Chapter III
Methodology

In order to develop the optimal solution of inventory level and replenishment with vendor managed inventory policy. The research methodology can be defined in section as below:

3.1 Study the supply chain collaboration method.

3.2 Study inventory planning and forecasting methods of successful practices.

3.3 Study current gasoline distribution and inventory method of the case study company.

Since the gasoline stations use the periodic review method for the existing inventory control. The gasoline ordering policy just only to fulfills the inventory to the maximum boundary of tank capacity without consideration the responsiveness to the fluctuation of customer demand. Therefore, managing the excess of inventory level and reduce the shortage of gasoline would introduced to cost reduction and retain more profitable from the efficiency system. Therefore the model of the optimal inventory and replenishment policy by apply the vendor managed inventory approach would develop and examine in this study.

3.4 Gathering data

3.4.1 Gathering the secondary data of gasoline distribution from two echelon of supply chain included Gasoline Central Depot and 40 Gasoline stations of the studied company.

3.4.2 The data of customer behaviors contain ordering history, sales volume, inventory level, gasoline prices, gas station tank container capacities, inventory control policy and other influent factors of four products item in past 12 months.

3.4.3 Calculate the average total cost, total sales and inventory volume/month of the exiting gasoline distribution policy.

3.5 Data analysis

3.5.1 Perform the forecasting formulation

The forecasting model is calculate based on the following elements

- Multiple Regression analysis used to identify linear relationship or coefficient value of each independent variable which effect end customer demand.

$$D = a + b1X1 + b2X2$$

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

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

    - Historical sales with 4 sliding weeks, used to calculate the moving average sales and the weight of the days.
    - Smoothing coefficient, used to weight the weeks in the historical sales period.
    - Period to cover, the number of days between the order day and the next delivery day.
    - Standard deviation coefficient.

- Leverage multiplier, used to lower or raise the proposed quantity.
- Available stock.
- Safety Stock.

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

$$\mathbf{SFt} = \mathbf{\{AWSt\text{-}1 + (smoothing\ coeff \times SD)\} \times \sum WDi \times b1 \times b2}$$

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)

b2 = Coefficient of Price fluctuate (Leverage)

The table of figure 3.1 below shows the Exponential smoothing forecast method with 4 sliding weeks of historical sales data. In addition, figure 3.2 describe the definition of period to cover customer demand.

					(1)	(5) = (1) ÷ 1570
Day	Week 1	Week 2	Week 3	Week 4	Totals per day	Weight of the day
Mon	35	40	50	60	185	0.118
Tue	40	45	55	65	205	0.131
Wed	45	50	60	70	225	0.143
Thu	50	55	65	75	245	0.156
Fri	55	60	70	80	265	0.169
Sat	55	60	62	58	235	0.150
Sun	50	55	48	57	210	0.134
Weekly sales (2)	330	365	410	465	1570	1.000
Smoothing coefficient (3)	0.25	0.25	0.25	0.25	1	
Weighted weekly average sales (4) = (2) x (3)	83	91	103	116	393	

Figure 3.1 Exponential smoothing with 4 sliding weeks.

Sun	Mon 1/1/06	Tue	Wed	Thu 4/1/04	Fri	Sat	Sun 7/1/04	Mon 8/1/04	Tue	Wed 10/1/04	Thu 11/1/04	Fri
	Order 1							Delivery 1				
				Order 2							Delivery 2	
	Period to cover											

Figure 3.2 Calculation of Period to cover.

3.5.2 Safety Stock models has taken in to account with two scenarios

3.5.2.1 Safety stock scenario1 which safety stock (SS1) defined by specific service level (Z) at 95%

SS1 = Z x SD of Demand over Time interval + Lead time

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 3.3 Safety Stock with normally distributed demand

3.5.2.2 Safety stock scenario2 which safety stock (SS2) defined by the maximum shortage forecast error in previous month.

SS2 = Max | (Forecast Sales(t-1) - Actual Sales(t-1) |

Where, Forecast Sales(t-1) - Actual Sales(t-1) < 0

3.5.3 Illustrate inventory control and replenishment scenarios including key parameter of customer demand, customer service level, reorder point and stock target level.

3.5.3.1 Continuous review with maximum forecast error approach. This approach continues review the inventory level at least once a day. The stock target level defines by the number of forecast quantities plus safety stock. Safety stocks vary by maximum shortage quantities of forecast error in previous month.

3.5.3.2 Minimum –Maximum Inventory approach design to generate the reorder level when the inventory level is lower than the specific minimum inventory which included the daily average sales and safety stock. Safety stocks vary by standard deviation of each month sales volume with specific service level at 95%. The maximum order quantities are limited by stock target level which generates from average sales over time interval and lead time plus safety stock.

3.5.3.3 Minimum – Maximum Inventory with maximum forecast error approach design to generate the reorder level when the inventory level is lower than the specific minimum inventory which included the daily average sales and safety stock. Safety stocks vary by maximum shortage quantities of forecast error in previous month. The maximum order quantities are limited by stock target level which generates from average sales over time interval and lead time plus safety stock. Figure 3.4 illustrate the idea of minimum – maximum inventory approach.

ROL = Lead time x Average sales + Safety Stock

Qi = Ft + Safety Stock – Current Stock

Qi <= Gasoline Station's Tank capacities i

Qi <= Maximum inventory level of each Tank

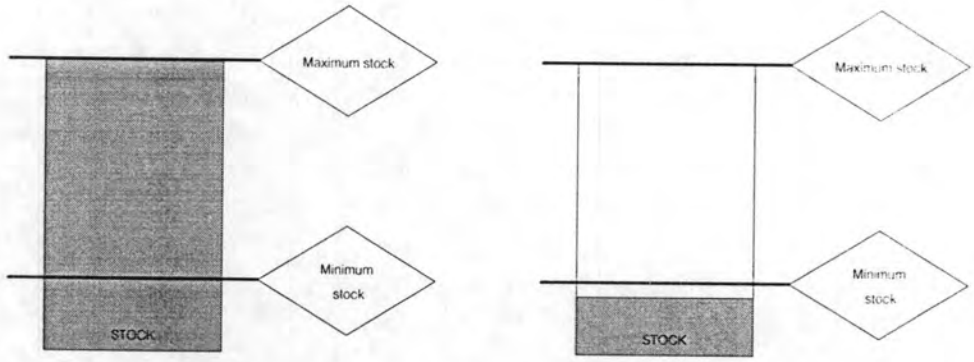


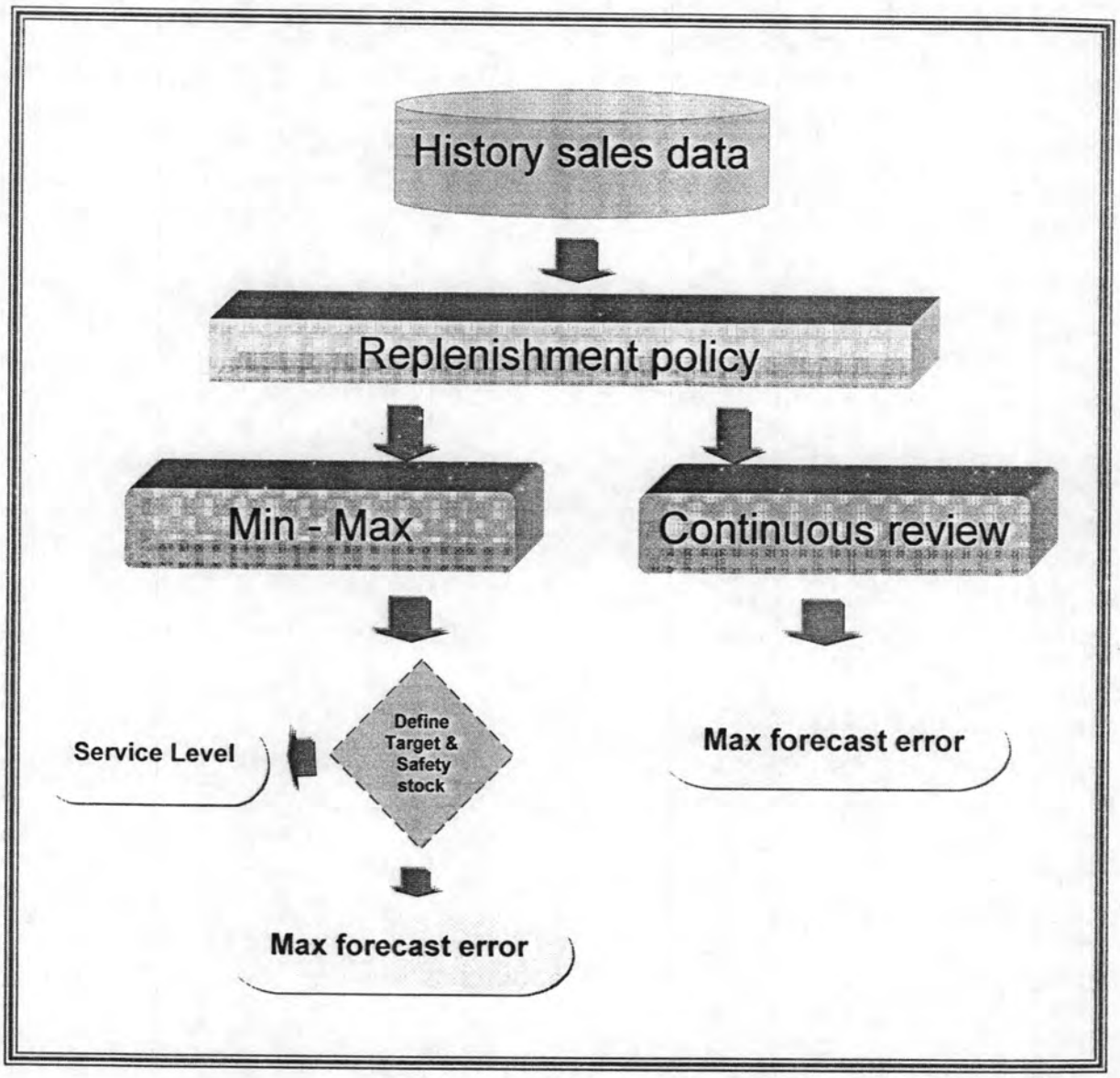
Figure3.4 Order is created when the stock level falls under the minimum stock level.

3.5.4 Adopt the inventory models to determine the optimal inventory control and replenishment policy.

3.5.5 Operate 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.

Gasoline station classification				
Sales volume				
Profit Margin	Criteria	High	Medium	Low
	High	HH	MH	LH
	Medium	HM	MM	LM
	Low	HL	ML	LL

Figure 3.5 Scenario of Inventory control and replenishment policy



3.5.6 Perform cost and benefit analysis of the propose inventory model to the existing model.