Chapter V

Simulation of Propose Inventory Management System with VMI

Basically type of information that can be shared between supply chain partner in a VMI partnership include inventory levels and position, sales data and forecast, order status, production and delivery schedule and capacity, and performance metric. VMI can generate benefits to the supply chain partner such as cost reduction according to better resource utilization for production and transportation, improve service level due to better coordination of replenishment orders, increased inventory turn. Angulo, Nachtmann and Waller (2004)

In this chapter, the forecasting model and inventory control systems has developed to identify the efficiency inventory control policy under the availability of information sharing between service station and central depot. However, in this experiment there are two types of information sharing including sales volumes and inventory position.

5.1 Customer demand forecasting

Forecasting is the process to predict the future, the ability to provide an accurate prediction of future plays an important role in most decision making processes. In most cases, the risks involved in decision making are reduced by forecasting future events and by predicting their uncontrollable aspects. For the gasoline distribution the proper and accuracy forecasting can result in reduce inventory cost and increase customer service level.

In general forecasting method can classify to qualitative and quantitative method. Qualitative forecasting method or judgment method usually based on the opinion of the experts or people who concern each activities such as vendor,

procurement. salesman or production department. Thus, accuracy of qualitative forecasting method may vary up to experience and judgment of the predictor.

Nevertheless, this method usually apply when the organization do not have the historical data such as new product launching. However, sometimes even has the available of historical data qualitative forecasting method may applied according to unreliable of data, out of date data or irrelevant to the future. Another forecasting method is quantitative method which has the historical data and known the factor affect. There are two approached relate to quantitative method included projective method which consider the pattern of historical data. Generally projective method is often based on time series which are series of observation taken at regular interval of time. Another quantitative approach is causal method which looks at the factor that affects the dependent variable such as regression analysis. Both of quantitative methods rely on accurate and numeric data which sometimes more reliable than the qualitative method.

As the existing gasoline distribution generates the forecasting under qualitative forecasting method which based on judgment and experience of predictor at each service station. Figure 5.1 below shows all plants monthly sales volumes and end day inventory concern four type of gasoline studied. In addition Figure 5.2 -5.4 show all plant monthly sales volumes and end day inventory of each gasoline type include Benzene oil 91 (500021), Benzene oil 95 (500025), Diesel oil (500033) and Gasohol (500041).

From these pictures the average level of end day inventory is constantly while as each month sales volumes has both low and peak period. In addition, three gasoline types include Benzene oil 91, Benzene oil 95 and Diesel oil have the highly level of end day inventory comparison to sales volumes which lead to over stock and handling cost while as Gasohol has the lower of end day inventory comparison to sales volume. Nevertheless, the lowest of end day inventory affect the risk of shortage and lower in customer service level. Accuracy and reliable of forecasting process lead to decreasing of inventory cost and increasing in customer service level.

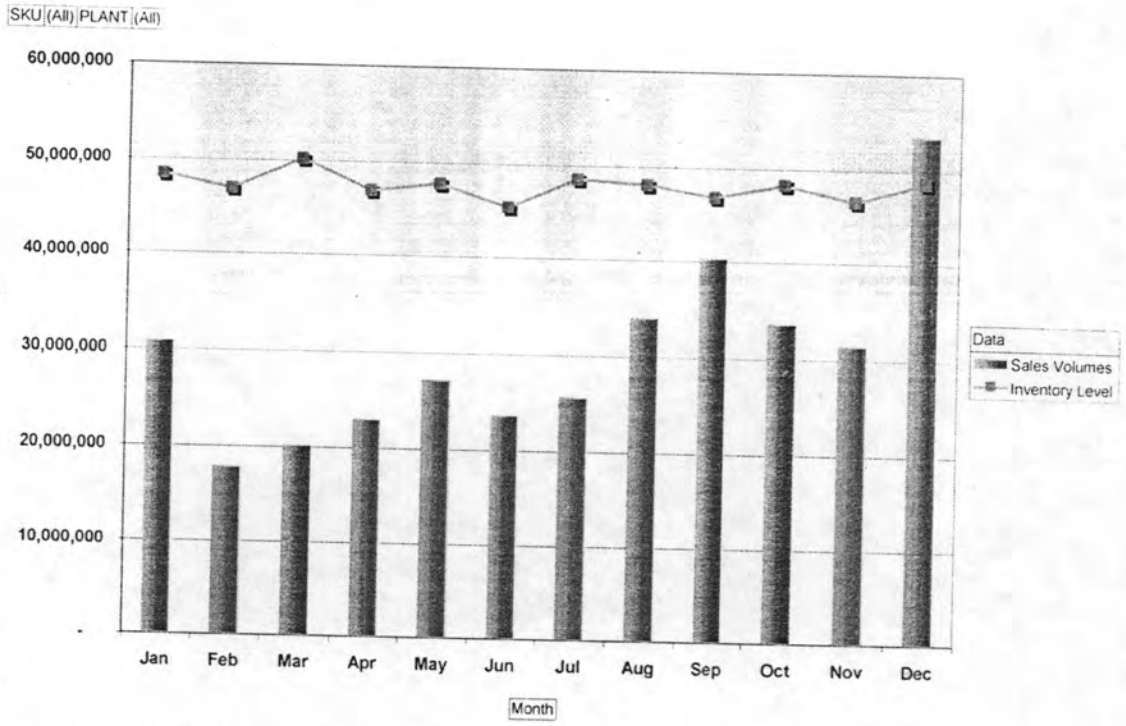

Figure 5.1 All SKU Monthly sales volume and end day inventory

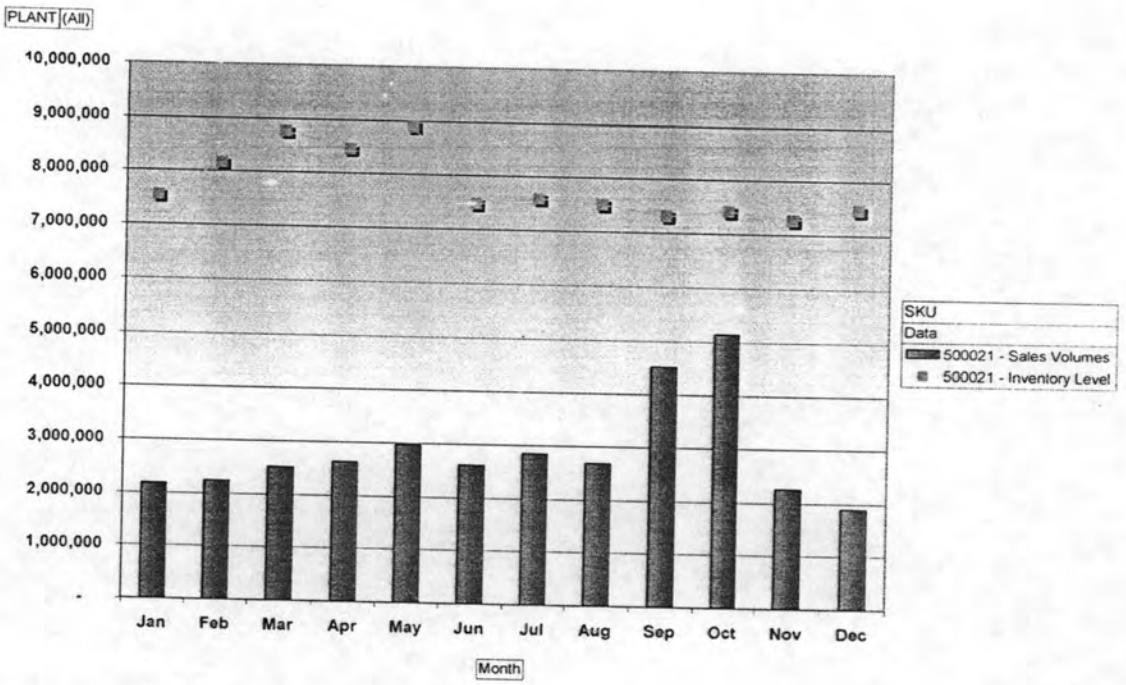

Figure 5.2 Benzene oil 91 Monthly sales volume and end day inventory

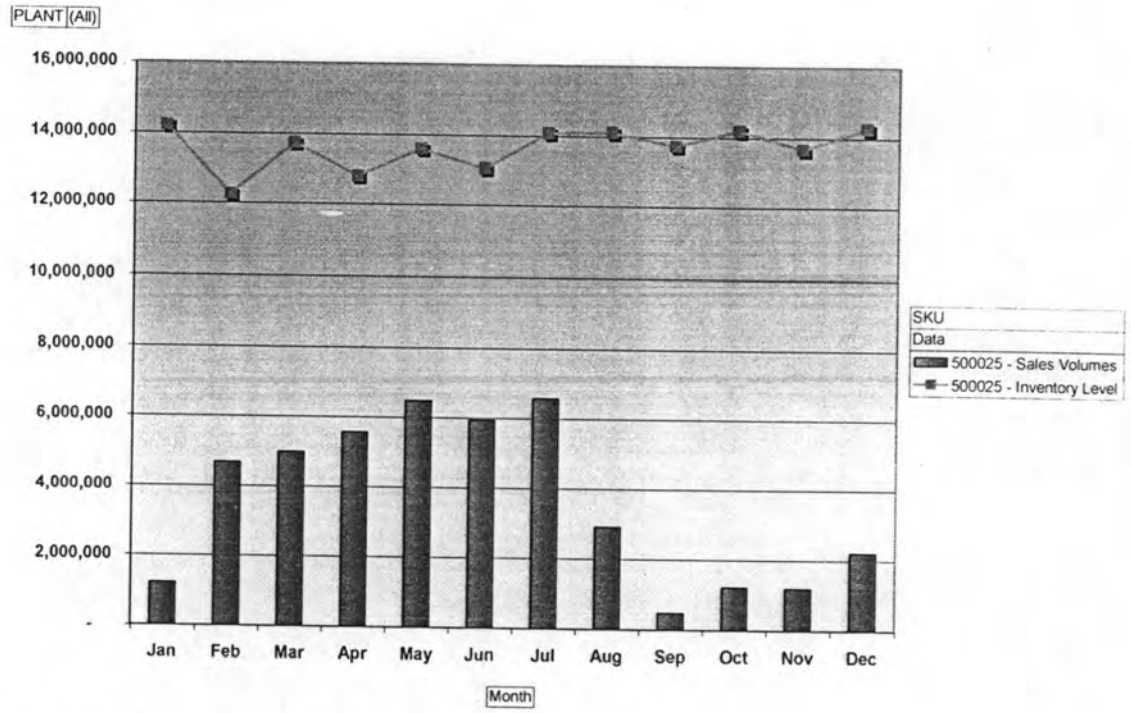

Figure 5.3 Benzene oil 95 Monthly sales volume and end day inventory

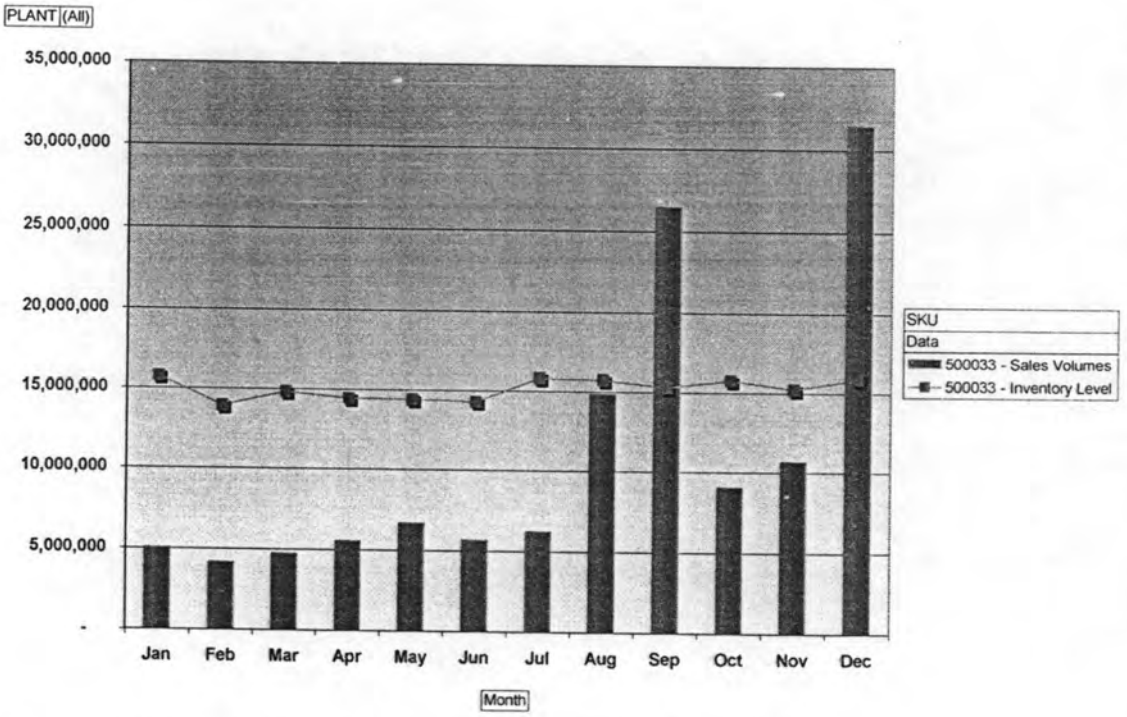

Figure 5.4 Diesel oil Monthly sales volume and end day inventory

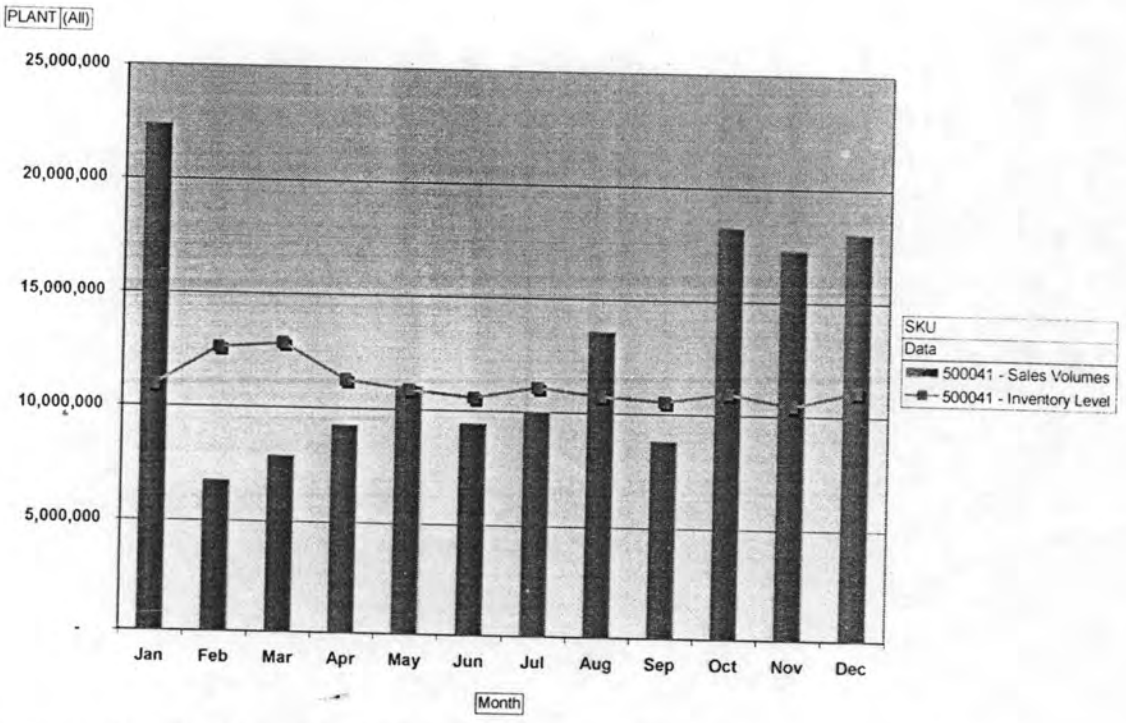

Figure 5.5 Gasohol Monthly sales volume and end day inventory

For this study, in order to predict the end customer demand at each service station, the historical sales data of 40 service stations in Bangkok during year 2006 has been generated in two forecasting elements which included multiple regression analysis and exponential smoothing approach.

5.1.1 Multiple Regressions Approach

Initially, SPSS program used to generate the multiple regression analysis in order to identify linear relationship or coefficient value of each independent variable which effect end customer demand. There are two factors of independent variable which has been taken in to account are long holidays and price fluctuations. Long holiday's periods that considered are three and four day's holidays which increasing of end customer demand and affect from increasing of their trip to up country. While as price fluctuation which relate to oil crisis problem affected end customer behavior and their fuel consumption. Basically when it has a changing in oil price, the announcing has performed one day in advance before the effective of new price. In the day that the increasing price announced, the end customer demand will sharply increase which lead to shortage

situation at service station. Meanwhile decreasing in oil price will lead to over stock at service station. Both dependent variables holidays and period that price fluctuate from oil crisis has been consider as qualitative variables. When has the holiday or price fluctuate from oil crisis, the independent variable has specified value one, in the contrast way for the normal period the independent value has specified value zero instead.

The linear relationship of each independent factor and dependent factor in gasoline distribution can calculate as follows.

$$\mathbf{D = a + b1X1 + b2X2}$$

Where,

D = End customer demand

a = Intercept or minimum demand

X1 = Long holiday

X2 = Price fluctuate from Oil Crisis

b1 = Coefficient of Long holiday

b2 = Coefficient of Price fluctuate

Figure 5.6 Regression Analysis Result

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Crisis, Holiday[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Sales

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.043[a]	.002	.002	8785.53043

a. Predictors: (Constant), Crisis, Holiday

b. Dependent Variable: Sales

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	239.506	41.704		173.591	.000		
	Holiday	139.834	231.364	.042	9.249	.000	1.000	1.000
	Crisis	335.932	151.231	.010	2.221	.026	1.000	1.000

a. Dependent Variable: Sales

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	239.5063	715.2725	328.9638	377.52046	49257
Residual	-9355.27	106240.5	.00000	8785.35206	49257
Std. Predicted Val	-.237	6.321	.000	1.000	49257
Std. Residual	-1.065	12.093	.000	1.000	49257

a. Dependent Variable: Sales

According to the transaction numbers of gasoline historical sales data are 49,276 records. Therefore, this study assumes that the dataset of historical sales data has a normal distribution. The regression method illustrates the linier regression analysis with Enter method which statistic method applied by estimate value and model fit value. Predict value indicated unstandardized value while as Residual value indicated standardized value. The regression equation generates the results as shown in figure 5.1.

As the result in figure 5.6, the regression equation indicated that end customer demands are positive related to X1 and X2 or long holiday and price fluctuate from oil crisis. Nevertheless, in the table of Model summary show that the values of R^2 equal to 0.002 which means independent variable X1 and X2 has a low significant to explain the variance of dependent variable or end customer demand. However, from the Coefficient table with significant ά value 0.05. Standardized coefficient value of independent variable holiday or X1 equal to 0.042 indicates that for each period of long holiday, the sales volumes have a positive effect 4.2% of average sales. Mean while standardized coefficient value of independent variable Oil crisis equal to 0.010 indicates that price fluctuate by oil crisis has a positive effect to end customer demand or daily sales volume only 1%. However, the significant value equal to 0.000 and 0.026 which less than significant ά level 0.05 means that the independent variables holiday and price fluctuate has relation with dependent variable sales quantities

In addition, Collinearity values, a statistic value to measures the interrelated between independent variables. The tolerance vale equal to 1.00 indicated that the independent variables holiday do not associate with price fluctuate.

Figure 5.7 Regression Analysis Result

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7E+009	2	3510024422	45.475	.000[a]
	Residual	4E+012	49254	77185544.93		
	Total	4E+012	49256			

a. Predictors: (Constant), Crisis, Holiday

b. Dependent Variable: Sales

Correlations

		Sales	Holiday	Crisis
Pearson Correlation	Sales	1.000	.042	.010
	Holiday	.042	1.000	.011
	Crisis	.010	.011	1.000
Sig. (1-tailed)	Sales	.	.000	.010
	Holiday	.000	.	.006
	Crisis	.010	.006	.
N	Sales	49257	49257	49257
	Holiday	49257	49257	49257
	Crisis	49257	49257	49257

From figure 5.7, table of ANOVA significant value equal to 0.00 which less than significant ά level 0.05 indicate that at least one of independent variable is interrelated with dependent variable. Another measurement of interrelated or associated between independent variables and dependent variable is Correlation coefficient value which have the range of value between + 1.00 and – 1.00. The correlation coefficient value equal to + 1.00 shows a perfect positive correlation, - 1.00 shows a perfect negative correlation and no correlation is indicated for coefficient equal to 0.00. From the ANOVA table above Pearson correlation shows the correlation value of independent variable holiday equal to 0.042 and price fluctuate from oil crisis equal to 0.010 has the positive correlation with dependent variable sales quantities. Further more one tail significant of holiday independent variable equal to 0.000 and crisis independent variable equal to 0010 which less than significant level ά 0.05 indicate that both independent variables has the associated with dependent variable.

5.1.2 Exponential Smoothing

Exponential Smoothing is a very popular scheme to produce a smoothed Time Series. Whereas in Moving averages the past observations are weighted equally, Exponential Smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. However in this study the weight which applied for exponential smoothing calculate from each day weight of each week. From figure 5.8, daily weight is equals to daily sales divide by whole week sales volume.

Day	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Total
Sales Volume	18	20	24	25	22	27	24	160
Daily weight	0.11	0.13	0.15	0.16	0.14	0.17	0.15	1.00

Figure 5.8 Daily weight calculations

Exponential smoothing performs to identify the weight and standard deviation of each independent variable as day of the week. The order quantities is calculate based on the following elements.

1) Four types of gasoline historical sales data which has been considered are Benzene oil 91 (500021), Benzene oil 95 (50025), Diesel oil (500033) and Gasohol (500041)

2) Operate historical sales data with four sliding weeks in order to calculate the moving average sales and the weight of each day.

3) Smoothing coefficient applied to weight each week in four weeks sliding of historical sales period which equal to 0.25.

4) Standard deviation coefficient of end customer demand at each service station varies by each four sliding weeks.

5) Leverage multiplier, used to lower or raise the proposed quantity. For this experiment, as the results from multiple regression analysis in figure 5.1, holiday coefficient value which equal to 0.42 and price fluctuate from oil crisis which equal to 0.10 would apply as leverage multiplier.

6) Available stock or stock on hand.

7) Back order is not applicable.

8) Period to cover, the number of days between the order day and the next delivery day. For this experiment, with one day lead time, therefore period to cover is equal to two days.

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	Order 1	**Deliver 1**				
		Order 2	**Deliver 2**			
	Period to cover					

Figure 5.9 Period to cover calculation

9) Safety stock models perform in 2 scenarios included Maximum forecast error method and Customer Service level with standard deviation method.

With these components, the Exponential smoothing can formulate the gasoline order quantities for each gasoline station as follow.

SFt = {AWSt-1 + (smoothing coeff x SD)} x ∑WDi x b1 x b2

Where,

SFt = Sales forecast of next period

AWSt-1 = Average weekly sales of previous period

$$= \sum_{1}^{4} \text{Actual weekly sales} / 4$$

Smoothing coeff. = 0.25

SD = Standard deviation

$$= \sqrt{\left(\sum_{i=1}^{4} (\text{Weekly sales } i - \text{WWAS})^2 / 4\right)}$$

WWAS = Weight weekly average sales

$$= \sum_{1}^{4} (\text{Weekly sales} \times 0.25)$$

$\sum$ WDi = Total weight of each day which cover time interval and lead time., i $\in$ {Mon, Tue, …. Sun}

b1 = Coefficient of Long holiday (Leverage)

= 1.042

b2 = Coefficient of price fluctuate (Leverage)

= 1.010

5.2 Inventory control and replenishment policies.

For this study, the inventory control and replenishment policy designed under the experiment that the information of sales volume and inventory level has been shared between service station and central depot. In addition, no different in lead time for delivery gasoline from central depot to each services station and it is constantly equal to one day. These inventory models developed to identify the most efficiency inventory system by applying VMI and have taken in to account of key parameter of customer

demand, customer service level, reorder point and stock target level. There are three models of inventory control considered included

- Continuous review with maximum forecast error approach
- Minimum –Maximum approach
- Minimum –Maximum with maximum forecast error approach

5.2.1 Continuous review with maximum forecast error approach.

This approach continues review the inventory level at least once a day. The quantity of safety stocks for each gasoline type varies by absolute maximum shortage quantities of forecast error in previous four week sliding. However, when the shortage quantities is less than 3,000 liters, the minimum safety stock would be specified at 3,000 liters as the results from the trail experiment of minimum safety stock level with quantities 1,000 liters, 2,000 liters and 3,000 liters. The results shown that the minimum safety stock 3,000 liters dedicate a good result of shortage and over stock reduction. Further more, the stock target level defined by the number of forecast quantities over time interval or period to cover plus safety stock. The quantities of gasoline purchase from central depot specific in thousand units with minimum order 1,000 liters. The equation of Continuous review with maximum forecast approach can illustrate as below.

Stock target level = **Sales forecast + Safety Stock**

Safety stock = Max | (Shortage Previous month) |

= Max | (SF t-1 - Sales t-1 < 0) |

Quantity to order = Stock target level - Stock on hand

Min Quantity order = 1,000 liters

Period to cover = 2 days

Delivery Lead time = 1 day

5.2.2 Minimum –Maximum Inventory Model

We designed this model to generate the reorder level when the inventory level is lower than the specific minimum inventory which included the average daily sales of four sliding weeks and safety stock. Safety stock equal to the specific service level multiplied with standard deviation of end customer demand over four weeks sliding. From figure 5.11 specific 95% customer service level equal to 1.64. Nevertheless, safety stocks of each month vary by the value of standard deviation of each four sliding weeks. In addition, the maximum inventory quantities are limited by stock target level which generates from average sales over time interval and lead time or two days times to cover plus safety stock. The quantities of gasoline purchase from central depot specific in thousand units with minimum order 1,000 liters. The equation of Minimum – Maximum Inventory Model can illustrate as below.

Stock target level	=	Sales forecast over time interval + SS
Safety Stock (SS)	=	Z x SD of Demand over Time interval
Service level Z 95%	=	1.64
Reorder point	=	Daily average sales + SS
Quantity to order	=	Stock target level - Stock on hand
Min Quantity order	=	1,000 liters
Period to cover	=	2 days
Delivery Lead time	=	1 day

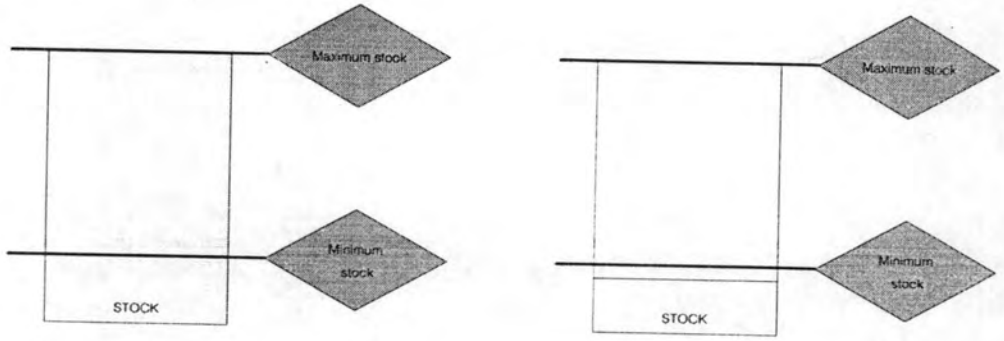

Figure5.10 Minimum – Maximum Inventory control model

The following table show how highly value of Z or service levels gives higher safety stocks and lower probabilities of shortages.

Z	Shortage (%)	Service Level (%)
0.00	50.00	50.00
0.84	20.00	80.00
1.00	15.90	84.10
1.04	15.00	85.00
1.28	10.00	90.00
1.48	7.00	93.00
1.64	5.00	95.00
1.88	3.00	97.00
2.00	2.30	97.70
2.33	1.00	99.00
2.58	0.50	99.50
3.00	0.10	99.90

Figure 5.11 Safety Stock with normally distributed demand

5.2.2.1 Minimum – Maximum Inventory with maximum forecast error approach

We designed this model to generate the reorder level when the inventory level is lower than the specific minimum inventory which included the average daily sales of four sliding weeks and safety stock.

Safety stocks vary by maximum shortage quantities of forecast error in previous month or previous four sliding weeks. However, according to the trail experiment of minimum safety stock from Continuous review with maximum forecast error approach above, the results and policy of minimum inventory quantity would be applied to this inventory approach. Therefore, when the shortage quantities are less than 3,000 liters, the minimum safety stock would be specified at 3,000 liters.

The maximum order quantities are limited by stock target level which generates from average sales over time interval and lead time plus safety stock. The equation of Minimum – Maximum Inventory with maximum forecast error approach can illustrate as below.

Stock target level = **Sales forecast over time interval + Safety stock**

Safety stock = Max | (Shortage Previous month) |

= Max | (SF(t-1) - Sales (t-1) < 0) |

Reorder point = Daily average sales + SS

Quantity to order = Stock target level - Stock on hand

Min Quantity order = 1,000 liters

Period to cover = 2 days

Delivery Lead time = 1 day

5.3 Cluster analysis

SPSS generate Cluster analysis to criteria the gasoline station potential by sales volume and profit margin in order to specific the optimal inventory and replenishment policy for each gasoline station classicizing. In this study, cluster analysis illustrate four subgroup of service station by the number of sales quantizes and end day inventory level. High number of sales volumes indicated high potential level of service station, further more low number of end day inventory level indicated high level of profit margin of each service station. Hierarchical cluster technique used to operate cluster analysis for this study as there are forty cases and two independent variables factors to classified group of service station. Standardized variable generated to create Z-score variables. Cluster method applied by Between-groups linkage or Average linkage between groups which calculate the shortest distance between cases in each cluster. If cluster *i* has the shortest distance with cluster *j* than the others cluster, therefore cluster *i* will combine with cluster *j*.