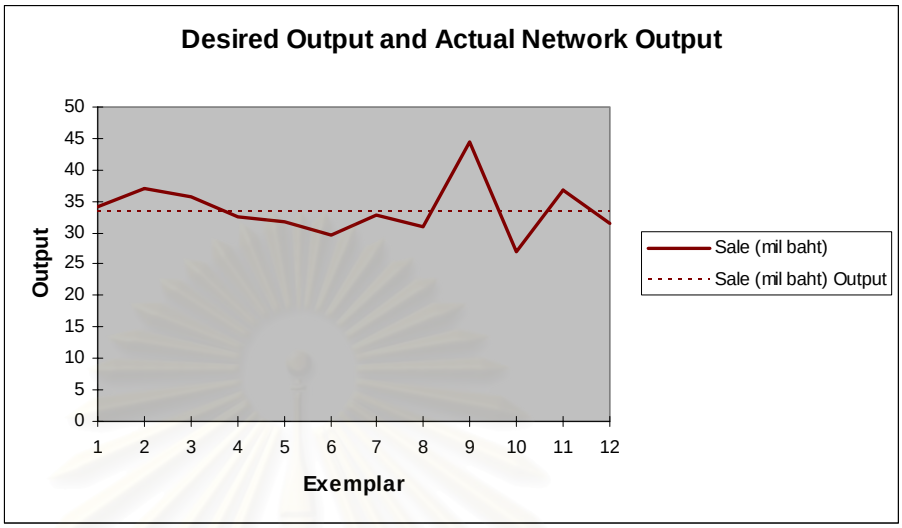


GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
17.9094	34.168504	30.5308914
17.9094	36.981905	30.5308914
17.9094	35.771983	30.5308914
19.2428	32.665378	30.5229766
19.2428	31.650556	30.5229766
19.2428	29.703663	30.5229766
19.30065	32.703767	30.5228044
19.30065	30.834193	30.5228044
19.30065	44.549969	30.5228044
18.89458	27.031401	30.5242193
18.89458	36.882315	30.5242193
18.89458	31.349847	30.5242193

Error = -9.4

MSE = 28.65

12. GDP, Index customer price, Interest rate and Sale volume

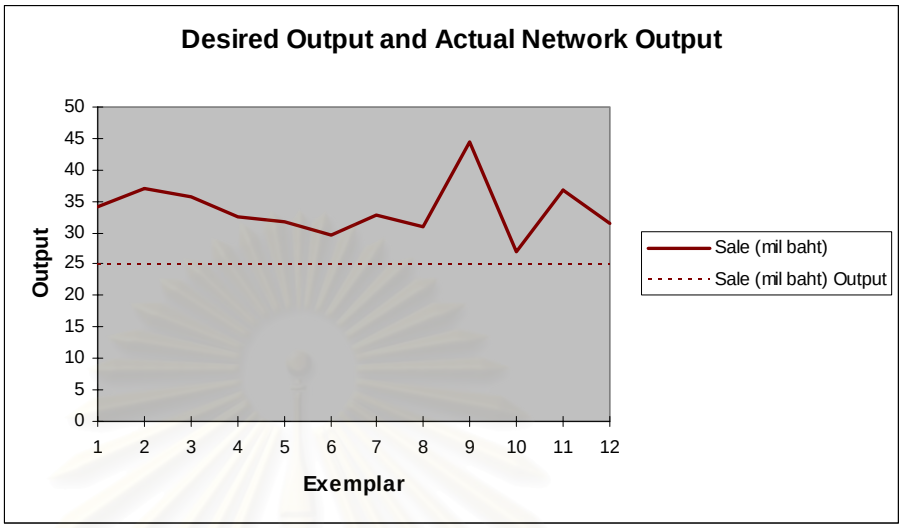


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	33.3144799
106.4	1.18	17.9094	36.981905	33.3144455
106.3	1.18	17.9094	35.771983	33.3144517
106.4	1.59	19.2428	32.665378	33.3158974
106.5	1.59	19.2428	31.650556	33.3158845
106.6	1.59	19.2428	29.703663	33.315872
106.9	2.09	19.30065	32.703767	33.3247382
107.7	2.09	19.30065	30.834193	33.3244707
107.9	2.09	19.30065	44.549969	33.3244161
108.5	2.63	18.89458	27.031401	33.3373649
108.9	2.63	18.89458	36.882315	33.3371728
109.1	2.63	18.89458	31.349847	33.3370876

Error = -1.09

MSE = 18.78

13. GDP, Index customer price and Sale volume

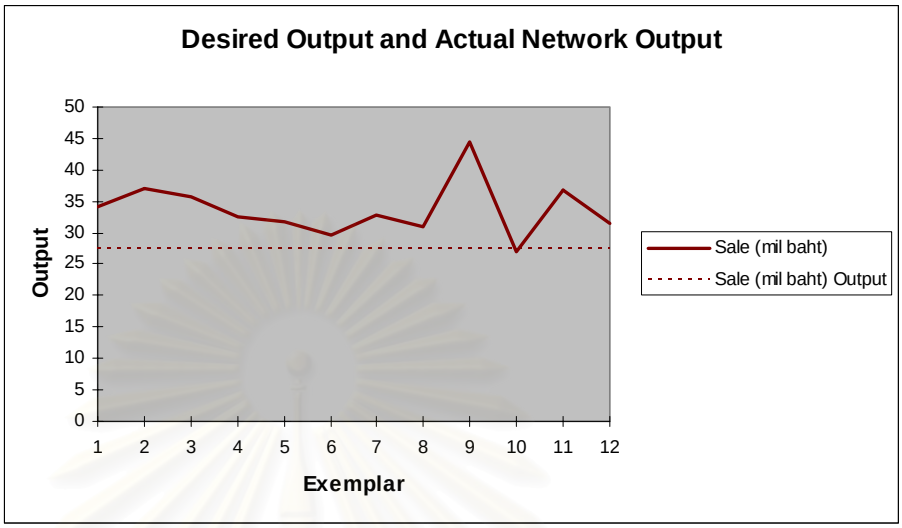


Index Customer Price	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	17.9094	34.168504	24.8678213
106.4	17.9094	36.981905	24.8677063
106.3	17.9094	35.771983	24.8677314
106.4	19.2428	32.665378	24.8675095
106.5	19.2428	31.650556	24.8674878
106.6	19.2428	29.703663	24.867465
106.9	19.30065	32.703767	24.8673795
107.7	19.30065	30.834193	24.8671262
107.9	19.30065	44.549969	24.8670485
108.5	18.89458	27.031401	24.8668119
108.9	18.89458	36.882315	24.8665783
109.1	18.89458	31.349847	24.8664472

Error = -26.2

MSE = 96.5

14. GDP, Interest rate and Sale volume



Interest Rate	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
1.18	17.9094	34.168504	27.4615085
1.18	17.9094	36.981905	27.4615085
1.18	17.9094	35.771983	27.4615085
1.59	19.2428	32.665378	27.4607058
1.59	19.2428	31.650556	27.4607058
1.59	19.2428	29.703663	27.4607058
2.09	19.30065	32.703767	27.4612771
2.09	19.30065	30.834193	27.4612771
2.09	19.30065	44.549969	27.4612771
2.63	18.89458	27.031401	27.4627
2.63	18.89458	36.882315	27.4627
2.63	18.89458	31.349847	27.4627

Error = -18.5

MSE = 57.44

After calculated the sale volume by using Neural Solution version 5, It can be summarize and show in the table 4.2.

Table 4.2: The testing Result

Test Set	Input Factor	Error	MSE
1.	1. Index customer price 2. Sale volume	33.25	144.18
2.	1. Index customer price 2. Interest rate 3. Sale volume	- 13.67	39.86
3.	1. Index customer price 2. Interest rate 3. Garment customer index 4. Sale volume	5.53	22.1
4.	1. Index customer price 2. Interest rate 3. Garment customer index 4. GDP 5. Sale volume	- 2.4	19.29
5.	1. Interest rate 2. Sale volume	21.95	73.36
6.	1. Interest rate 2. Garment customer index 3. Sale volume	-6.6	23.58
7.	1. Interest rate 2. Garment customer index 3. GDP 4. Sale volume	16.14	48.2
8.	1. Garment customer index	12.9	37.51

	2. Sale volume		
9.	1. Garment customer index 2. Index customer price 3. Sale volume	-11.96	34.87
10.	1. Garment customer index, 2. GDP 3. Sale volume	13.31	38.75
11.	1. GDP 2. Sale volume	-9.4	28.65
12.	1. GDP 2. Index customer price 3. Interest rate 3. Sale volume	-1.09	18.78
13.	1. GDP 2. Index customer price 3. Sale volume	-26.2	96.5
14.	1. GDP 2. Interest rate 3. Sale volume	-18.5	57.44

From 14 test set, the least MSE is TEST SET number 12. Therefore, the forecasting sale amount for the next 12 month will be 33.34 million baht.

4.4.3 Conclusion

After the forecaster can get the lowest MSE which are test set 12, the company have to compare between the old method (Moving Average) and the new, method (Neural network) in order to find the suitable method.

Table 4.3 will illustrate the comparison of MSE and Error between Moving average technique and Neural Network Technique.

Table 4.3: The comparison between Moving Average technique and Neural Network technique

Forecasting Method	Error	MSE
1. Moving Average	-5.163	29.165
2. Neural Network (Test Set 12)	-1.09	18.78

From the table 4.3, in term of both Error and MSE, the Neural Network can give the best result. Therefore, it can be conclude that if the forecaster choosing the right input factor, it will result in better forecast than moving average technique.

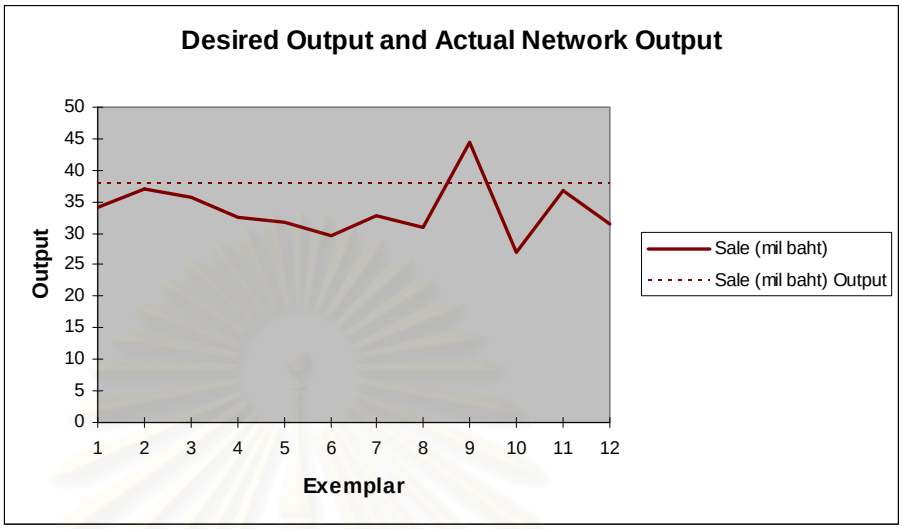
4.5. Sensitivity Analysis

After we can realize that test set 12 can give the best forecasting result, but we cannot guarantee that this variable for neural network calculation of Test Set 12 can give the best result. The forecaster need to try a different variable.

4.5.1. Momentum Analysis

The first factor that the forecaster will test is Momentum. The analysis will illustrate the effect of the forecasting result when the momentum was changed. The result of testing are shown below

1. Momentum is 0.1

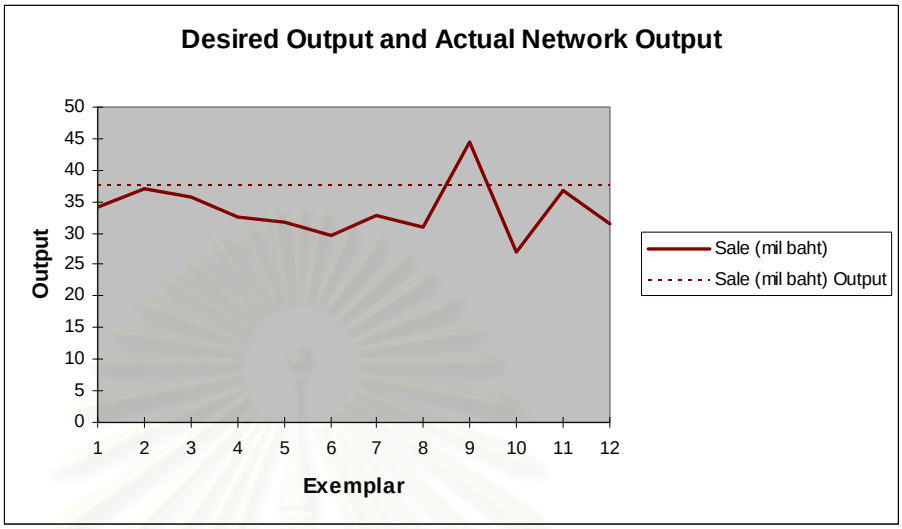


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	37.9342092
106.4	1.18	17.9094	36.981905	37.9342102
106.3	1.18	17.9094	35.771983	37.93421
106.4	1.59	19.2428	32.665378	37.9342097
106.5	1.59	19.2428	31.650556	37.9342099
106.6	1.59	19.2428	29.703663	37.9342101
106.9	2.09	19.30065	32.703767	37.9342139
107.7	2.09	19.30065	30.834193	37.9342156
107.9	2.09	19.30065	44.549969	37.9342161
108.5	2.63	18.89458	27.031401	37.9342443
108.9	2.63	18.89458	36.882315	37.9342453
109.1	2.63	18.89458	31.349847	37.9342458

Error = 12.6 percent

MSE = 36.64

2. Momentum is 0.2

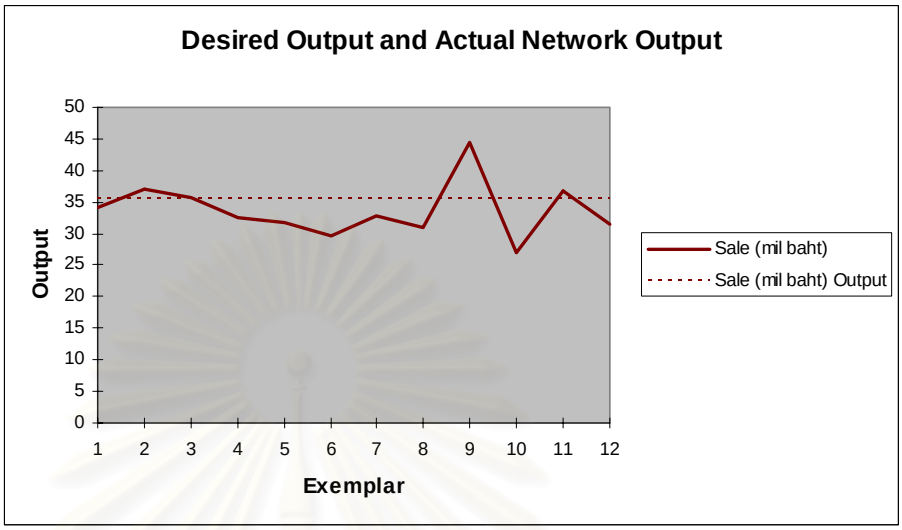


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	37.6351907
106.4	1.18	17.9094	36.981905	37.6352274
106.3	1.18	17.9094	35.771983	37.6352199
106.4	1.59	19.2428	32.665378	37.6354691
106.5	1.59	19.2428	31.650556	37.635478
106.6	1.59	19.2428	29.703663	37.6354869
106.9	2.09	19.30065	32.703767	37.6357402
107.7	2.09	19.30065	30.834193	37.6358186
107.9	2.09	19.30065	44.549969	37.6358377
108.5	2.63	18.89458	27.031401	37.6360944
108.9	2.63	18.89458	36.882315	37.6361256
109.1	2.63	18.89458	31.349847	37.6361403

Error = 11.71

MSE = 34.19

3. Momentum = 0.3

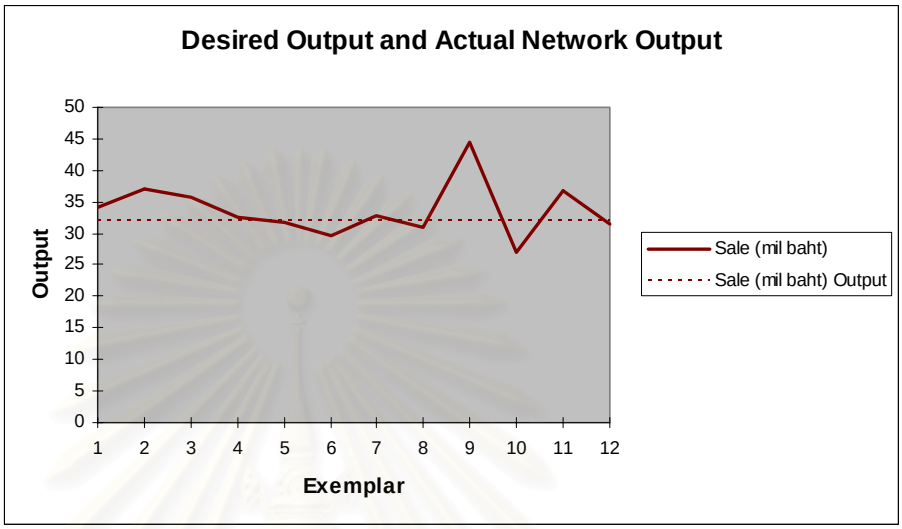


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	35.4032706
106.4	1.18	17.9094	36.981905	35.4032406
106.3	1.18	17.9094	35.771983	35.4032461
106.4	1.59	19.2428	32.665378	35.4041717
106.5	1.59	19.2428	31.650556	35.4041546
106.6	1.59	19.2428	29.703663	35.4041377
106.9	2.09	19.30065	32.703767	35.4057144
107.7	2.09	19.30065	30.834193	35.4054523
107.9	2.09	19.30065	44.549969	35.4053919
108.5	2.63	18.89458	27.031401	35.4074692
108.9	2.63	18.89458	36.882315	35.4072821
109.1	2.63	18.89458	31.349847	35.4071938

Error = -5.08

MSE = 21.57

4. Momentum = 0.4

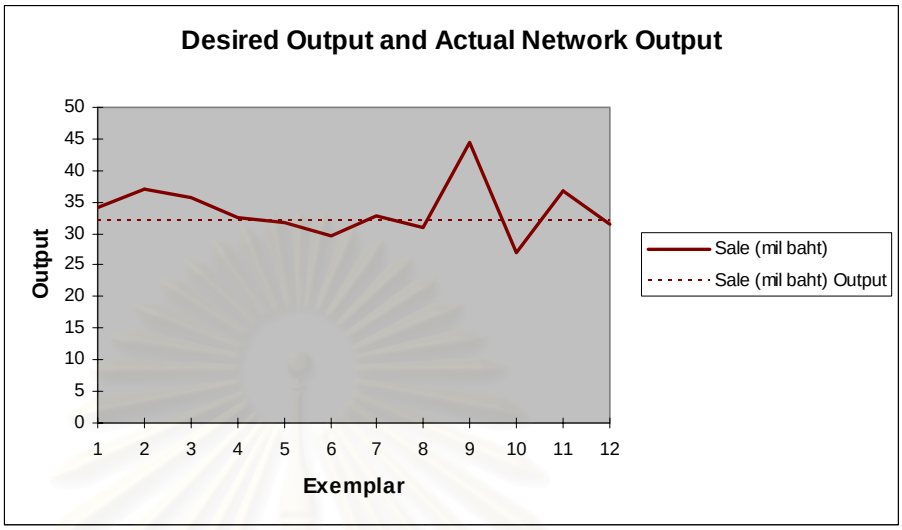


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	32.0506141
106.4	1.18	17.9094	36.981905	32.0503208
106.3	1.18	17.9094	35.771983	32.0503745
106.4	1.59	19.2428	32.665378	32.0515353
106.5	1.59	19.2428	31.650556	32.0514493
106.6	1.59	19.2428	29.703663	32.0513673
106.9	2.09	19.30065	32.703767	32.0584013
107.7	2.09	19.30065	30.834193	32.0557717
107.9	2.09	19.30065	44.549969	32.0552785
108.5	2.63	18.89458	27.031401	32.0812732
108.9	2.63	18.89458	36.882315	32.0774972
109.1	2.63	18.89458	31.349847	32.075694

Error = -4.84

MSE = 21.32

5. Momentum = 0.5

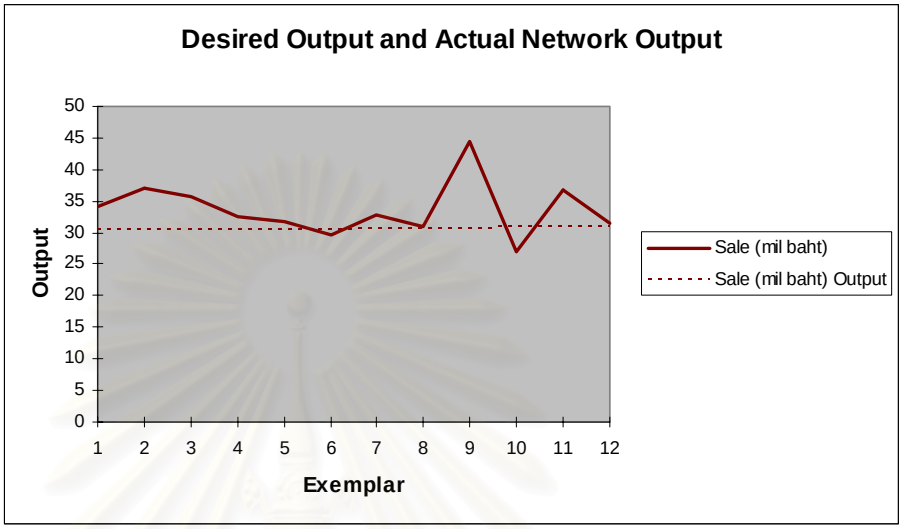


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	31.9507653
106.4	1.18	17.9094	36.981905	31.9506971
106.3	1.18	17.9094	35.771983	31.9507106
106.4	1.59	19.2428	32.665378	31.9511021
106.5	1.59	19.2428	31.650556	31.9510875
106.6	1.59	19.2428	29.703663	31.951073
106.9	2.09	19.30065	32.703767	31.951338
107.7	2.09	19.30065	30.834193	31.9512226
107.9	2.09	19.30065	44.549969	31.9511934
108.5	2.63	18.89458	27.031401	31.9513817
108.9	2.63	18.89458	36.882315	31.9513234
109.1	2.63	18.89458	31.349847	31.951294

Error = -5.165

MSE = 21.66

6. Momentum = 0.6

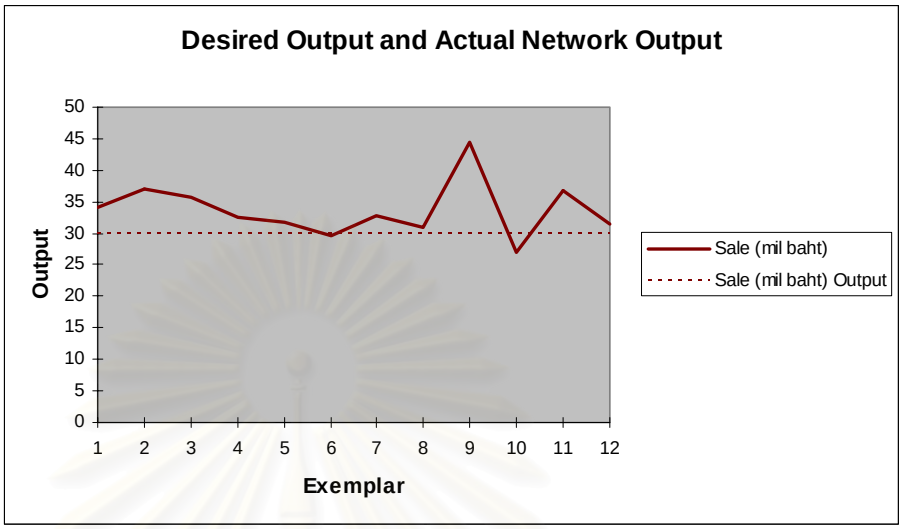


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht)	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	30.4572232
106.4	1.18	17.9094	36.981905	30.4562389
106.3	1.18	17.9094	35.771983	30.4564303
106.4	1.59	19.2428	32.665378	30.4942916
106.5	1.59	19.2428	31.650556	30.4933442
106.6	1.59	19.2428	29.703663	30.4924278
106.9	2.09	19.30065	32.703767	30.8179948
107.7	2.09	19.30065	30.834193	30.776895
107.9	2.09	19.30065	44.549969	30.7654231
108.5	2.63	18.89458	27.031401	30.9108154
108.9	2.63	18.89458	36.882315	30.9106599
109.1	2.63	18.89458	31.349847	30.910556

Error = -8.9

MSE = 27.98

7. Momentum = 0.8

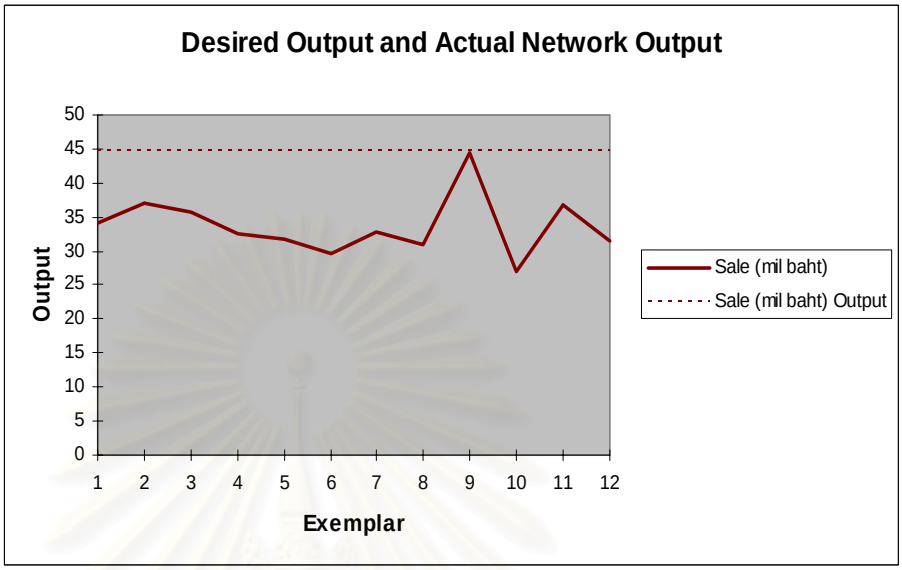


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	29.9637816
106.4	1.18	17.9094	36.981905	29.9631446
106.3	1.18	17.9094	35.771983	29.9632693
106.4	1.59	19.2428	32.665378	29.9670902
106.5	1.59	19.2428	31.650556	29.9669532
106.6	1.59	19.2428	29.703663	29.9668184
106.9	2.09	19.30065	32.703767	29.9763552
107.7	2.09	19.30065	30.834193	29.9748543
107.9	2.09	19.30065	44.549969	29.9745068
108.5	2.63	18.89458	27.031401	29.9808253
108.9	2.63	18.89458	36.882315	29.9798732
109.1	2.63	18.89458	31.349847	29.9794188

Error = -11.04

MSE = 32.48

8. Momentum = 0.9

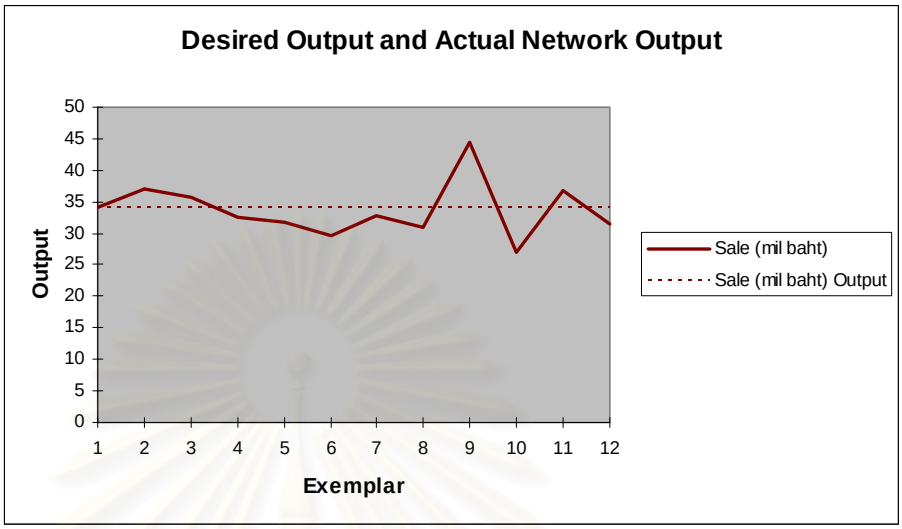


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	44.5997443
106.4	1.18	17.9094	36.981905	44.5997761
106.3	1.18	17.9094	35.771983	44.5997694
106.4	1.59	19.2428	32.665378	44.59993
106.5	1.59	19.2428	31.650556	44.5999395
106.6	1.59	19.2428	29.703663	44.5999493
106.9	2.09	19.30065	32.703767	44.6002957
107.7	2.09	19.30065	30.834193	44.6003898
107.9	2.09	19.30065	44.549969	44.6004131
108.5	2.63	18.89458	27.031401	44.6008341
108.9	2.63	18.89458	36.882315	44.6008659
109.1	2.63	18.89458	31.349847	44.6008809

Error = 32.28

MSE = 137.64

9. Momentum = 1

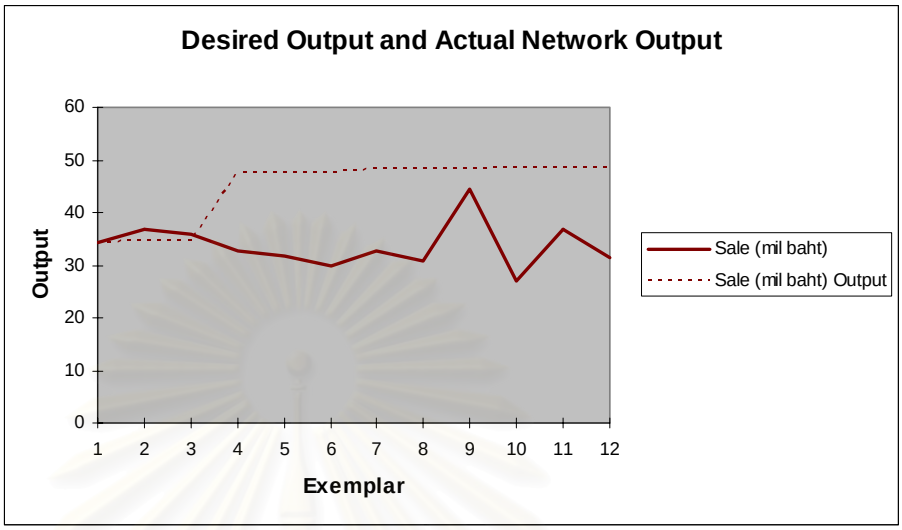


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	34.1934608
106.4	1.18	17.9094	36.981905	34.1934608
106.3	1.18	17.9094	35.771983	34.1934608
106.4	1.59	19.2428	32.665378	34.1934608
106.5	1.59	19.2428	31.650556	34.1934608
106.6	1.59	19.2428	29.703663	34.1934608
106.9	2.09	19.30065	32.703767	34.1934608
107.7	2.09	19.30065	30.834193	34.1934608
107.9	2.09	19.30065	44.549969	34.1934608
108.5	2.63	18.89458	27.031401	34.1934608
108.9	2.63	18.89458	36.882315	34.1934608
109.1	2.63	18.89458	31.349847	34.1934608

Error = 1.5

MSE = 18.88

10. Momentum = ConjugateGardient

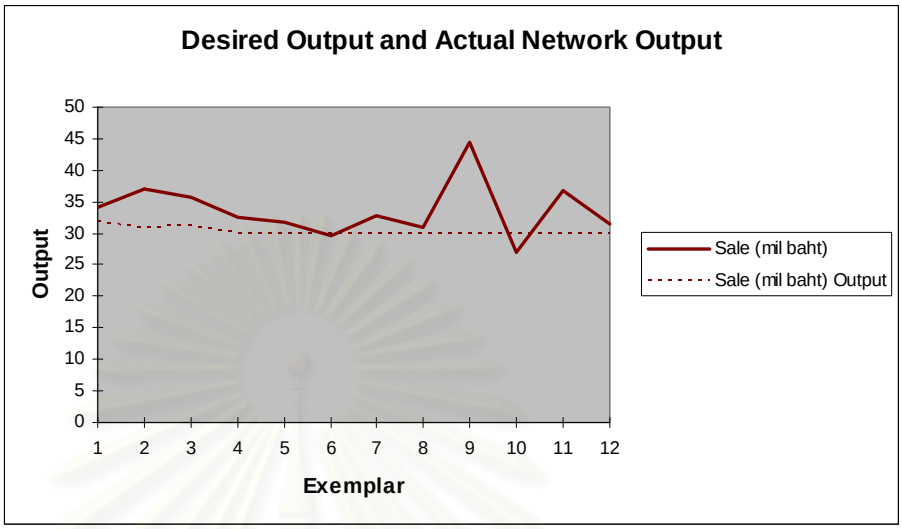


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	34.3246529
106.4	1.18	17.9094	36.981905	34.6909606
106.3	1.18	17.9094	35.771983	34.6153646
106.4	1.59	19.2428	32.665378	47.5686168
106.5	1.59	19.2428	31.650556	47.5800931
106.6	1.59	19.2428	29.703663	47.5913521
106.9	2.09	19.30065	32.703767	48.2181018
107.7	2.09	19.30065	30.834193	48.2361073
107.9	2.09	19.30065	44.549969	48.2406216
108.5	2.63	18.89458	27.031401	48.4751268
108.9	2.63	18.89458	36.882315	48.4772013
109.1	2.63	18.89458	31.349847	48.4781479

Error = 32.7

MSE = 187.27

11. Momentum = LevenbergMarquar

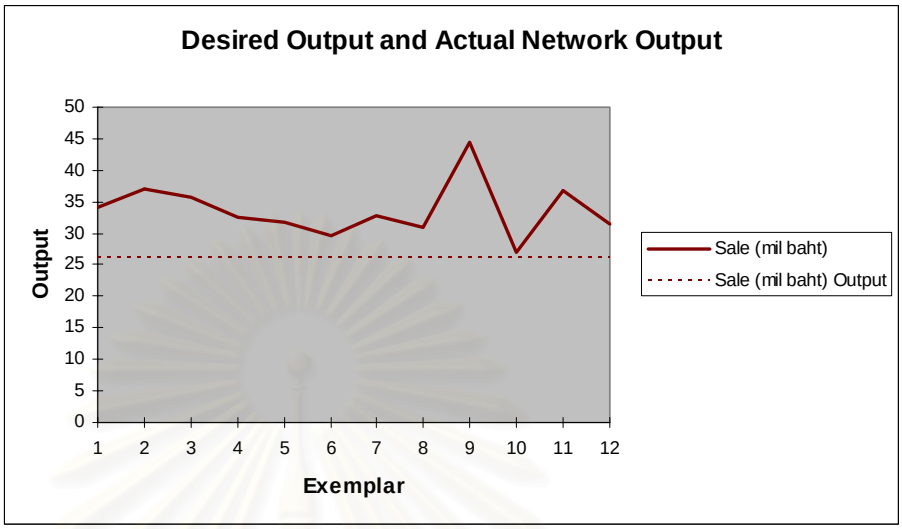


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	31.8117373
106.4	1.18	17.9094	36.981905	30.9986069
106.3	1.18	17.9094	35.771983	31.1734906
106.4	1.59	19.2428	32.665378	29.8902024
106.5	1.59	19.2428	31.650556	29.8931528
106.6	1.59	19.2428	29.703663	29.8958994
106.9	2.09	19.30065	32.703767	29.8518888
107.7	2.09	19.30065	30.834193	29.8719382
107.9	2.09	19.30065	44.549969	29.8741775
108.5	2.63	18.89458	27.031401	29.8736098
108.9	2.63	18.89458	36.882315	29.8753807
109.1	2.63	18.89458	31.349847	29.8758501

Error = -10.24

MSE = 29.76

12. Momentum = Quickprop

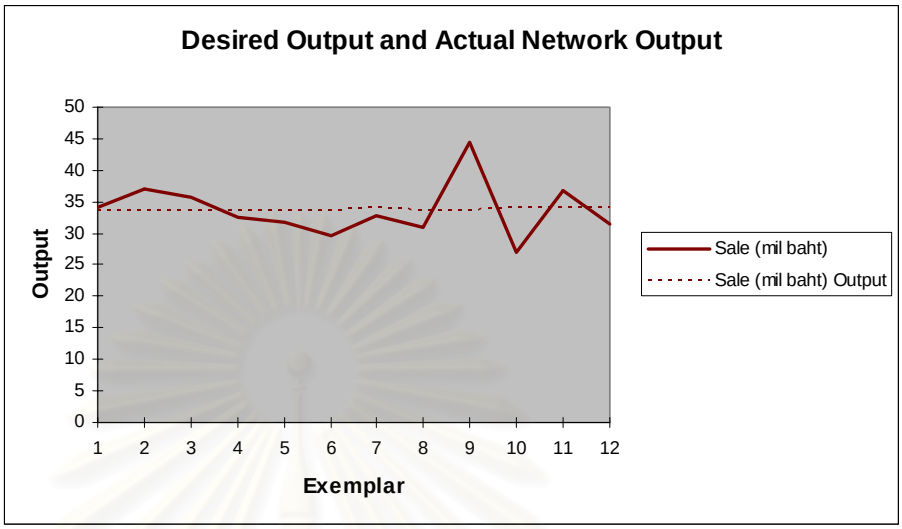


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	26.1150603
106.4	1.18	17.9094	36.981905	26.1148212
106.3	1.18	17.9094	35.771983	26.1148672
106.4	1.59	19.2428	32.665378	26.1150735
106.5	1.59	19.2428	31.650556	26.1150495
106.6	1.59	19.2428	29.703663	26.1150259
106.9	2.09	19.30065	32.703767	26.1155789
107.7	2.09	19.30065	30.834193	26.1154501
107.9	2.09	19.30065	44.549969	26.115419
108.5	2.63	18.89458	27.031401	26.1161374
108.9	2.63	18.89458	36.882315	26.1160859
109.1	2.63	18.89458	31.349847	26.1160603

Error = -22.49

MSE = 76.02

13. Momentum = DeltaBarDelta



Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	33.5605998
106.4	1.18	17.9094	36.981905	33.5605997
106.3	1.18	17.9094	35.771983	33.5605998
106.4	1.59	19.2428	32.665378	33.5606027
106.5	1.59	19.2428	31.650556	33.5606024
106.6	1.59	19.2428	29.703663	33.5606022
106.9	2.09	19.30065	32.703767	34.1819935
107.7	2.09	19.30065	30.834193	33.5797641
107.9	2.09	19.30065	44.549969	33.5638049
108.5	2.63	18.89458	27.031401	34.184003
108.9	2.63	18.89458	36.882315	34.1839862
109.1	2.63	18.89458	31.349847	34.1839707

Error = 0.23

MSE = 19.43

After forecasting sale volume by changing the momentum factor, It can be summarize and show in the table 4.4.

Table 4.4: Momentum Analysis

No.	Momentum	Error (percent)	MSE
1.	Momentum = 0.1	12.6	36.64
2.	Momentum = 0.2	11.71	34.19
3.	Momentum = 0.3	- 5.08	21.57
4.	Momentum = 0.4	- 4.84	21.32
5.	Momentum = 0.5	- 5.165	21.66
6.	Momentum = 0.6	- 8.9	27.98
7.	Momentum = 0.8	- 11.04	32.48
8.	Momentum = 0.9	32.28	137.64
9.	Momentum = 1.0	1.5	18.88
10.	ConjugateGardient	32.7	187.27
11.	LevenbergMarquar	- 10.24	29.76
12.	Quickprop	- 22.49	76.02
13.	DeltaBarDelta (Standard)	0.23	19.43

From the table 4.4, After the forecaster test the MSE of each type of transfer function by changing the momentum factor, the DeltaBarDelta can show the best result with the error around 0.23, and MSE around 19.43. Comparing with the test set 12 (with default parameter) which was shown in the table 4.5.

Table 4.5: Comparison of MSE and Error between Test Set 12 and DeltaBarDelta

No	Error	MSE
Test Set 12 (momentum = 0.7)	- 1.09	18.78
DeltaBarDelta	0.23	19.43

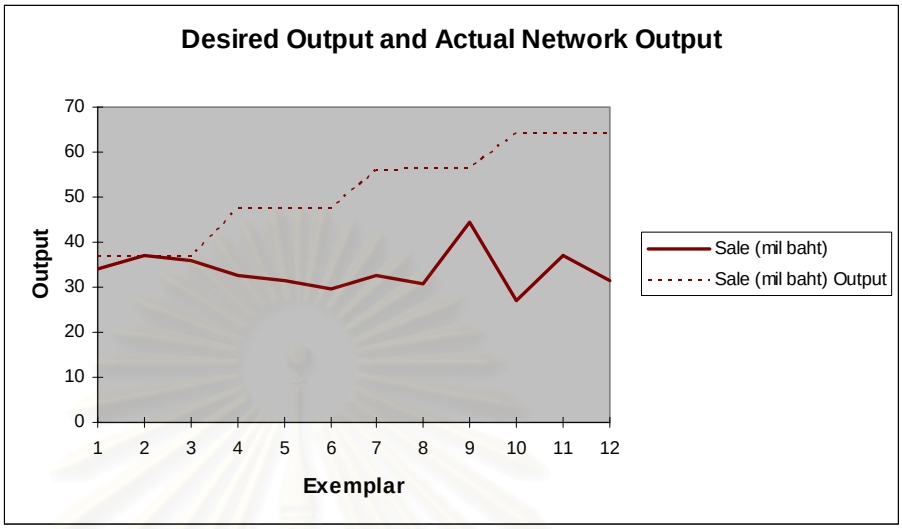
Eventhouhg, the Error of DeltaBarDelta factor is less than Test Set 12, but the MSE of Test Set 12 is less than a MSE of DeltaBarDelta. The forecaster will choose the Test Set 12 (momentum = 0.7) because the MSE of test set 12 is less than MSE of DeltaBarDelta. Although, the error of DeltaBarDelta is less than Test Set 12, but it cannot guarantee that the forecasting result will be close to the actual demand month by month. Because the error can be both positive and negative, so the error per month may be a lot, and it can cause a lot inventory. For MSE, it use a square, so it will not have a negative result of the less MSE will close to the actual demand.

4.5.2. Transfer Function

Another factor that may effect to the forecasting result is transfer function. This analysis will illustrate the effect of the forecasting result when the transfer function was changed. The results of testing are shown below:

.

1. Transfer Function is AXON

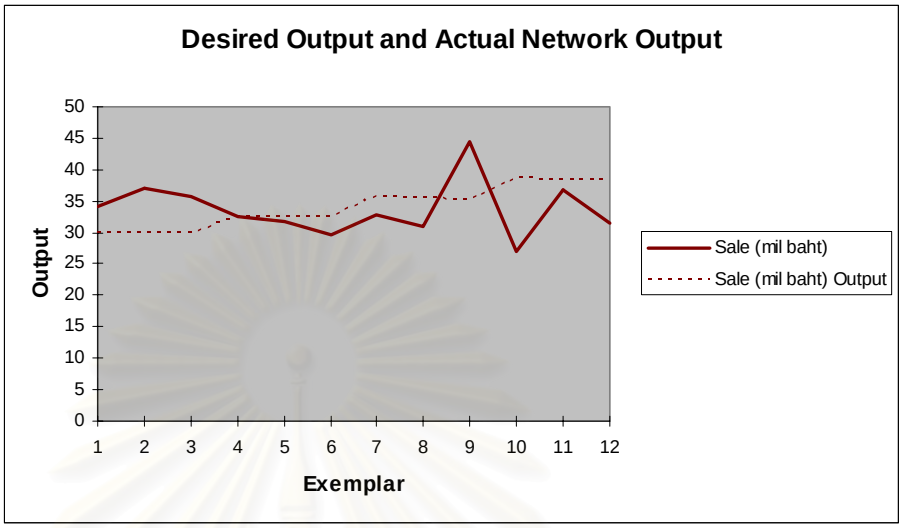


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	36.7469288
106.4	1.18	17.9094	36.981905	36.8252935
106.3	1.18	17.9094	35.771983	36.8096206
106.4	1.59	19.2428	32.665378	47.5594744
106.5	1.59	19.2428	31.650556	47.5751473
106.6	1.59	19.2428	29.703663	47.5908202
106.9	2.09	19.30065	32.703767	56.0496584
107.7	2.09	19.30065	30.834193	56.1750418
107.9	2.09	19.30065	44.549969	56.2063876
108.5	2.63	18.89458	27.031401	63.9873433
108.9	2.63	18.89458	36.882315	64.050035
109.1	2.63	18.89458	31.349847	64.0813808

Error = 51.79

MSE = 441.78

2. Transfer Function is Bias Axon

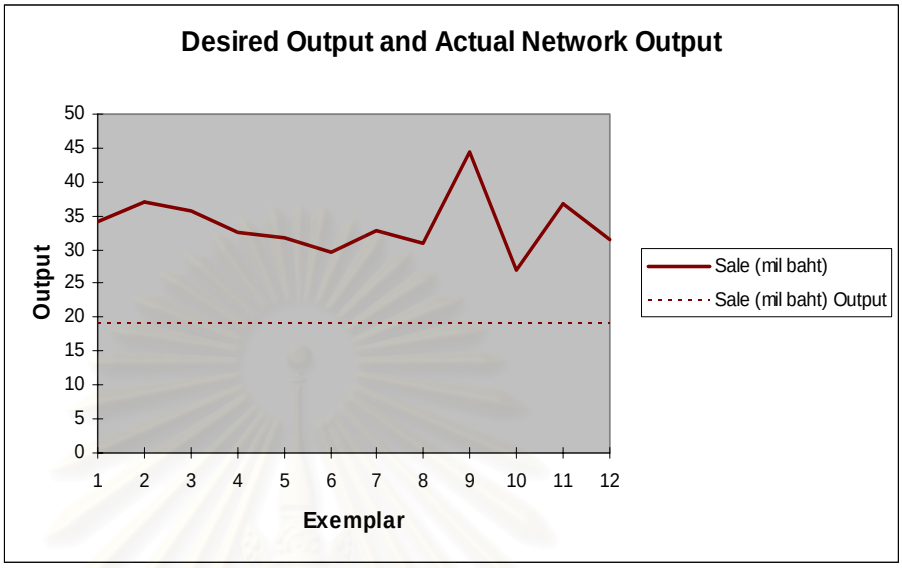


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	29.9483417
106.4	1.18	17.9094	36.981905	29.784707
106.3	1.18	17.9094	35.771983	29.8174339
106.4	1.59	19.2428	32.665378	32.514727
106.5	1.59	19.2428	31.650556	32.4820001
106.6	1.59	19.2428	29.703663	32.4492731
106.9	2.09	19.30065	32.703767	35.6233254
107.7	2.09	19.30065	30.834193	35.3615098
107.9	2.09	19.30065	44.549969	35.2960559
108.5	2.63	18.89458	27.031401	38.6166581
108.9	2.63	18.89458	36.882315	38.4857504
109.1	2.63	18.89458	31.349847	38.4202965

Error = 1.11

MSE = 34.56

3. Transfer Function is Linear Sigmoid Axon

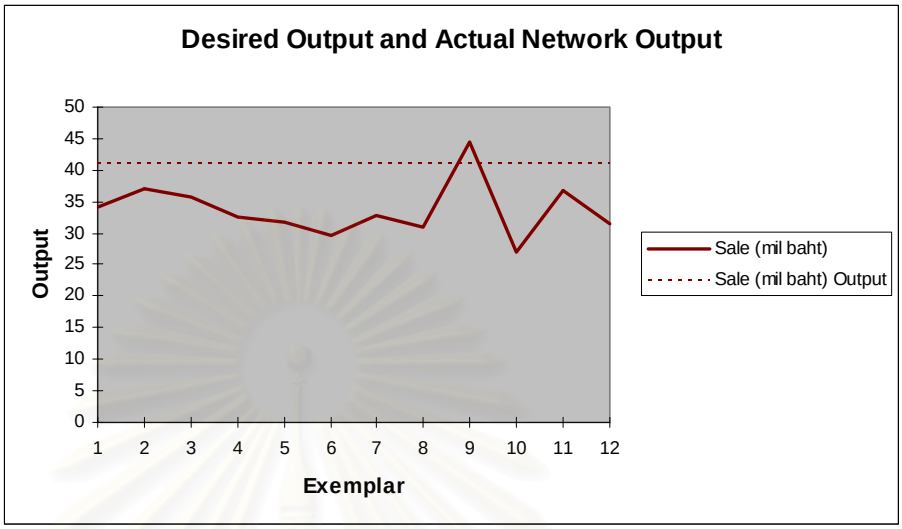


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	19.1673633
106.4	1.18	17.9094	36.981905	19.1673633
106.3	1.18	17.9094	35.771983	19.1673633
106.4	1.59	19.2428	32.665378	19.1673633
106.5	1.59	19.2428	31.650556	19.1673633
106.6	1.59	19.2428	29.703663	19.1673633
106.9	2.09	19.30065	32.703767	19.1673633
107.7	2.09	19.30065	30.834193	19.1673633
107.9	2.09	19.30065	44.549969	19.1673633
108.5	2.63	18.89458	27.031401	19.1673633
108.9	2.63	18.89458	36.882315	19.1673633
109.1	2.63	18.89458	31.349847	19.1673633

Error = -43.1

MSE = 229.57

4. Transfer Function is Linear Tanh Axon

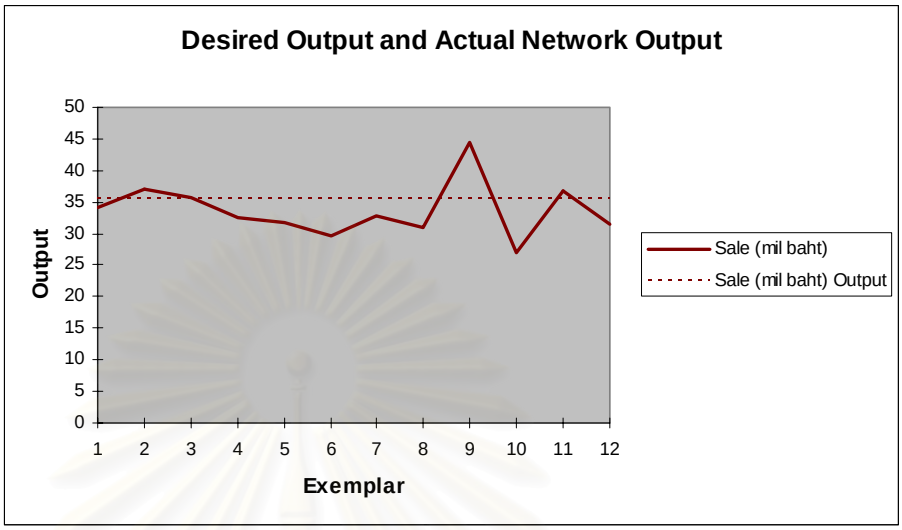


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	40.8865832
106.4	1.18	17.9094	36.981905	40.887197
106.3	1.18	17.9094	35.771983	40.8870742
106.4	1.59	19.2428	32.665378	40.8855355
106.5	1.59	19.2428	31.650556	40.8856583
106.6	1.59	19.2428	29.703663	40.885781
106.9	2.09	19.30065	32.703767	40.8831042
107.7	2.09	19.30065	30.834193	40.8842426
107.9	2.09	19.30065	44.549969	40.884551
108.5	2.63	18.89458	27.031401	40.8824661
108.9	2.63	18.89458	36.882315	40.883083
109.1	2.63	18.89458	31.349847	40.8833914

Error = 21.35

MSE = 70.38

5. Transfer Function is Sigmoid

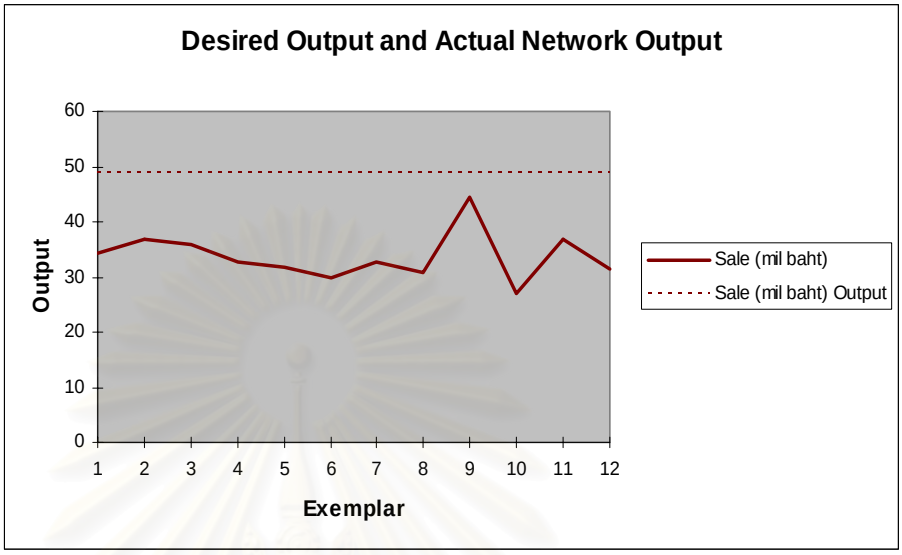


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	35.4096608
106.4	1.18	17.9094	36.981905	35.4096608
106.3	1.18	17.9094	35.771983	35.4096608
106.4	1.59	19.2428	32.665378	35.4096608
106.5	1.59	19.2428	31.650556	35.4096608
106.6	1.59	19.2428	29.703663	35.4096608
106.9	2.09	19.30065	32.703767	35.4096608
107.7	2.09	19.30065	30.834193	35.4096608
107.9	2.09	19.30065	44.549969	35.4096608
108.5	2.63	18.89458	27.031401	35.4096608
108.9	2.63	18.89458	36.882315	35.4096608
109.1	2.63	18.89458	31.349847	35.4096608

Error = 5.1

MSE = 21.58

6. Transfer Function is Soft Max Axon



Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	49.0085977
106.4	1.18	17.9094	36.981905	49.0085977
106.3	1.18	17.9094	35.771983	49.0085977
106.4	1.59	19.2428	32.665378	49.0085977
106.5	1.59	19.2428	31.650556	49.0085977
106.6	1.59	19.2428	29.703663	49.0085977
106.9	2.09	19.30065	32.703767	49.0085977
107.7	2.09	19.30065	30.834193	49.0085977
107.9	2.09	19.30065	44.549969	49.0085977
108.5	2.63	18.89458	27.031401	49.0085977
108.9	2.63	18.89458	36.882315	49.0085977
109.1	2.63	18.89458	31.349847	49.0085977

Error = 45.46

MSE = 253.26

After forecasting sale volume by changing the transfer function factor, It can be summarize and show in the table 4.6.

Table 4.6: Transfer Function Analysis

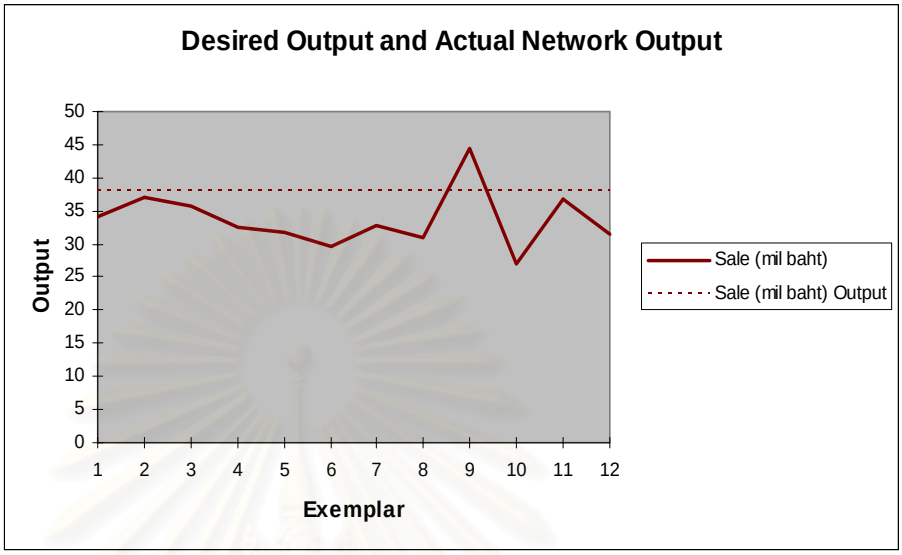
No.	Transfer Function	Error (percent)	MSE
1.	Axon	51.79	441.78
2.	Bias Axon	1.11	34.56
3.	Linear SigmoidAxon	- 43.1	229.57
4.	Linear TanhAxon	21.35	70.38
5.	Sigmoid	5.1	21.58
6.	SoftMaxAxon	45.46	253.26

From the table 4.6, when comparing the result of table 4.6 to the default parameter of test set 12, it can show that the default transfer function of test set 12 can give the best result in term of Error and MSE (-1.09 and 18.78).

4.5.3. Learning Round

Another factor that may affect the forecasting result is Learning Round. This analysis will illustrate the effect of the forecasting result when the learning rate was changed. This testing will used the learning rate range between 10000 to 50000. The result of testing is shown below.

1. Learning Round is 10000

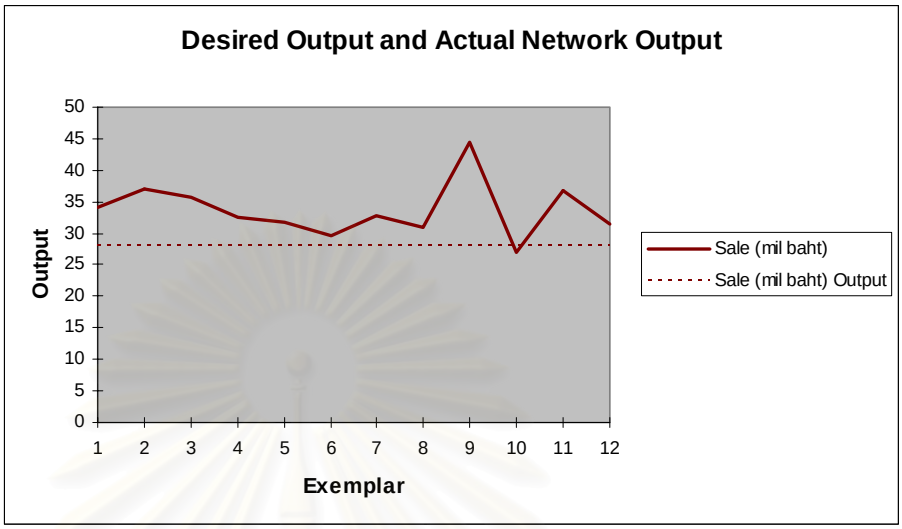


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	37.9711032
106.4	1.18	17.9094	36.981905	37.9710894
106.3	1.18	17.9094	35.771983	37.9710919
106.4	1.59	19.2428	32.665378	37.971262
106.5	1.59	19.2428	31.650556	37.9712526
106.6	1.59	19.2428	29.703663	37.9712436
106.9	2.09	19.30065	32.703767	37.9724524
107.7	2.09	19.30065	30.834193	37.9720263
107.9	2.09	19.30065	44.549969	37.9719437
108.5	2.63	18.89458	27.031401	37.9848138
108.9	2.63	18.89458	36.882315	37.9821061
109.1	2.63	18.89458	31.349847	37.9809736

Error = 12.71

MSE = 36.99

2. Learning round is 15000

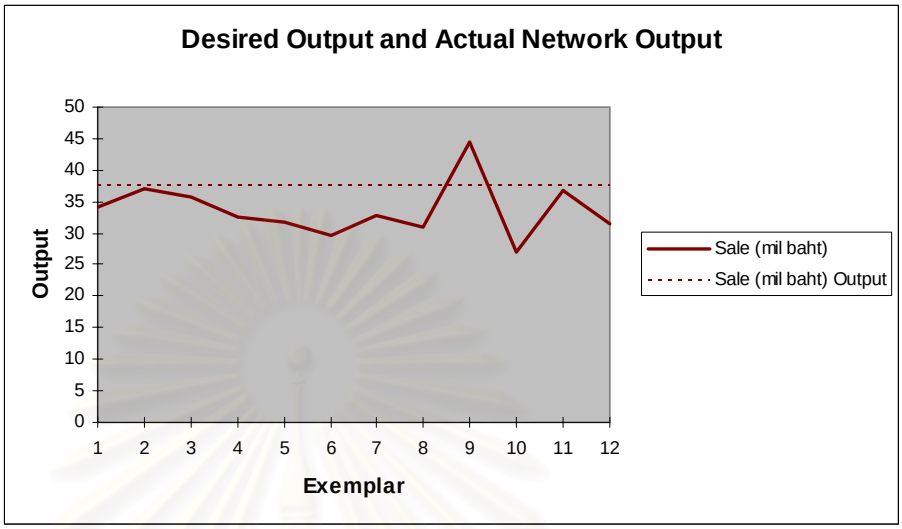


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	27.9503701
106.4	1.18	17.9094	36.981905	27.9502369
106.3	1.18	17.9094	35.771983	27.9502653
106.4	1.59	19.2428	32.665378	27.9496662
106.5	1.59	19.2428	31.650556	27.9496209
106.6	1.59	19.2428	29.703663	27.9495742
106.9	2.09	19.30065	32.703767	27.9489885
107.7	2.09	19.30065	30.834193	27.9484241
107.9	2.09	19.30065	44.549969	27.9482656
108.5	2.63	18.89458	27.031401	27.9472731
108.9	2.63	18.89458	36.882315	27.9468775
109.1	2.63	18.89458	31.349847	27.9466719

Error = -17.04

MSE = 51.6

3. Learning Round is 20000

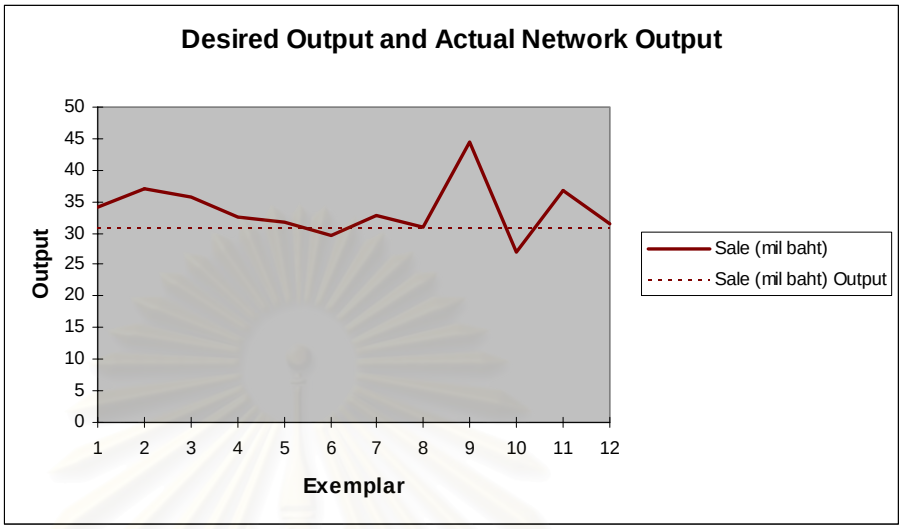


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	37.6104353
106.4	1.18	17.9094	36.981905	37.6104304
106.3	1.18	17.9094	35.771983	37.6104313
106.4	1.59	19.2428	32.665378	37.6104442
106.5	1.59	19.2428	31.650556	37.6104433
106.6	1.59	19.2428	29.703663	37.6104423
106.9	2.09	19.30065	32.703767	37.6106831
107.7	2.09	19.30065	30.834193	37.6106564
107.9	2.09	19.30065	44.549969	37.6106507
108.5	2.63	18.89458	27.031401	37.6153518
108.9	2.63	18.89458	36.882315	37.6150522
109.1	2.63	18.89458	31.349847	37.6149169

Error = 11.64

MSE = 34.006

4. Learning Round is 25000

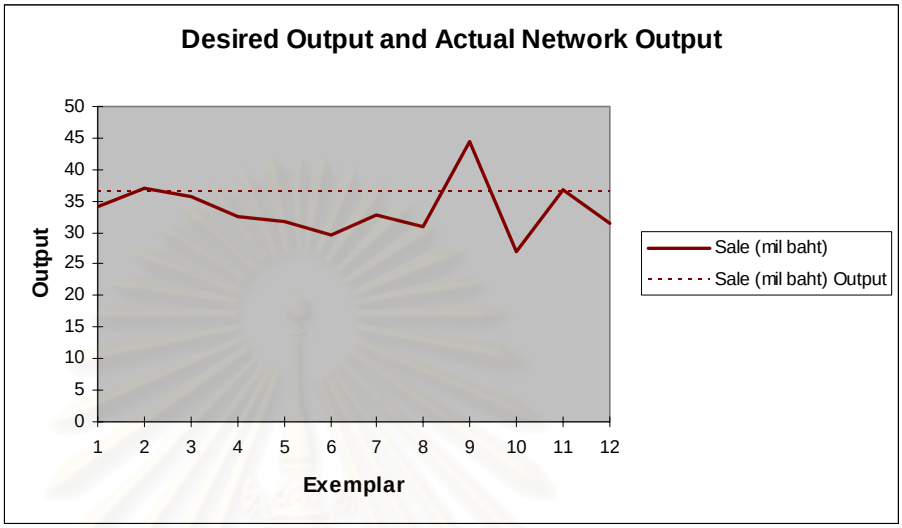


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	30.6540812
106.4	1.18	17.9094	36.981905	30.6540695
106.3	1.18	17.9094	35.771983	30.6540718
106.4	1.59	19.2428	32.665378	30.6540947
106.5	1.59	19.2428	31.650556	30.6540939
106.6	1.59	19.2428	29.703663	30.6540932
106.9	2.09	19.30065	32.703767	30.6544286
107.7	2.09	19.30065	30.834193	30.6544257
107.9	2.09	19.30065	44.549969	30.6544251
108.5	2.63	18.89458	27.031401	30.654706
108.9	2.63	18.89458	36.882315	30.6547026
109.1	2.63	18.89458	31.349847	30.654701

Error = -9.01

MSE = 27.85

5. Learning Round is 30000

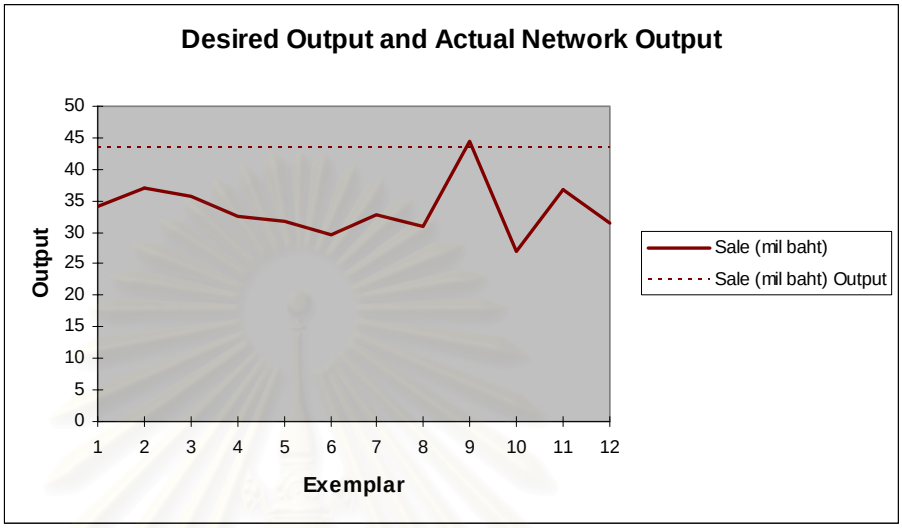


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	36.5252287
106.4	1.18	17.9094	36.981905	36.5252285
106.3	1.18	17.9094	35.771983	36.5252285
106.4	1.59	19.2428	32.665378	36.525329
106.5	1.59	19.2428	31.650556	36.5253281
106.6	1.59	19.2428	29.703663	36.5253273
106.9	2.09	19.30065	32.703767	36.5264853
107.7	2.09	19.30065	30.834193	36.5264151
107.9	2.09	19.30065	44.549969	36.5264005
108.5	2.63	18.89458	27.031401	36.545213
108.9	2.63	18.89458	36.882315	36.5446497
109.1	2.63	18.89458	31.349847	36.544381

Error = 8.42

MSE = 26.71

6. Learning Round is 35000

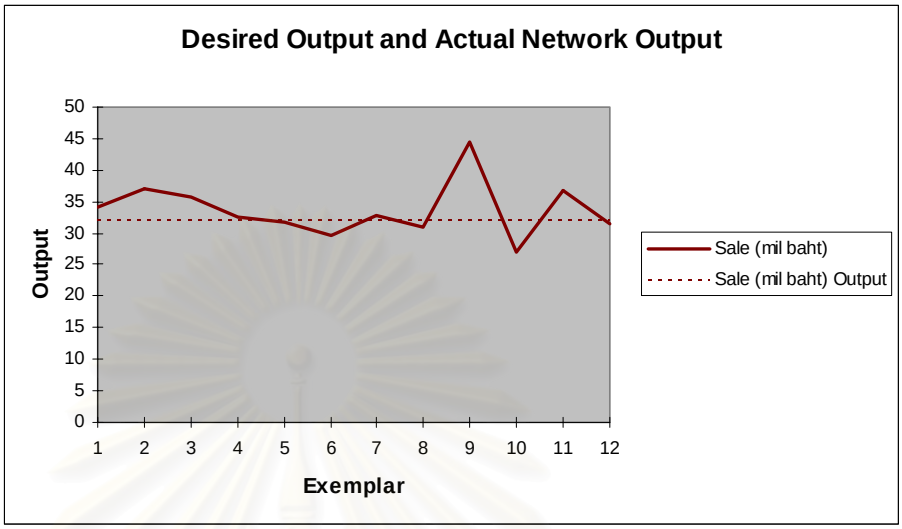


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	43.3229614
106.4	1.18	17.9094	36.981905	43.3229648
106.3	1.18	17.9094	35.771983	43.3229641
106.4	1.59	19.2428	32.665378	43.3231492
106.5	1.59	19.2428	31.650556	43.3231538
106.6	1.59	19.2428	29.703663	43.3231585
106.9	2.09	19.30065	32.703767	43.3240561
107.7	2.09	19.30065	30.834193	43.3242387
107.9	2.09	19.30065	44.549969	43.3242876
108.5	2.63	18.89458	27.031401	43.3277057
108.9	2.63	18.89458	36.882315	43.3278359
109.1	2.63	18.89458	31.349847	43.3278978

Error = 28.59

MSE = 111.437

7. Learning Round is 40000

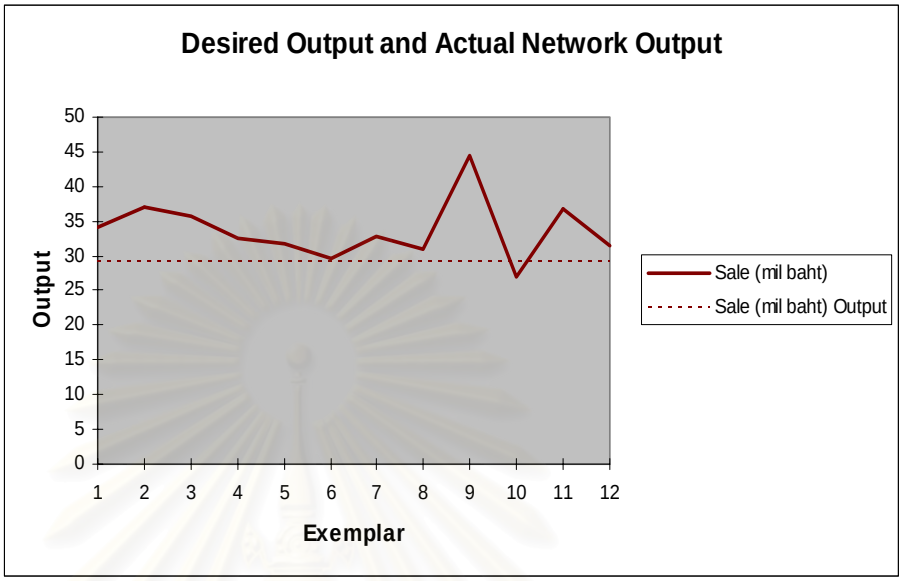


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	31.9880057
106.4	1.18	17.9094	36.981905	31.9879921
106.3	1.18	17.9094	35.771983	31.9879946
106.4	1.59	19.2428	32.665378	31.9881403
106.5	1.59	19.2428	31.650556	31.9881364
106.6	1.59	19.2428	29.703663	31.9881328
106.9	2.09	19.30065	32.703767	31.9895945
107.7	2.09	19.30065	30.834193	31.9894622
107.9	2.09	19.30065	44.549969	31.9894322
108.5	2.63	18.89458	27.031401	31.9919703
108.9	2.63	18.89458	36.882315	31.9919295
109.1	2.63	18.89458	31.349847	31.9919083

Error = -5.05

MSE = 21.53

8. Learning Round is 45000

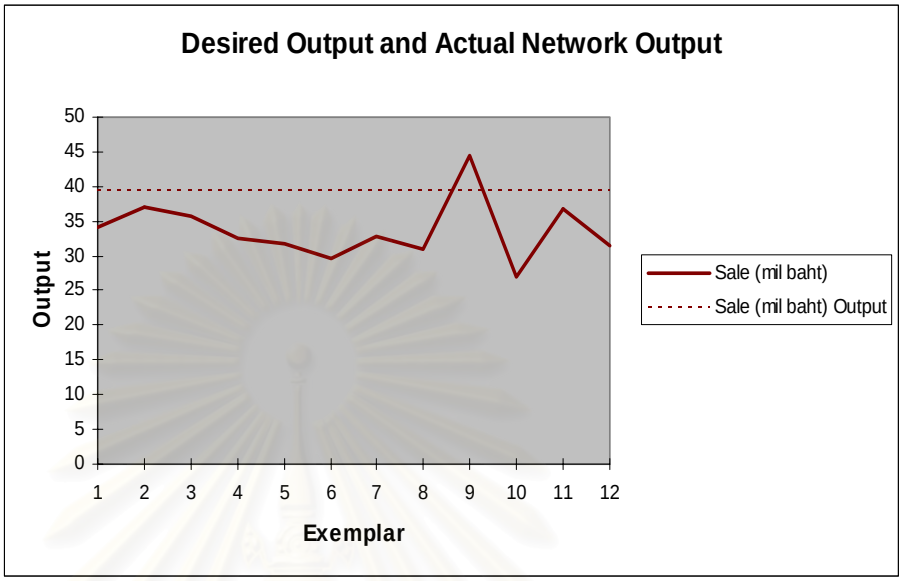


Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	29.0945122
106.4	1.18	17.9094	36.981905	29.0944923
106.3	1.18	17.9094	35.771983	29.0944964
106.4	1.59	19.2428	32.665378	29.0945397
106.5	1.59	19.2428	31.650556	29.0945359
106.6	1.59	19.2428	29.703663	29.0945322
106.9	2.09	19.30065	32.703767	29.0946743
107.7	2.09	19.30065	30.834193	29.0946498
107.9	2.09	19.30065	44.549969	29.0946432
108.5	2.63	18.89458	27.031401	29.0947705
108.9	2.63	18.89458	36.882315	29.0947599
109.1	2.63	18.89458	31.349847	29.0947544

Error = -13.63

MSE = 39.76

9. Learning Round is 50000



Index Customer Price	Interest Rate	GDP (mil)	Sale (mil baht))	Sale (mil baht) Output
105.9	1.18	17.9094	34.168504	39.4150634
106.4	1.18	17.9094	36.981905	39.4150628
106.3	1.18	17.9094	35.771983	39.4150629
106.4	1.59	19.2428	32.665378	39.4151245
106.5	1.59	19.2428	31.650556	39.4151244
106.6	1.59	19.2428	29.703663	39.4151243
106.9	2.09	19.30065	32.703767	39.4153089
107.7	2.09	19.30065	30.834193	39.4153085
107.9	2.09	19.30065	44.549969	39.4153084
108.5	2.63	18.89458	27.031401	39.4158335
108.9	2.63	18.89458	36.882315	39.4158348
109.1	2.63	18.89458	31.349847	39.4158355

Error = 16.99

MSE = 51.39

After forecasting sale volume by changing the Learning Round factor, It can be summarize and show in the table 4.7.

Table 4.7: Learning Round Analysis

No	Learning Round	Error (Percent)	MSE
1.	10000	12.71	36.99
2.	15000	-17.04	51.6
3.	20000	11.64	34.006
4.	25000	-9.01	27.85
5.	30000	8.42	26.71
6.	35000	28.59	111.437
7.	40000	- 5.05	21.53
8.	45000	-13.64	39.76
9.	50000	16.99	51.39

From the table 4.7, when comparing the result of table 4.7 to the default parameter of test set 12 with the learning round 5000, it can show that the default transfer function of test set 12 can give the best result in term of Error and MSE (-1.09 and 18.78).

4.6. Conclusion

After the forecaster try to change the parameter, it can be conclude that the default parameter with momentum 0.7, Transfer function is Tran Axon, and Learning Round is 5000 can give the least MSE. Therefore, it can conclude that the default parameter is the most suitable parameter, and it will use in this calculation.

CHAPTER V

PRODUCTION PLANNING

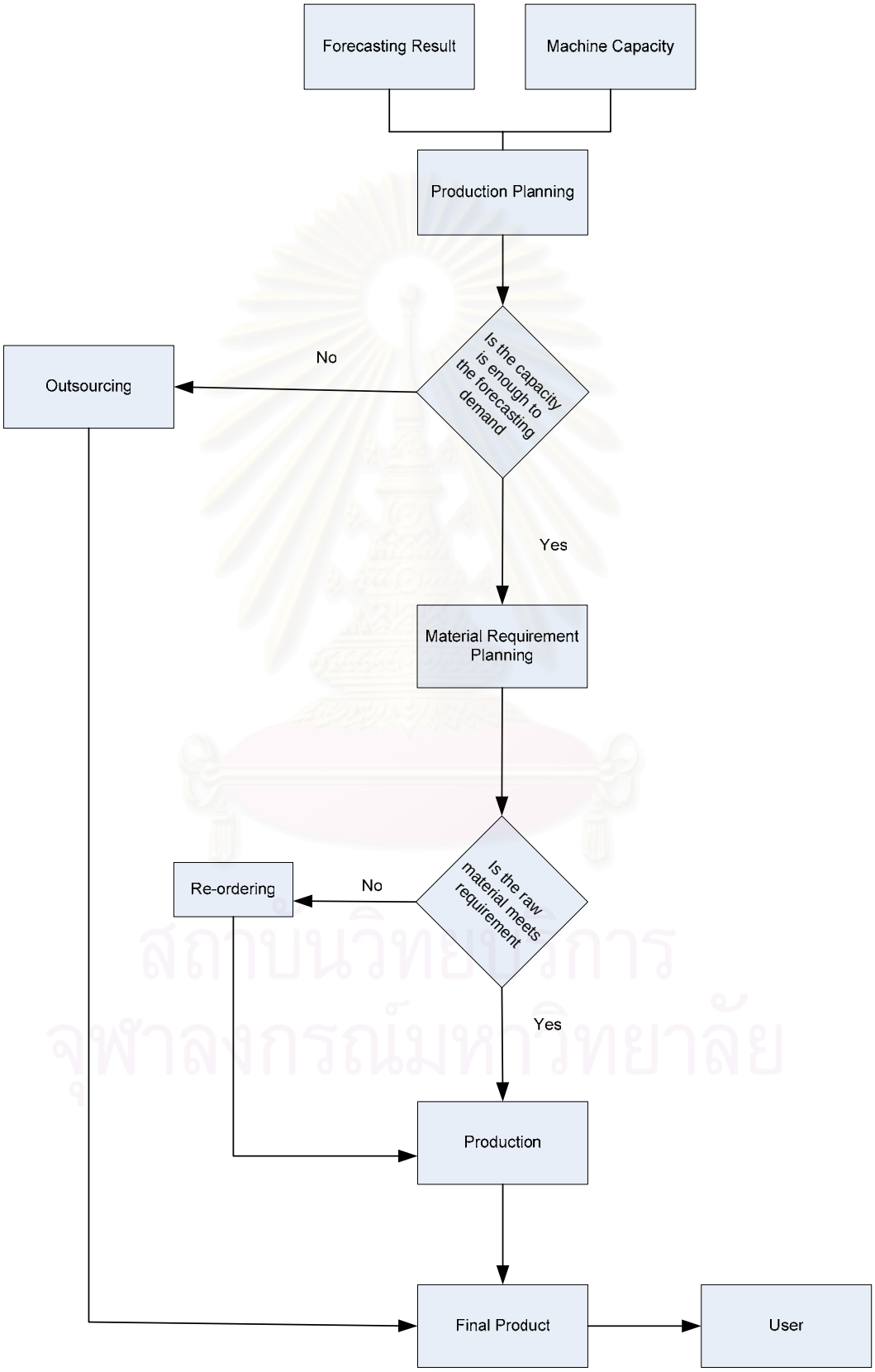
5.1 Introduction

This Chapter will be describe about the original production planning process (which applying a moving average technique) comparing with a new production planning process (which applying a neural network forecasting technique). The writer will describe the Production planning process of the sample company in the following section.

5.2 The production Planning Process

The first step of the production planning process is to gathering the forecasting result and the capacity planning result of the machine. After the company can gather the forecasting result by using neural network technique, the company will use this result instead of original forecasting result (Moving average technique). The pictures 5.1 will illustrate the production process of this company. This process will use by both neural network technique and moving average technique, then the writer will compare the result in order to find the best forecasting technique.

Picture 5.1: Illustrate the flow chart of production



5.2.1 Production Planning and Master Scheduling

The production planner will receive the forecasting result from forecaster, and calculate the machine capacity. This machine must produced 4 types of products which are Product A, Product B, Product C, and the sample product. The maximum capacity for this machine is 33000 kilogram per month. The following table will illustrate the demand forecasting for product A, B, and C per month

Table 5.1: Illustrate the demand forecasting for product A, B, and C

Demand Forecasting For Product A	Demand Forecasting for Product B	Demand Forecasting for Product C
4790	7100	3,450.00
4260	6800	3,700.00
3900	6500	4,100.00
5210	5900	4,200.00
5100	3100	7,500.00
5400	4600	6,300.00
4200	5100	5,400.00
4500	6700	4,200.00
6100	5800	4,500.00
4200	4900	6,500.00

Because the sample product is a high margin of demand, so the company will dedicated the capacity of the machine about 18000 kilogram per month continuality every month.

After the production planner knows both forecasting demand and machine capacity, the production planner will design a master schedule and planning the production process. After the company can get the production capacity of the machine and the demand forecasting, The Company have to compare the capacity of

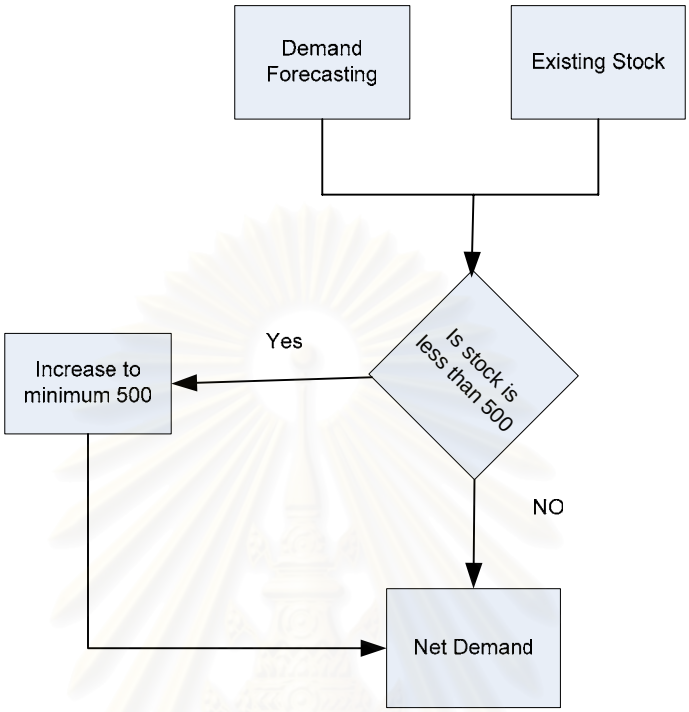
the machine and the demand of the sample product. If the forecasting demand is more than capacity of the machine, the company needs to outsource the excess demand.

The demand which was excess the forecasting result, the company would outsource because they did not have available machine to produce the excess demand. This type of machine is not easily to change the production from one product to another product because it need a very long time to set up the machine and clean the machine, it normally take time about one day. The companies will loss a profit around 631 baht per kilogram when they outsource a product. From last 10 month, by applying moving average technique, the company may loose the profit around 3,830,000 baht, but if the company apply neural network technique the company may loose the profits around 1,830,000 baht which is 52.26 percent reduction. It can be seen in the table 5.2 and 5.3.

The availability of the finished product is very important because if the finished product is shortage, the company will loose the credits from the customer, therefore the production planner will set the safety stock around 500 kilogram. The safety stock will show in the picture 5.2 (for the moving average technique) and 5.3 (for neural network technique).

After the planner know net demand (including safety stock), the planner will specified the production volume as shown in table 5.2 and 5.3. The flowchart of this process will be describing bellows.

Picture 5.2: The safety Stock Process



After the planner get a net demand of the sample product, the planner will plan the resource allocation that need to put in during production for the sample product. From table 5.2 and 5.3, it is obviously showing that the production rates from the moving average forecasting technique do not meet the capacity of the machine. This caused the higher over time rate than using neural network forecasting method. When applying a new neural network forecasting method for the example product, it can be conclude that (comparing with moving average technique) the neural network technique can obtain the less human cost than moving average technique around 0.125 bath per kilogram (the neural network technique give 5.108 bath and the moving average technique can give 5.229). When the companies apply neural network technique the company can save the human factor cost with in ten month around 56,625 baht.

By applying Neural network technique, the company can optimize the capacity of the machine. As you can see from the table 5.2 and 5.3, The company will loss the opportunity to produce the sample product around 9550 kg when apply moving average technique, but the company will loose the opportunity to produce the sample

product if applying neural network technique around 2000 kg, which is 80 percent decrease.

Table 5.2: Present the Master Scheduling of the sample product using moving average technique

	Moving KG	Safety Stock	Net Demand	Production	Actual Demand	Inventory/month	cumulative inventory
Jul-49	17738	500	18,239	18300	19290	-990.7893333	-990.7893333
Aug-49	18475	500	18,975	19000	17449	1550.32	1550.32
Sep-49	18385	0	18,386	18400	16274	2125.679467	3675.999467
Oct-49	17615	0	17,616	17600	18189	-589.4613333	3086.538133
Nov-49	16359	0	16,359	16400	18896	-2496.078933	590.4592
Dec-49	15476	0	15,477	15500	17541	-2041.477333	-2041.477333
Jan-50	15331	500	15,832	15800	18213	-2413.459733	-2413.459733
Feb-50	17971	500	18,471	18500	17248	1251.866133	1251.866133
Mar-50	17318	0	17,318	17300	23788	-6488.994667	-6488.994667
Apr-50	18393	500	18,894	18900	13520	5379.868267	5379.868267
				175700		180680	

	Moving KG	Regular Production	Weekend	not office time	Human Cost	Outsourcing KG	Outsourcing Cost	inventory Holding cost	Total Cost
Jul-49	17738.65	12	0	1	95625	1000	1150000	0	
Aug-49	18475.09	12	0	2	101250		0	194177.58	
Sep-49	18385.65	12	0	1	95625		0	460418.9332	
Oct-49	17615.63	12	0	0	90000		0	386588.9012	
Nov-49	16359.04	11	0	0	82500		0	73955.0148	
Dec-49	15476.98	10	0	1	80625	2050	2357500	0	
Jan-50	15331.84	11	0	0	82500	2420	2783000	0	
Feb-50	17971.19	12	0	1	95625		0	156796.2332	
Mar-50	17318.32	12	0	0	90000	6490	7463500	0	
Apr-50	18393.54	12	0	2	106875		0	673828.5004	
					920625		13754000	1945765.163	16620390

Table 5.3: Present the Master Scheduling of the sample product using Neural Network technique

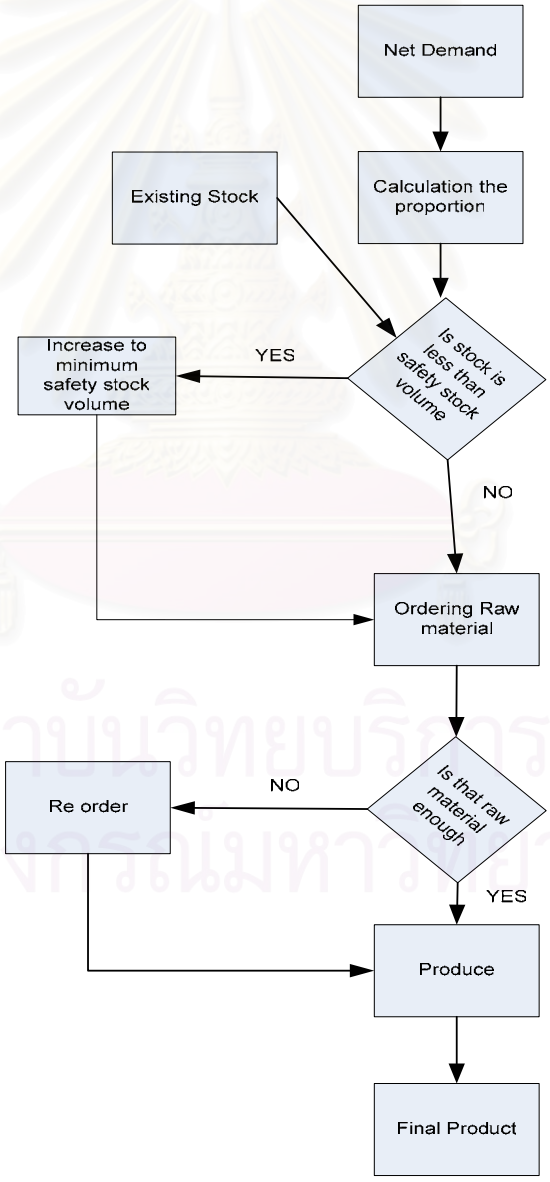
	Neural KG	Safety Stock	Net Demand	Production	Actual KG	Inventory/month/KG	cumulative inventory
Jul-49	17767.72	500	18267.72	18300	19290.79	-990.789	-990.789
Aug-49	17767.7	500	18267.7	18300	17449.68	850.32	850.32
Sep-49	17767.71	0	17267.71	17800	16274.32	1525.679	2375.999
Oct-49	17768.48	0	17768.48	17800	18189.46	-389.461	1986.538
Nov-49	17768.47	0	17768.47	17800	18896.08	-1096.08	890.4592
Dec-49	17768.47	0	17768.47	17800	17541.48	258.5227	1148.982
Jan-50	17773.19	0	17773.19	17800	18213.46	-413.46	735.5221
Feb-50	17773.05	0	17773.05	17800	17248.13	551.8661	1287.388
Mar-50	17773.02	0	17773.02	17800	23788.99	-5988.99	-4701.61
Apr-50	17779.93	500	18279.93	18300	13520.13	4779.868	4779.868
				179500			

	Regular Production	Weekend	not office time	Human Cost	Outsourcing KG	Outsourcing Cost	inventory Holding cost	Total Cost
Jul-49	12	0	1	95625	1000	1150000	0	
Aug-49	12	0	1	95625		0	106502.6	
Sep-49	12	0	0	90000		0	297593.9	
Oct-49	12	0	0	90000		0	248813.9	
Nov-49	12	0	0	90000		0	111530	
Dec-49	12	0	0	90000		0	143910	
Jan-50	12	0	0	90000		0	92124.15	
Feb-50	12	0	0	90000		0	161245.4	
Mar-50	12	0	0	90000	4710	5416500	0	
Apr-50	12	0	1	95625		0	598678.5	
				916875		6566500	1760398	9243773

5.2.2 Material Requirement Planning

After the planner knows the amount of product needed to produce, the planner will plan the material requirement for each month, and then they will order the raw material. If the company faced with the excess demand, firstly, the company must consider their production capacity, if they have enough capacity to produce the excess demand, they will reordering the raw material with the higher cost.

Picture 5.3: Illustrate the material ordering process



Normally, the production capacity was not enough for extra production because if the company desires to produce the excess product instead of outsourcing, the company has to waste two day to set up the machine.

In order to produce a sample product, it needs five raw materials which are raw material A, B, C, D, and E. The proportions of the sample product are as follow:

Raw material A = 65 percent
Raw material B = 15 percent
Raw material C = 2.5 percent
Raw material D = 2 percent
Raw material E = 15.5 percent

After the planner knew the proportion of the sample product, then the purchaser will order the amount of raw material which was according to the demand forecasting. During the production, the production supervisor will evaluate the raw material stock. If the raw material was nearly empty, the production supervisor will re-order the raw material.

The following table will illustrate the result of raw material requirement planning of the sample products.

Table 5.4: Illustrate the demand for Material A (Using Moving Average Technique)

	Net Demand	Material A	Material A require	safety stock	Net Material A ordering	Material A Actual	Material A inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	11895	11900	300	12200	12539	-339	-339	9760000	0
Aug-49	19000	12350	12350	300	12650	11342	1307	1307	10120000	156924
Sep-49	18400	11960	11960	0	11960	10578	1381	2689	9568000	322727
Oct-49	17600	11440	11450	0	11450	11823	-373	2306	9160000	276749
Nov-49	16400	10660	10660	0	10660	12282	-1622	683	8528000	82055
Dec-49	15500	10075	10080	0	10080	11401	-1321	-643	8064000	0
Jan-50	15800	10270	10270	300	10570	11838	-1268	-1268	8456000	0
Feb-50	18500	12025	12030	300	12330	11211	1118	1118	9864000	134245
Mar-50	17300	11245	11250	0	11250	15462	-4212	-3094	9000000	0
Apr-50	18900	12285	12290	300	12590	8788	3801	3801	10072000	456229
									92592000	1428933

Table 5.5: Illustrate the demand for Material A (Neural Network Technique)

	Net Demand	Material A	Material A require	safety stock	Net Material A ordering	Material A Actual	Material A inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	11895	11900	300	12200	12539	-339	-339	9467200	0
Aug-49	18300	11895	11900	300	12200	11342	857	857	9467200	102924
Sep-49	17800	11570	11570	0	11570	10578	991	1849	8978320	221927
Oct-49	17800	11570	11570	0	11570	11823	-253	1596	8978320	191549
Nov-49	17800	11570	11570	0	11570	12282	-712	883	8978320	106055
Dec-49	17800	11570	11570	0	11570	11401	168	1051	8978320	126220
Jan-50	17800	11570	11570	0	11570	11838	-268	783	8978320	93970
Feb-50	17800	11570	11570	0	11570	11211	358	1141	8978320	137016
Mar-50	17800	11570	11570	0	11570	15462	-3892	-2751	8978320	0
Apr-50	18300	11895	11900	300	12200	8788	3411	3411	9467200	409429
									91249840	1389096

Table 5.6: Illustrate the demand for Material B (Using Moving Average Technique)

	Net Demand	Material B	Material B require	safety stock	Net Material B ordering	Material B Actual	Material B inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	2745	2750	80	2830	2893	-63	-63	2830000	0
Aug-49	19000	2850	2850	80	2930	2617	312	312	2930000	46882
Sep-49	18400	2760	2760	0	2760	2441	318	631	2760000	94709
Oct-49	17600	2640	2640	0	2640	2728	-88	542	2640000	81447
Nov-49	16400	2460	2460	0	2460	2786	-326	216	2460000	43316
Dec-49	15500	2325	2330	0	2330	2631	-301	-84	2330000	0
Jan-50	15800	2370	2370	80	2450	2732	-282	-282	2450000	0
Feb-50	18500	2775	2780	80	2860	2587	272	272	2860000	54555
Mar-50	17300	2595	2600	0	2600	3568	-968	-695	2600000	0
Apr-50	18900	2835	2840	80	2920	2028	891	891	2920000	133797
									26780000	454708

Table 5.7: Illustrate the demand for Material B (Neural Network Technique)

	Net Demand	Material B	Material B require	safety stock	Net Material B ordering	Material B Actual	Material B inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	2745	2750	80	2830	2893	-63	-63	2745100	0
Aug-49	18300	2745	2750	80	2830	2617	212	212	2745100	31882
Sep-49	17800	2670	2670	0	2670	2441.	228	441	2589900	66209
Oct-49	17800	2670	2670	0	2670	2728	-58	382	2589900	57447
Nov-49	17800	2670	2670	0	2670	2786	-116	266	2589900	39987
Dec-49	17800	2670	2670	0	2670	2631	38	305	2589900	45803
Jan-50	17800	2670	2670	0	2670	2732	-62	243	2589900	36501
Feb-50	17800	2670	2670	0	2670	2587	82	326	2589900	48918
Mar-50	17800	2670	2670	0	2670	3568	-898	-572	2589900	0
Apr-50	18300	2745	2750	80	2830	2028	801	801	2745100	120297
									26364600	447046

Table 5.8: Illustrate the demand for Material C (Using Moving Average Technique)

	Net Demand	Material C	Material C require	safety stock	Net Material C ordering	Material C Actual	Material C inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	457.5	458	10	468	482	-14	-14	702000	0
Aug-49	19000	475	475	10	485	436	48	48	727500	10970
Sep-49	18400	460	460	0	460	406	53	101	690000	22927
Oct-49	17600	440	440	0	440	454	-14	87	660000	19611
Nov-49	16400	410	410	0	410	464	-54	32	615000	9829
Dec-49	15500	387.5	388	0	388	438	-50	-17	582000	0
Jan-50	15800	395	395	10	405	455	-50	-50	607500	0
Feb-50	18500	462.5	463	10	473	431	41	41	709500	12538
Mar-50	17300	432.5	433	0	433	594	-161	-119	649500	0
Apr-50	18900	472.5	473	10	483	338	144	144	724500	32624
									6667500	108502

Table 5.9: Illustrate the demand for Material C (Neural Network Technique)

	Net Demand	Material C	Material C require	safety stock	Net Material C ordering	Material C Actual	Material C inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	457.5	458	10	468	482	-14	-14	680940	0
Aug-49	18300	457.5	458	10	468	436	31	31	680940	7145
Sep-49	17800	445	445	0	445	406	38	69	647475	15727
Oct-49	17800	445	445	0	445	454	-9	60	647475	13536
Nov-49	17800	445	445	0	445	464	-19	40	647475	9171
Dec-49	17800	445	445	0	445	438	6	47	647475	10625
Jan-50	17800	445	445	0	445	455	-10	36	647475	8300
Feb-50	17800	445	445	0	445	431	13	50	647475	11404
Mar-50	17800	445	445	0	445	594	-149	-99	647475	0
Apr-50	18300	457.5	458	10	468	338	129	129	680940	29249
									6575145	105161

Table 5.10: Illustrate the demand for Material D (Using Moving Average Technique)

	Net Demand	Material D	Material D require	safety stock	Net Material D ordering	Material D Actual	Material D inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	366	366	10	376	385	-9	-9	639200	0
Aug-49	19000	380	380	10	390	348	41	41	663000	10456
Sep-49	18400	368	368	0	368	325	42	83	625600	21297
Oct-49	17600	352	352	0	352	363	-11	71	598400	18291
Nov-49	16400	328	328	0	328	371	-43	28	557600	9591
Dec-49	15500	310	310	0	310	350	-40	-12	527000	0
Jan-50	15800	316	316	10	326	364	-38	-38	554200	0
Feb-50	18500	370	370	10	380	344	35	35	646000	11912
Mar-50	17300	346	346	0	346	475	-129	-94	588200	0
Apr-50	18900	378	378	10	388	270	117	117	659600	29987
									6058800	101537

Table 5.11: Illustrate the demand for Material D (Neural Network Technique)

	Net Demand	Material D	Material D require	safety stock	Net Material D ordering	Material D Actual	Material D inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	366	366	10	376	385	-9	-9	603534	0
Aug-49	18300	366	366	10	376	348	27	27	603534	6886
Sep-49	17800	356	356	0	356	325	30	57	587044	14667
Oct-49	17800	356	356	0	356	363	-7	49	587044	12681
Nov-49	17800	356	356	0	356	371	-15	34	587044	8723
Dec-49	17800	356	356	0	356	350	5	39	587044	10042
Jan-50	17800	356	356	0	356	364	-8	31	587044	7933
Feb-50	17800	356	356	0	356	344	11	42	587044	10748
Mar-50	17800	356	356	0	356	475	-119	-77	587044	0
Apr-50	18300	366	366	10	376	270	105	105	603534	26927
									5919910	98610

Table 5.12: Illustrate the demand for Material E (Using Moving Average Technique)

	Net Demand	Material E	Material E require	safety stock	Net Material E ordering	Material E Actual	Material E inventory	inventory sum	Cost of raw mat	inventory holding cost
Jul-49	18300	2836.5	2840	80	2920	2990	-153	-153	1418250	0
Aug-49	19000	2945	2950	80	3030	2704	240	240	1472500	18022
Sep-49	18400	2852	2850	0	2850	2522	329	569	1426000	42733
Oct-49	17600	2728	2730	0	2730	2819	-91	478	1364000	35881
Nov-49	16400	2542	2540	0	2540	2879	-337	141	1271000	14113
Dec-49	15500	2402.5	2400	0	2400	2718	-316	-175	1201250	0
Jan-50	15800	2449	2450	80	2530	2823	-374	-374	1224500	0
Feb-50	18500	2867.5	2870	80	2950	2673	194	194	1433750	19403
Mar-50	17300	2681.5	2680	0	2680	3687	-1005	-811	1340750	0
Apr-50	18900	2929.5	2930	80	3010	2095	833	833	1464750	62540
									13616750	192695

Table 5.13: Illustrate the demand for Material E (Neural Network Technique)

	Net Demand	Material E	Material E require	safety stock	Net Material E ordering	Material E Actual	Material E inventory	inventory sum	Cost of raw mat	Inventory holding cost
Jul-49	18300	2836.5	2840	80	2920	2990	-153	-153	1375702	0
Aug-49	18300	2836.5	2840	80	2920	2704	131	131	1375702	9884
Sep-49	17800	2759	2760	0	2760	2522	236	368	1338115	27620
Oct-49	17800	2759	2760	0	2760	2819	-60	307	1338115	23093
Nov-49	17800	2759	2760	0	2760	2879	-120	187	1338115	14072
Dec-49	17800	2759	2760	0	2760	2718	40	227	1338115	17077
Jan-50	17800	2759	2760	0	2760	2823	-64	163	1338115	12271
Feb-50	17800	2759	2760	0	2760	2673	85	249	1338115	18686
Mar-50	17800	2759	2760	0	2760	3687	-928	-679	1338115	0
Apr-50	18300	2836.5	2840	80	2920	2095	740	740	1375702	55565
									13493912	178273

As you can see on above table, the raw material demand of the sample product which used moving average technique is not smoothing when comparing by using Neural Network technique. Therefore, the price of ordering raw material (using neural network technique) is cheaper than a price of ordering raw material (using moving average technique) around 3 percent. This can reduce the total cost of the raw material around 1,300,000 baht per ten month.

From table above, the inventory holding cost of neural network forecasting technique is less than the inventory holding cost of moving average technique around 3.3 percent.

5.3 Conclusion

In this section, the writer will explain the benefit of changing the production planning by using a new forecasting method (Neural Network). By doing this, the company can get a lot of benefit which are as follows.

Firstly, the original inventory problem of the company was reduced because after applying a neural network forecasting method, the forecasting demand of the sample product is more accurately. The inventory holding cost by using moving average technique around 4,232,000 baht, but the inventory holding cost by using neural network forecasting technique is about 3,978,000 baht. It is mean that when the company applies a new neural forecasting method technique, the company can reduce the inventory holding cost around 254,000 baht, which was 6 percent reduction.

Secondly, after the company applies the neural network forecasting technique, the total cost of outsourcing was reduced. The total cost for moving average is 8,060,000 baht, but the total cost for neural network is 5,806,000, therefore it can be conclude that if the company apply the neural network forecasting technique, the company can save the outsourcing cost around 2,254,000 baht (28 percent reduction).

Thirdly, the ordinary forecasting method (Moving Average) can give the forecasting result is not as accurately as the forecasting result from neural network technique. Therefore, a cost that occurred because of do not use full capacity of the

machine is 71,625 baht for the moving average forecasting technique, and 15,000 baht for neural forecasting method. It can conclude that when the company applies the neural network forecasting technique, the company can reduce the cost around 56,625 baht which is 79 percent reduction.

Fourthly, because of the company cannot complete the capacity of the machine, so the company will loose the opportunity to produce the product. Comparing between using Moving average forecasting technique and Neural Network forecasting technique. From the first technique, the company will loose the opportunity to produce a product around 7,821,450 baht, but the neural network technique will loss the opportunity to produce the product around 1,590,000 baht. Therefore, when the company applies the neural network forecasting technique, the company can produce the product around 6,232,000 baht.

Fifthly, because the company can maintain the level of ordering, the company can get a lower cost of raw material. When the company applies a neural network forecasting method, the company can get a very stable demand of ordering the raw material, but if the company uses the traditional moving average forecasting technique, the company will purchase raw material with no discount because the level of ordering raw material is not stable. From the case study company, when the company applies moving average technique, the total cost of raw material is 830 baht per kg, but if the company applies a neural network forecasting technique, the total cost of raw material will be 800 baht per kilogram. Which is 30 baht reduced?

Lastly, After the company apply the neural network forecasting method, the company can reduce a total cost for this sample product which was not include outsourcing cost around 10,600,000 baht per ten month.

CHAPTER VI

CONCLUSION

6.1 Introduction

Due to, the problem of inventory that result from poor forecasting method that this company are currently used. The company needs to introduced a new method of forecasting which are neural network with back propagation technique. This chapter will cover the summary of this study, the conclusion and the recommendation for the further study.

6.2 Summary of the Study

6.2.1 Demand Forecasting

In this forecasting, the forecaster will use four input factor which are :

1. GDP
2. Index customer price
3. Interest rate
4. Garment customer index

The forecaster need to set up the parameter which is important to forecast in the program neural solution version 5. The parameter are shown below

Step Size in Hidden is equal to 1

Step Size in Out Put is equal to 0.1

Momentum is equal to 0.7

Maximum Epoch is equal to 5000 round

Transfer function is Tran Axon Function

In this thesis, the forecaster will use MSE and Error to measure the result of the forecasting. The result of neural network forecasting is better than the result of moving average forecasting. The comparing result are shown in the table 5.1

Table 6.1: Comparing the result of forecasting method

Forecasting Method	Error	MSE
1. Moving Average	-5.163	29.165
2. Neural Network (Test Set 12)	-1.09	18.78

From table 5.1, it can show that a neural network (test set 12) is better than moving average technique. In term of neural network, it has many variable parameters, so the forecaster will try to change the parameter such as momentum, transfer function and learning round.

After the forecaster change the parameter, the result is not better than the neural network with default parameter.

Therefore, The writer will conclude that the Neural network with default parameter will give the best result than moving technique. The inventory problem of the company will be solved when the company apply the neural network technique instead of Moving average technique. The more precisely forecasting, the less inventory problem occurs.

6.2.2 Production Planning

The benefit of the company when applying a neural network technique instead of moving average technique in term of production planning was shown in table 6.2.

Table 6.2: Comparing the result of forecasting technique in term of production process

	Moving Average Technique	Neural Network Technique	Cost Reduction	Percent Cost Reduction
Inventory Holding Cost	4,232,000	3,978,000	254,000	6
Outsourcing Cost	3,827,000	1,827,000	2,000,000	52.25
Cost of Raw Material/kg	830	800	30	3
Total Cost (exclude Raw material cost)	8,060,000	5,806,000	2,254,000	28

From the Table 6.2, the inventory holding cost both moving average technique and neural network technique can be calculated by the inventory holding cost from the moving average technique in the table 5.2 and 5.3. The moving average technique need to outsourcing around 11,960 kg (you can see in the table 5.2) and the company will loss the profits around 320 baht per kilogram, therefore the company will loose the profits around 3,827,000 baht per ten month when the company apply moving average technique. The company need to outsource the sample product around 5,710 kg for the neural network technique, therefore the company will loss the profits around 1,827,000 baht per ten month (you can see in the table 5.3).

From the table 6.2, it can conclude that when the company applies the neural network technique, the company can save a total cost around 2,254,000 baht per ten month which is 28 percent reduction.

6.3 Recommendation for future study

1. The input factor should be carefully choose because it may have some factor that have more correlation to the out put, but it still not use in this thesis. The variable selection should be considered in dept because it will effect to the reliability of the forecasting models. Improper variable select as the input to the network will deviate the accuracy of the forecasting so unnecessary variables must not be included to the input. Independence of variables must be evaluated and no dependent variables should be selected as the input to the network.

2. In this Thesis, a test of dependency between interest rate, unemployment rate, consumer price index, oil Price, GDP, in House Garment Consumer Rate, synthetic Fiber Production, export Rate and import Rate should be conduct.

3. The further thesis can be done by extending the study to many options such as new experiments such as training with another neural network's algorithms. Using different variables or using different network architecture can be done in case that they might give better results.

4. The input data which was used in this thesis may be not available during the forecasting period, so the forecaster should find some replacement data. For example, the GDP may not available (issued) on time, so the forecaster may find some potential data to replace the GDP data. The writer will recommend the GPP data instead of GDP data incase the GDP was not available on time.

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APPENDICES

APPENDIX A

INSTRUCTION MANUAL OF NEURAL SOLUTION version 5

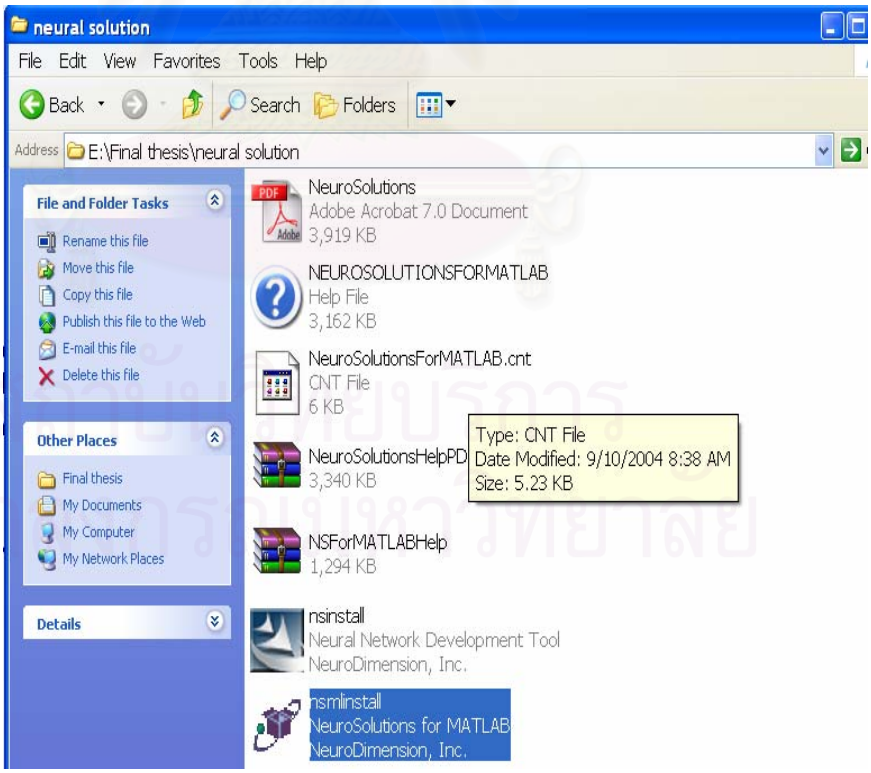
This section provides the instruction to forecast Sale Volume of sample Products with Neural Solution version 5

Procedure

The procedures of forecasting sale volume with neural solution version 5 are as follows:

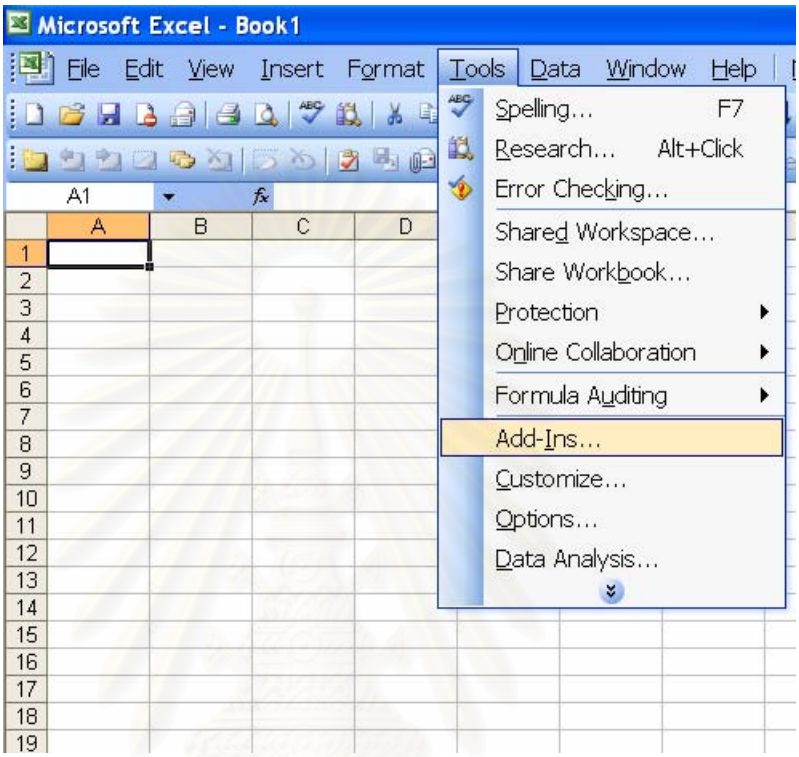
1. Install Program Neural Solution version 5 in your computer PC. Note: the Neural solution for excel must be install when install neural solution version 5

Picture A: Display the installation bottom



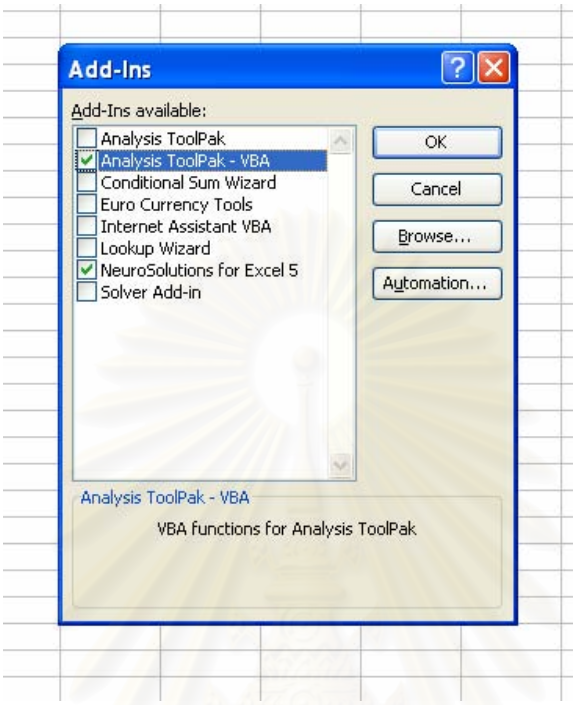
2. Open Microsoft Excel, Select Add-Ins at the tool panel.

Picture B: Display an Add-Ins tabs



Ensure that the Neural Solution for Excel5 check box was already checked. The neural solution for Excel 5 check box are shown in the following picture.

Picture C: Display the neural solution for excel 5 check box

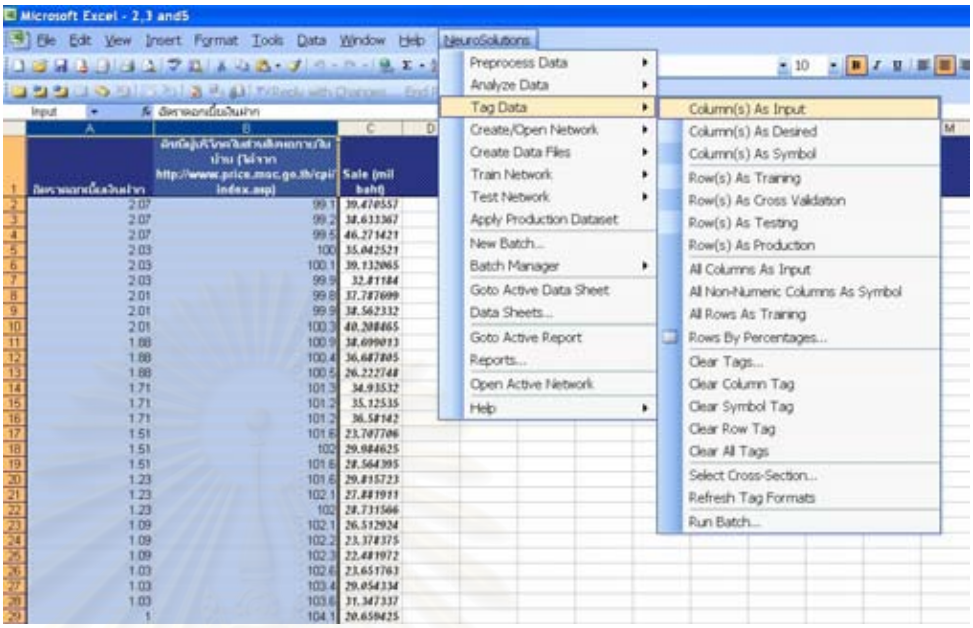


By following the above task, you can use the excel spread sheet as an input files.

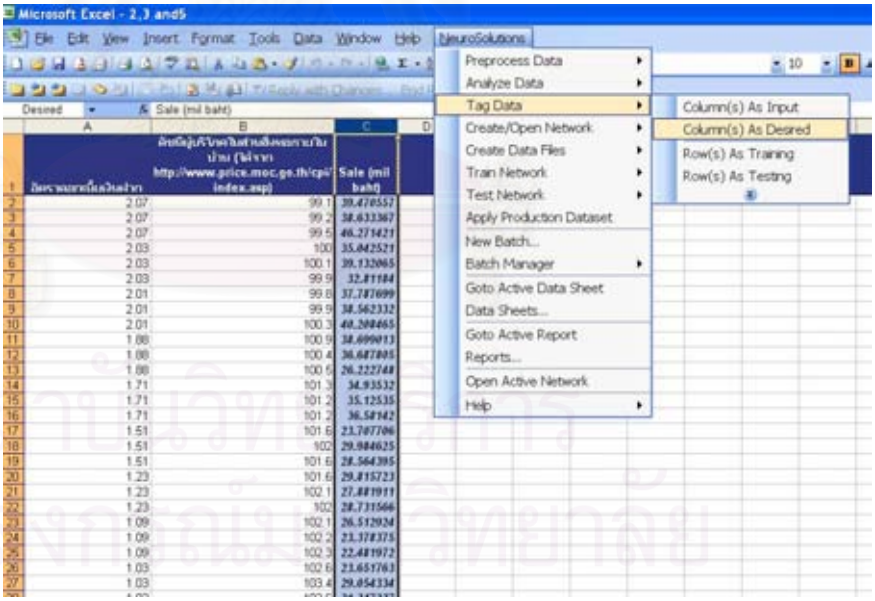
3. When you need to use the program to forecast, you can open the Input file in excel format.

4. After open the input file, the forecaster must selected column as input, column as desire, row as training and row as testing.

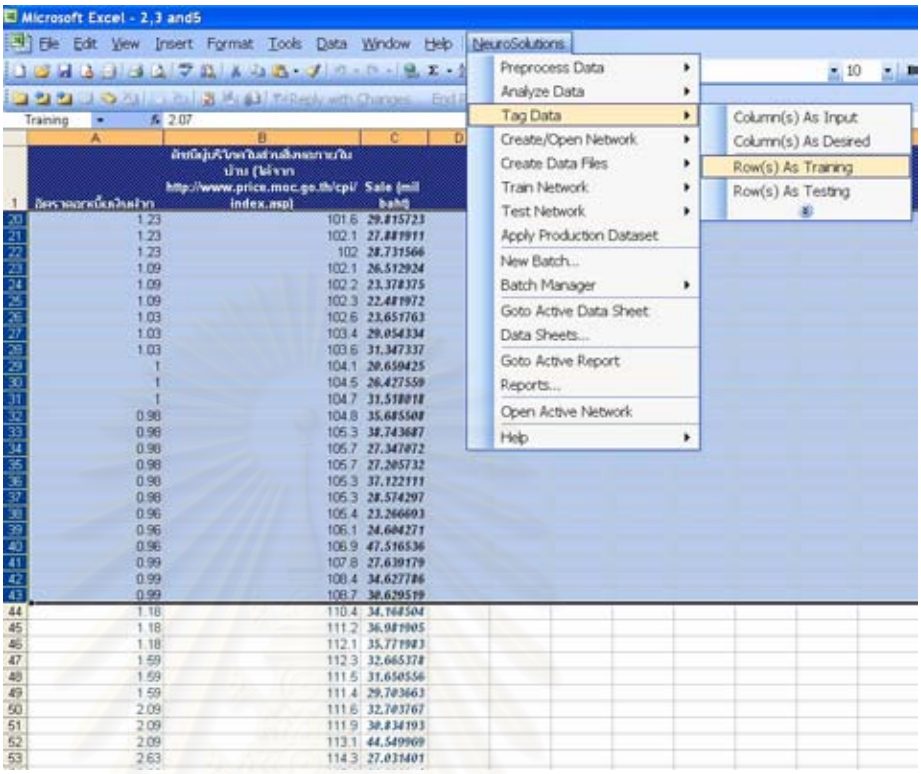
Picture A.4: Display how to selected column as input



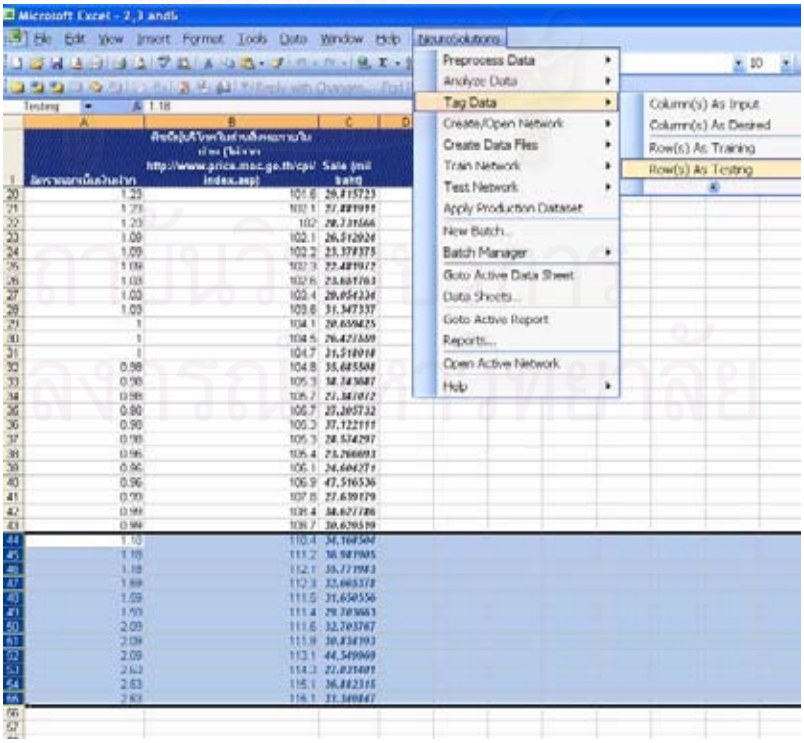
Picture A.5: Display how to selected column as desired



Picture A.6: Display how to selected Row as training

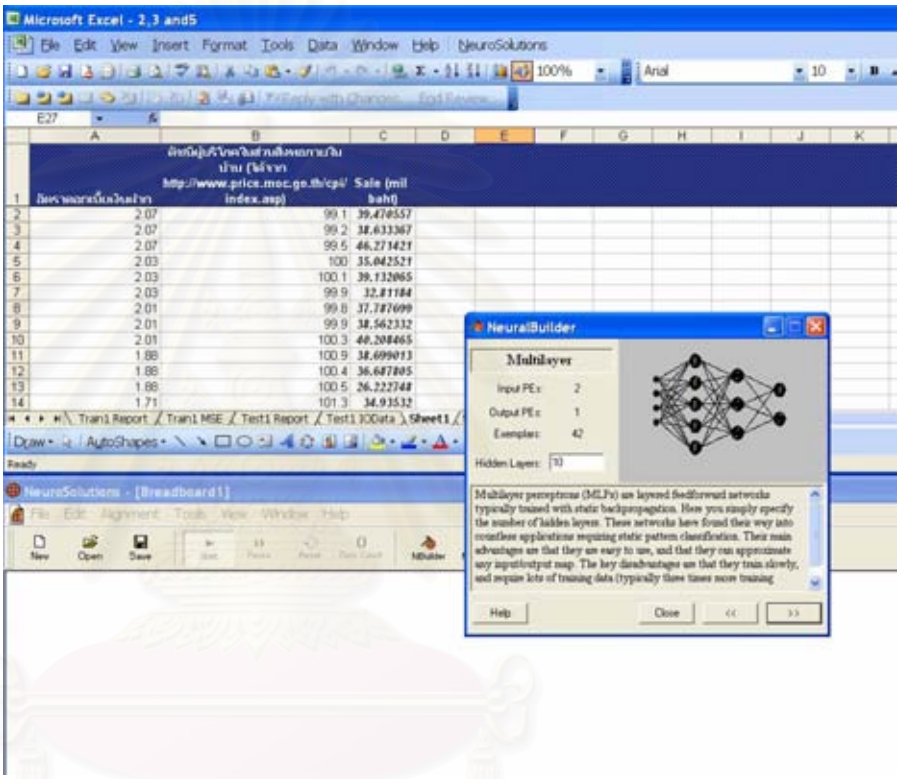


Picture A.7: Display how to selected Row as Testing



5. After you finish step 4, you have to create /open network to open the neural solution version 5 programs.

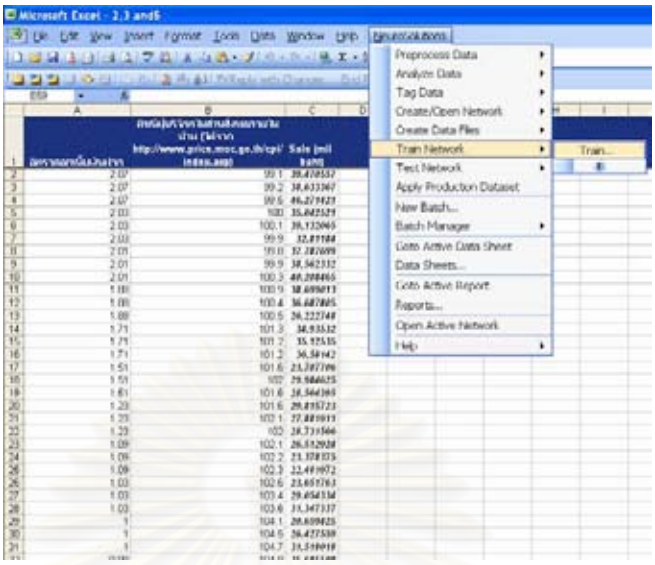
Picture A.8: Display how to create /open network to open the neural solution programs



6. You should use the default parameter of the program to forecast the output. Except the number of hidden layer

7. After you finish step 6, you have to Train the network.

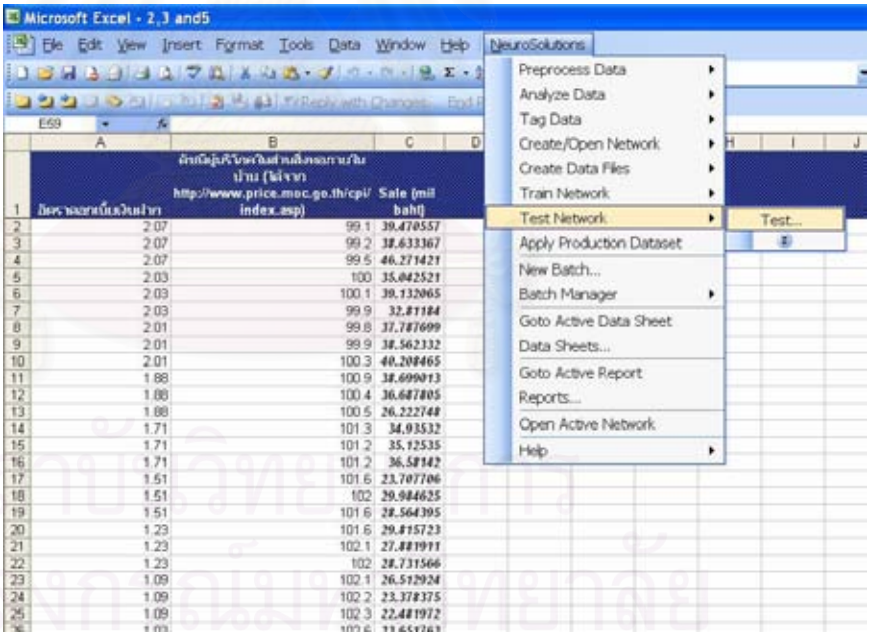
Picture A.9: Display how to train the network



In the step 7, you should keep the default setting.

8. After you finish step 7, you have to Test the Network.

Picture A.9: Display how to test the network



9. After you finish step 8, you will have the forecasting result by neural solution version 5.

APPENDIX B
THE INPUT DATA OF SALE VOLUME DEMAND FORECASTING BY NEURAL NETWORK

Table B.1 Provide the Input data of Sale Volume Demand Forecasting by Neural Network

Table B.1: Input Data

	Synthetic Fiber Production	Export	Interest rate	Unemployment Rate	Customer Price Index	Oil Price	Garment Consumer Index	GDP	Sale Volume
Jan-45	74,556	210620	2.07	1,406.3	101.2	13.69	99.1	13,551.15	39,470,557
Feb-45	63,730	223156	2.07	934.9	101.6	13.89	99.2	13,551.15	38,633,367
Mar-45	74,845	201543	2.07	901.5	101.6	13.79	99.5	13,551.15	46,271,421
Apr-45	74,721	213561	2.03	1,248.1	101.3	13.49	100	13,251.84	35,042,521
May-45	75,593	235805	2.03	1,003.5	101.4	11.99	100.1	13,251.84	39,132,065
Jun-45	64,467	243025	2.03	641.0	101.6	11.89	99.9	13,251.84	32,811,840
Jul-45	64,747	231760	2.01	597.7	101.7	11.99	99.8	13,439.99	37,787,699
Aug-45	76,215	252207	2.01	614.3	102.3	12.69	99.9	13,439.99	38,562,332
Sep-45	74,911	287150	2.01	675.0	102.7	12.59	100.3	13,439.99	40,208,465
Oct-45	77,009	298410	1.88	887.3	102.2	12.89	100.9	14,263.45	38,699,013
Nov-45	71,985	287540	1.88	512.5	102.3	13.09	100.4	14,263.45	36,687,805
Dec-45	75,928	276315	1.88	488.3	102.3	13.39	100.5	14,263.45	26,222,748

Jan-46	66,258	295432	1.71	1,153.6	102.5	14.69	101.3	14,726.85	34,935,320
Feb-46	69,479	269031	1.71	781.2	103.1	14.89	101.2	14,726.85	35,125,350
Mar-46	75,115	256001	1.71	996.3	103.1	14.79	101.2	14,726.85	36,581,420
Apr-46	61,871	267133	1.51	926.7	103.8	14.49	101.6	14,268.37	23,707,706
May-46	66,422	278541	1.51	944.5	104.2	12.99	102	14,268.37	29,984,625
Jun-46	67,054	305323	1.51	719.4	103.9	12.89	101.6	14,268.37	28,564,395
Jul-46	69,265	263405	1.23	489.5	103.9	12.99	101.6	14,630.78	29,815,723
Aug-46	70,994	286712	1.23	548.7	103.8	13.69	102.1	14,630.78	27,881,911
Sep-46	72,936	286765	1.23	622.6	104.1	13.59	102	14,630.78	28,731,566
Oct-46	77,232	324591	1.09	868.8	103.6	13.89	102.1	15,663.75	26,512,924
Nov-46	65,657	301965	1.09	540.4	103.4	14.09	102.2	15,663.75	23,378,375
Dec-46	68,419	298346	1.09	535.5	103.1	14.39	102.3	15,663.75	22,481,972
Jan-47	75,618	280185	1.03	1,279.6	103.3	14.59	102.6	15,859.15	23,651,763
Feb-47	70,773	285153	1.03	829.3	103.4	14.59	103.4	15,859.15	29,054,334
Mar-47	83,946	308783	1.03	840.7	103.7	14.59	103.6	15,859.15	31,347,337
Apr-47	71,652	284671	1	988.2	104.2	14.59	104.1	15,723.15	20,659,425
May-47	76,625	312920	1	917.9	104.3	14.59	104.5	15,723.15	26,427,559

Jun-47	74,254	336522	1	733.4	104.1	14.59	104.7	15,723.15	31,518,018
Jul-47	68,760	328638	0.98	493.0	104	14.59	104.8	16,142.86	35,685,508
Aug-47	79,662	331512	0.98	545.9	104.1	14.59	105.3	16,142.86	38,743,687
Sep-47	77,803	351428	0.98	637.8	104.5	14.59	105.7	16,142.86	27,347,072
Oct-47	79,341	363262	0.98	562.3	105.1	14.59	105.7	17,309.62	27,205,732
Nov-47	71,202	354107	0.98	537.1	104.6	14.59	105.3	17,309.62	37,122,111
Dec-47	64,223	337638	0.98	534.9	104.7	14.59	105.3	17,309.62	28,574,297
Jan-48	67,123	305638	0.96	1,152.0	105.6	14.59	105.4	17,152.21	23,266,693
Feb-48	67,179	297832	0.96	808.8	105.4	15.19	106	17,152.21	24,604,271
Mar-48	72,462	368171	0.96	734.9	105.5	15.19	106.9	17,152.21	47,516,536
Apr-48	62,768	317753	0.99	788.1	105.9	18.19	107.8	16,939.63	27,639,179
May-48	65,475	359708	0.99	725.1	106.3	18.19	108.4	16,939.63	34,627,786
Jun-48	64,434	368894	0.99	693.6	105.9	19.79	108.7	16,939.63	30,629,516
Jul-48	68,311	390925	1.18	523.5	105.9	22.59	110.4	17,909.40	33,168,504
Aug-48	71,132	425002	1.18	503.4	106.4	23.39	111.2	17,909.40	35,981,905
Sep-48	67,324	427978	1.18	471.7	106.3	24.19	112	17,909.40	34,771,983
Oct-48	69,833	391302	1.59	633.9	106.4	24.19	112.3	19,242.80	32,665,378

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Nov-48	65,192	400289	1.59	447.8	106.5	23.79	111.5	19,242.80	31,650,556
Dec-48	67,801	385814	1.59	507.4	106.6	23.09	111.4	19,242.80	27,703,663
Jan-49	68,696	363056	2.09	769.0	106.9	24.29	111.6	19,300.65	27,703,767
Feb-49	67,225	371441	2.09	555.0	107.7	24.29	111.9	19,300.65	30,834,193
Mar-49	65,681	433246	2.09	642.6	107.9	25.49	113	19,300.65	42,549,969
Apr-49	63,385	355277	2.63	759.3	108.5	26.29	114.3	18,894.58	24,031,401
May-49	62,198	406829	2.63	508.3	108.9	26.49	115.1	18,894.58	36,882,315
Jun-49	55,195	415869	2.63	560.5	109.1	27.54	115.1	18,894.58	30,349,847

Biography

My name is Mr. Natkamol Chintakowit, borne 27 September 1983 at Bangkok. I graduated bachelor's degree in Information Engineering, Faculty of Engineering at Kingmonkut institute of technology since 2004. Nowadays, I work at Thai airways international public company as a Computer Engineer.