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Forecasting and Purchasing Planning for Shelf Life-Limited Instruments Equipment Spare Parts

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Abstract

Forecasting and Purchasing Planning for Shelf Life-Limited Instruments Equipment Spare Parts with a case study of company, purchasing spare parts from factories by selecting a forecasting method and applying a mathematical model. The purposes of this research are to improve the inventory quantity to be suitable for customers' demand, to reduce holding cost and to minimize the total inventory cost. In the past, the company operations didn't have purchasing planning strategy in the case study, the purchasing would be ordered when the inventory level is 0 that result shortage spare parts sometimes and the company had the policy about the spare parts with a limited 5-years lifetime. There were 17 items or 80% of total expired spare parts value that would be taken for forecasting and purchasing planning in this case study. We propose a new strategy about applying a mathematical model for purchasing planning spare parts that minimize the total inventory cost by using a new safety stock (SS) and customers' demand that is the most accurate forecasting method with the lowest Mean Absolute Deviation (MAD) from 5 forecasting methods: 1) Moving Average, 2) Single Exponential Smoothing, 3) Double Exponential Smoothing, 4) Holt-Winters Smoothing, 5) Monte Carlo Simulation. From experiments, 17 items of the spare parts were the most suitable with Moving Average, Single Exponential Smoothing and Double Exponential Smoothing Method. In addition, this study calculated the new safety stock level at 95% confident level for new purchasing planning next year. Finally, The results of this study were found that the mathematical model for purchasing planning spare parts, could prevent the inventory shortage, reduce holding cost and minimize the total inventory cost from the current purchases of all items by 8,384,223 baht or decrease the average cost of 493,189.59 baht/year that is 17.55%

Keywords: Forecasting, Purchasing Planning, Inventory Control, Mathematical Model, Cost Minimization

I. INTRODUCTION

Inventory or raw materials is an important factor for business operation. In general, industrial factories stock about 10,000 – 50,000 lists of inventory. Therefore, to control the inventory effectively, the organizations have to know each inventory list [1][2]. If the management is improper; the negative effects might be on different parts of business operations such as production interruption because of material shortages, leading to a delay in deliveries and customers' dissatisfaction. As a result, forecasting and purchase planning is an option to minimize inventory cost for expired inventory, and to reduce loss of opportunity to provide customer service as well.

The industrial company for this case study was in business of production and distribution of measuring tools to industrial factory that imported spare parts from Japan and was a distributor. There are 2 methods of measuring tool production: make to order and make to stock. Make to order is the production according to customers' demand, whereas make to stock is the production for later distributing to customers. But In present, the company in this case study operated to sell the spare parts that is "make to stock" which was not suitable to customers' demand and amount of spare parts were over customers' demand. There were a lot of expired spare parts in the warehouse and these expired items were destroyed because of the company policy determined to destroy all expired spare parts from inventory when the spare parts of inventory have 5-years lifetime. Some raw material of spare parts has limit lifetime or technology of production has to be developed. This effect makes the company lose too much inventory costs and opportunity to invest money on other beneficial activities. In 2016, 27.38% of spare parts was expired or destroyed as shown in Fig. 1.

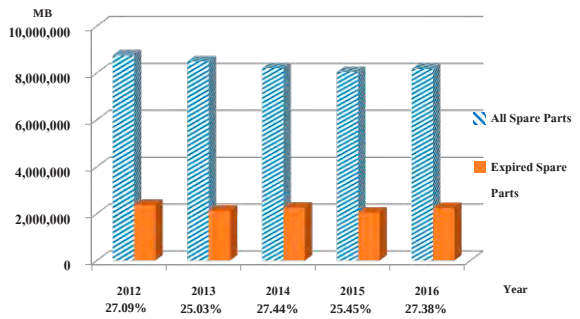


Fig. 1. Amount of spare parts was expired or destroy in 2012 – 2016

According to the above analysis of problems from previous studies, it is necessary to have comparative forecasting to find the best way to confirm the details. Time Series Forecasting [3] was used to compare Monte Carlo forecasting [4] and planning for purchasing inventory with limited lifetime. In this case uses the Lot Sizing Problem of Wagner and Whitin's method [5]-[9] for optimizes cost by linear programming. This problem will be used for solving minimize total cost.

Therefore, The process of this research as shown in Fig. 2, that studied 5 forecasting method to demand forecasting from customers' orders quantity in past of make to stock production in order to analyze the demand and orders quantity in the future. In addition, this study calculated the new safety stock level at 95% Service level for purchasing planning on next year. After that, the mathematical model was applied to plan the purchase of spare parts or determine the proper purchasing quantity and minimize the total cost of spare parts: ordering cost, holding cost, and shortage cost.

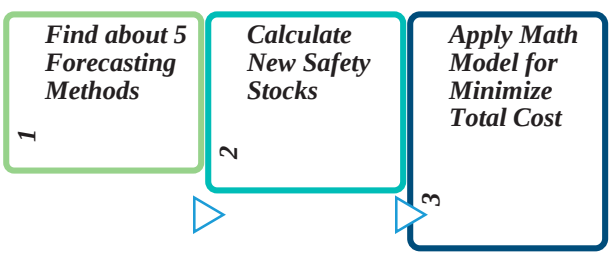


Fig. 2. The process of this research

II. OBJECTIVES

The main objectives of the study are as follows.

1. To improve the volume of the inventory storage suitable for customers' demand in past by using demand forecasting method.

2. To plan and determine the order quantity of spare parts on measuring tools with limited lifetime by using the mathematical model.

3. To minimize the total inventory cost of shelf life-limited spare parts at least 15%

III. RESEARCH METHODS

A. Problem analysis and data collection

The data from January 2012 to December 2016 were collected according to spare part categories and Pareto Graph Plot [10]. Fig. 3 shows that the mostly expired spare parts or destroy (80%) was on 17 items of all 54 items which was spare parts most important which was not suitable to customers' demand and impacted on higher cost from determine higher price thus the company wasted the investment and sales benefits.

In 2017, the manager director of the company decided to cancel about storage of spare parts. This result was inadequate spare parts at times or shortage cost.

This research analyzes spare parts all 17 items as shown in Fig. 3.

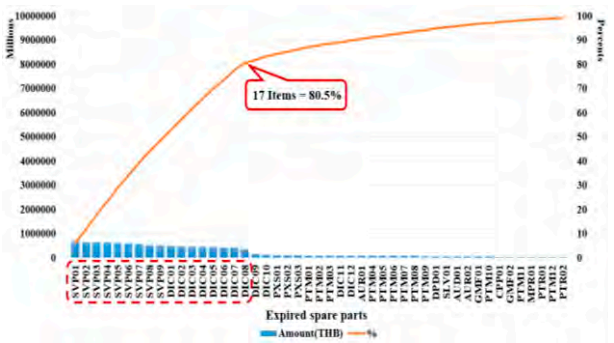


Fig. 3. Pareto chart for average costs of expired spare parts in 2012 – 2016

B. Notation

The following notations are used throughout this research in forecasting method, calculated the new safety stock and the mathematical formulation:

F_t	Forecasted value in period t
ℓ_t	Level estimated value in period t
n	Number of forecasting period
b_t	Trend estimated value in period t
S_t	Season estimated value in period t
A_t	Demand value in period t
p	Period for season
α	Smoothing constant
γ	Weighted smoothing for trend
δ	Weighted smoothing for season
t	Time period with t = 1, 2, 3,...., n (month)

SS	Safety Stock
Z_α	Service standard level α
σ_{dL}	Standard deviation of lead time for spare parts
σ_d	Standard deviation of spare parts demand
L	Lead time for spare parts
X_t	Order quantity of spare parts in period *t*
Y_t	Order indication with order = 1, no order = 0
TC	Total cost (baht)
U	Price per a spare part (baht)
S	Cost per inventory purchase (baht)
H	Cost for inventory storage in period (per piece)
I_t	Quantity of ending inventory in period *t*
R_t	Quantity of received inventory in period *t*
D_t	Quantity of demand for spare parts in period *t*
MAX	The number of the maximum order per time
M	Maximum number

Where: ($0 \le \alpha \le 1$), ($0 \le \gamma \le 1$) and ($0 \le \delta \le 1$)

Both α and γ parameters of this research obtained from result ARIMA optimal in Minitab program, n parameter was used with all forecasting method that is n = 12.

C. Forecasting Methods

This present paper studied the customers' demand in past about spare parts model SVP01 for demand forecasting make to stock in the future. Five methods were used, namely 1) Moving Average, 2) Single Exponential Smoothing, 3) Double Exponential Smoothing, 4) Holt-Winter's Smoothing, and 5) Monte Carlo Simulation. This research predicted the order demand for 12 months in advance with the first 4 forecasting methods by using Minitab Version 17.

1) Moving Average Method:

$$F_{t+1} = \frac{(A_t + A_{t-1} + A_{t-2} + ... + A_{t-n+1})}{n} \quad (1)$$

2) Single Exponential Smoothing Method:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \quad (2)$$

3) Double Exponential Smoothing Method:

$$F_{t+n} = \ell_t + nb_t \quad (3)$$

$$\ell_t = \alpha A_t + (1-\alpha)(\ell_{t-1} + b_{t-1}) \quad (4)$$

$$b_t = \gamma(\ell_t - \ell_{t-1}) + (1-\gamma)b_{t-1} \quad (5)$$

4) Holt Winter's Method:

Additive

$$F_{t+n} = \ell_t + nb_t + S_{t+n-p} \quad (6)$$

$$\ell_t = \alpha(A_t - S_{t-l}) + (1-\alpha)(\ell_{t-1} + b_{t-1}) \quad (7)$$

$$b_t = \gamma(\ell_t - \ell_{t-1}) + (1-\gamma)b_{t-1} \quad (8)$$

$$S_t = \delta(A_t - \ell_t) + (1-\delta)S_{t-1} \quad (9)$$

Multiplicative

$$F_{t+n} = (\ell_t + nb_t)S_{t+n-p} \quad (10)$$

$$\ell_t = \alpha(A_t / S_{t-l}) + (1-\alpha)(\ell_{t-1} + b_{t-1}) \quad (11)$$

$$b_t = \gamma(\ell_t - \ell_{t-1}) + (1-\gamma)b_{t-1} \quad (12)$$

$$S_t = \delta(A_t / \ell_t) + (1-\delta)S_{t-1} \quad (13)$$

5) Monte Carlo Simulation Technique:

This technique is the repeated random sampling method to form mathematical model data, resulting in cost solving the problem of controlling cost in the inventory by using Microsoft Excel Program to apply Monte Carlo Simulation Technique as shown in TABLE I.

RN = Random Number

TABLE I. APPLICATION EXAMPLE OF MONTE CARLO SIMULATION TECHNIQUE

x	frequency	f(x)		F(X)	Range of RN	
0	2	0.03333	0.00000	0.03333	0.00000 <RN<	0.03333
1	1	0.01667	0.03333	0.05000	0.03333 <RN<	0.05000
.	.	.	.	.	.	
.	.	.	.	.	.	
.	.	.	.	.	.	
19	3	0.05000	0.95000	1.00000	0.95000 <RN<	1.00000

After data was collected for 5 forecasting methods and selected the results of experiment from comparing the most accurate forecasting method with the lowest Mean Absolute Deviation (MAD).

6) Calculation of Mean Absolute Deviation (MAD):

This research used Mean Absolute Deviation (MAD) which is the technique for measuring precision to solve the problem of average error calculation considered differently from real sales and real forecasting regardless of symbol.

$$\text{MAD} = \frac{1}{n}\sum_{t=1}^{n}|A_t - F_t| \quad (14)$$

D. Calculation of safety stock level (SS)

All spare parts of the factory used in the case study possessed constant lead time so if the spare parts demand is unstable, the lead time will be constant. The safety stock will be calculated at 95% Confidence level.

$$SS = Z_{\alpha}\sigma_{dL} \tag{15}$$

$$\sigma_{dL} = \sigma_{d}\sqrt{L} \tag{16}$$

E. Purchasing planning with a mathematical model

Wagner and Whitin's mathematical model was applied to calculate in the future order quantities of spare parts by using the previous demand data, to minimize the total cost of inventory, and to reduce the problem of shortage cost with the following equation.

$$MIN\ TC = \sum_{t=1}^{T} UX_{t} + \sum_{t=1}^{T} (SY_{t} + HI_{t}) \tag{17}$$

Subject to

$$I_{t} = I_{t-1} + R_{t} - D_{t} \quad ;\forall t \tag{18}$$

$$X_{t-1} = R_{t} \quad ;\forall t \tag{19}$$

$$X_{t} \le MY_{t} \quad ;\forall t \tag{20}$$

Y_{t} = 0 or 1 $;\forall t$ (21)

$$I_{t} \ge SS \quad ;\forall t \tag{22}$$

$$I_{t} \le MAX \quad ;\forall t \tag{23}$$

In the formulation above, the objective function (17) represents the main objective to minimize the total inventory cost of purchasing. Constraint (18), the quantity of the ending inventory in period t is the same as the quantity of the previous one (I_{t-1}), increases the order quantity of the arrival inventory (R_{t}), and reduce the demand quantity of the inventory in period t (D_{t}). Constraint (19), the spare parts order has a one-month lead time. Constraint (20), if there is an order of the spare parts ($X_{t} > 0$), Y_{t} variable which equals 1. Constraint (21), the decision variable of a spare parts order is 0 or 1 in each period. Constraint (22), the inventory quantity is higher than or equal to the safety stock (SS). Constraint (23), the quantity of each inventory order is lower than or the equal to the maximum inventory (MAX).

IV. RESULT AND DISCUSSION

A. Forecasting findings

The raw data of previous 17 items on spare parts demand from 2012 to 2016 as shown in TABLE II. Those was forecasted with 5 forecasting methods: 1) Moving Average, 2) Single Exponential Smoothing, 3) Double Exponential Smoothing, 4) Holt Winters model, and 5) Monte Carlo Simulation.

TABLE II. THE RAW DATA OF 17 ITEMS ON SPARE PARTS DEMAND FROM 2012 TO 2016

Item	Year	Model	1	2	3	4	5	6	7	8	9	10	11	12	Sum
	2012		8	9	10	1	10	11	12	2	8	19	20	6	116
	2013		10	12	1	7	2	16	13	10	0	12	3	11	97
1	2014	SVP01	10	20	8	5	4	13	7	15	18	6	1	3	110
	2015		10	16	3	9	4	11	10	0	7	8	1	14	93
	2016		9	6	16	10	7	16	0	12	17	6	10	15	124
		Average	9.4	12.6	7.6	6.4	5.4	13.4	8.4	7.8	10	10.2	7	9.8	108
	2012		7	4	13	8	10	12	11	5	15	10	9	14	118
	2013		12	13	10	0	8	12	14	9	15	18	12	13	136
2	2014	SVP02	19	10	15	17	16	19	12	15	7	0	6	8	144
	2015		12	13	10	6	14	11	15	19	17	1	10	5	133
	2016		18	10	7	11	16	12	9	12	15	4	10	5	129
		Average	13.6	10	11	8.4	12.8	13.2	12.2	12	13.8	6.6	9.4	9	132
	2012		13	7	10	12	11	9	13	8	9	12	11	10	125
	2013		13	8	7	12	11	13	10	16	15	16	9	16	146
3	2014	SVP03	3	10	17	13	7	6	10	17	13	8	10	16	130
	2015		15	18	14	10	14	12	14	8	7	9	9	4	134
	2016		1	5	13	16	15	3	10	9	4	12	10	14	112
		Average	9	9.6	12.2	12.6	11.6	8.6	11.4	11.6	9.6	11.4	9.8	12	129.4
	2012		9	14	11	15	12	8	14	10	9	12	15	16	145
	2013		15	11	12	7	15	12	8	10	15	12	9	11	137
4	2014	SVP04	14	8	14	7	5	13	9	15	8	11	14	10	128
	2015		8	3	12	7	9	13	11	8	1	7	11	9	99
	2016		10	4	7	12	11	9	13	8	9	12	11	7	113
		Average	11.2	8	11.2	9.6	10.4	11	11	10.2	8.4	10.8	12	10.6	124.4
	2012		11	7	12	9	15	2	10	11	1	9	16	12	115
	2013		1	8	5	14	15	0	11	9	20	10	8	6	107
5	2014	SVP05	16	1	9	12	14	14	10	7	13	14	3	11	124
	2015		15	2	8	19	14	10	16	8	12	15	10	7	136
	2016		19	9	11	14	16	8	10	7	11	15	12	8	140
		Average	12.4	5.4	9	13.6	14.8	6.8	11.4	8.4	11.4	12.6	9.8	8.8	124.4
	2012		11	10	14	4	6	19	10	9	13	1	8	7	112
	2013		9	10	16	19	4	18	14	12	7	11	15	18	153
6	2014	SVP06	9	6	18	3	10	12	7	8	11	10	16	4	114
	2015		14	12	1	9	8	14	6	11	4	10	6	2	97
	2016		16	8	8	4	2	17	10	7	0	11	9	11	103
		Average	11.8	9.2	11.4	7.8	6	16	9.4	9.4	7	8.6	10.8	8.4	115.8
	2012		6	2	19	12	8	11	14	10	7	14	12	9	124
	2013		10	11	3	16	12	9	18	13	8	10	12	9	131
7	2014	SVP07	16	11	17	0	1	15	18	13	12	7	17	10	137
	2015		6	11	9	16	8	14	15	11	15	14	8	10	137
	2016		9	19	13	16	14	8	14	7	11	10	15	16	152
		Average	9.4	10.8	12.2	12	8.6	11.4	15.8	10.8	10.6	11	12.8	10.8	136.2
	2012		7	8	13	10	11	12	9	14	13	10	6	7	120
	2013		10	8	12	17	16	11	14	18	10	9	14	15	154
8	2014	SVP08	6	11	10	8	14	16	19	7	14	11	5	16	137
	2015		11	13	7	14	15	16	11	14	10	17	8	16	152
	2016		12	8	13	12	6	10	11	13	9	5	10	13	122
		Average	9.2	9.6	11	12.2	12.4	13	12.8	13.2	11.2	10.4	8.6	13.4	137
	2012		9	10	8	12	13	12	11	14	15	12	16	15	147
	2013		18	17	11	15	14	12	8	10	11	9	12	7	144
9	2014	SVP09	13	11	10	12	8	11	14	15	13	9	10	13	139
	2015		14	12	10	11	15	12	8	14	10	7	9	11	133
	2016		13	8	15	12	14	10	13	8	14	12	11	7	137
		Average	13.4	11.6	10.8	12.4	12.8	11.4	10.8	12.2	12.6	9.8	11.6	10.6	140
	2012		12	14	13	10	9	18	12	13	18	11	9	16	155
	2013		6	10	5	13	13	18	13	7	15	9	11	2	122
10	2014	DIC01	10	1	18	12	11	14	2	11	2	6	18	1	106
	2015		9	18	6	9	1	17	11	5	19	15	17	12	139
	2016		11	10	3	13	14	9	12	7	15	11	8	10	123
		Average	9.6	10.6	9	11.4	9.6	15.2	10	8.6	13.8	10.4	12.6	8.2	129
	2012		0	15	18	14	12	7	0	18	18	9	8	15	134
	2013		2	11	14	11	12	7	13	12	9	10	11	10	122
11	2014	DIC02	12	14	11	8	15	18	16	17	9	11	7	16	154
	2015		14	12	10	16	15	7	11	15	19	12	11	6	148
	2016		9	16	15	12	11	10	14	4	10	11	12	12	136
		Average	7.4	13.6	13.6	12.2	13	9.8	10.8	13.2	13	10.6	9.8	11.8	138.8
	2012		8	9	15	11	14	16	12	14	9	13	16	10	147
	2013		12	13	14	12	11	9	20	22	16	18	20	16	183
12	2014	DIC03	15	9	14	12	13	17	11	8	14	14	10	6	143
	2015		11	13	16	12	11	10	13	12	8	14	13	10	143
	2016		12	15	4	14	9	13	10	11	12	8	10	7	125
		Average	11.6	11.8	12.6	12.2	11.6	13	13.2	13.4	11.8	13.4	13.8	9.8	148.2
	2012		16	9	8	11	15	12	19	8	12	14	10	13	147
	2013		18	8	7	12	15	10	9	16	15	11	18	19	158
13	2014	DIC04	10	16	22	17	15	19	16	14	12	16	17	10	184
	2015		14	16	15	12	10	13	14	9	15	12	16	11	157
	2016		14	13	15	12	16	14	12	14	15	13	11	9	158
		Average	14.4	12.4	13.4	12.8	14.2	13.6	14	12.2	13.8	13.2	14.4	12.4	160.8

Item	Year	Model	1	2	3	4	5	6	7	8	9	10	11	12	Sum
	2012		14	15	13	9	14	12	8	15	11	10	14	12	147
	2013		17	11	16	14	18	16	14	12	10	15	14	16	173
14	2014	DIC05	18	17	22	19	10	17	15	18	14	16	9	11	186
	2015		15	11	13	10	7	18	14	16	12	10	14	15	155
	2016		17	10	13	7	16	10	14	11	15	16	13	8	150
		Average	16.2	12.8	15.4	11.8	13	14.6	13	14.4	12.4	13.4	12.8	12.4	162.2
	2012		14	3	7	13	14	6	8	14	9	10	15	5	118
	2013		19	14	9	10	15	12	3	8	19	20	11	9	149
15	2014	DIC06	10	7	18	1	12	7	11	2	20	12	6	9	115
	2015		10	8	10	10	4	15	8	20	5	19	14	1	124
	2016		10	15	12	2	4	12	10	16	14	11	12	10	128
		Average	12.6	9.4	11.2	7.2	9.8	10.4	8	12	13.4	14.4	11.6	6.8	126.8
	2012		16	12	13	8	2	17	18	14	13	16	10	3	142
	2013		11	18	7	18	13	12	17	11	16	8	15	14	160
16	2014	DIC07	12	16	7	20	16	19	22	17	18	16	10	8	181
	2015		16	11	13	12	10	15	12	11	9	15	11	10	145
	2016		13	16	14	13	16	8	16	11	9	10	12	11	149
		Average	13.6	14.6	10.8	14.2	11.4	14.2	17	12.8	13	13	11.6	9.2	155.4
	2012		11	15	13	11	5	10	7	12	15	1	4	13	117
	2013		10	7	8	11	4	19	14	5	8	6	9	7	108
17	2014	DIC07	19	2	9	17	16	11	10	18	16	4	5	19	146
	2015		9	14	16	3	12	12	14	8	9	5	10	14	126
	2016		11	14	10	9	4	12	16	6	12	14	13	8	129
		Average	12	10.4	11.2	10.2	8.2	12.8	12.2	9.8	12	6	8.2	12.2	125.2

3 forecasting methods: 1) Moving Average, 2) Single Exponential Smoothing, 3) Double Exponential Smoothing were calculated with Minitab Program Version 17. 2 forecasting methods: Holt Winters and Monte Carlo Simulation methods were used solver with Microsoft Excel Program. The method of forecasting the evaluation was suitable for measuring the differences of actual data and the results were calculated with Mean Absolute Deviation (MAD). The lowest deviation is the more suitable the forecasting method. But Holt Winters method found delta parameter for 17 items or all items that is 0. So, this data can not use forecasting with Holt winter method because these items don't have seasonal data. The resulting summary of 4 forecasting methods are shown in Fig 4 and Fig. 5.

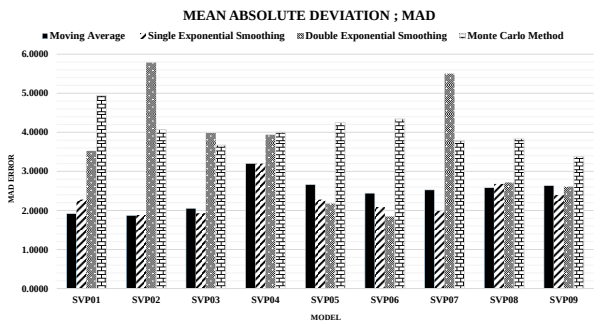


Fig. 4. The comparative results of forecasting error model SVP01 to SVP09

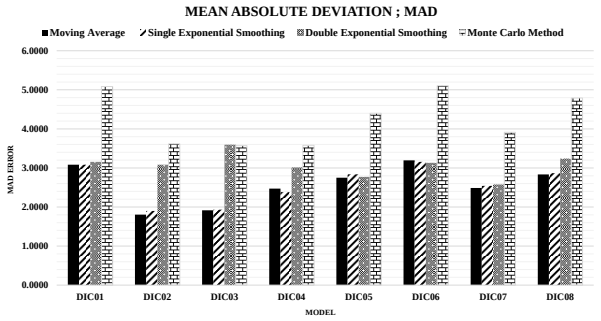


Fig. 5. The comparative results of forecasting error model DIC01 to DIC08

So The suitable forecasting method for 17 items, the Moving Average method is suitable for SVP01, SVP02, SVP08, DIC01, DIC02, DIC03, DIC05, DIC07, DIC08 while the Single Exponential Smoothing method is suitable for SVP03, SVP04, SVP07, SVP09, DIC04 and the Double Exponential Smoothing method is suitable for SVP05, SVP06 and DIC06 as shown in TABLE III.

TABLE III. THE RESULT METHOBS

Item	Model	Result Method	When n=? or alpha=?
1	SVP01	Moving Average	n = 12
2	SVP02	Moving Average	n = 12
3	SVP03	Single Exponential Smoothing	alpha = 0.01
4	SVP04	Single Exponential Smoothing	alpha = 0.08
5	SVP05	Double Exponential Smoothing	alpha = 0.49, gamma = 0.05
6	SVP06	Double Exponential Smoothing	alpha = 0.49, gamma = 0.06
7	SVP07	Single Exponential Smoothing	alpha = 0.03
8	SVP08	Moving Average	n = 12
9	SVP09	Single Exponential Smoothing	alpha = 0.27
10	DIC01	Moving Average	n = 12
11	DIC02	Moving Average	n = 12
12	DIC03	Moving Average	n = 12
13	DIC04	Single Exponential Smoothing	alpha = 0.03
14	DIC05	Moving Average	n = 12
15	DIC06	Double Exponential Smoothing	alpha = 0.58, gamma = 0.04
16	DIC07	Moving Average	n = 12
17	DIC08	Moving Average	n = 12

*** Alpha and Gamma were got from ARIMA of MINITAB 17

The forecasting method with the lowest Mean Absolute Deviation (MAD) was Moving Average. It can be concluded that this method is suitable for forecasting the suitable quantity of 17 items. In addition, the average demand of 17 items in the next 12 months was forecasted as shown in TABLE IV.

TABLE IV. THE RESULT OF FORECASTING

Product		Forecast in 2017 (pcs/month)											
Item	Model	1	2	3	4	5	6	7	8	9	10	11	12
1	SVP01	11	11	11	11	11	11	11	11	11	11	11	11
2	SVP02	11	11	11	11	11	11	11	11	11	11	11	11
3	SVP03	11	11	11	11	11	11	11	11	11	11	11	11
4	SVP04	10	10	10	10	10	10	10	10	10	10	10	10
5	SVP05	11	11	11	11	11	11	11	11	10	10	10	10
6	SVP06	10	10	10	10	10	10	11	11	11	11	11	11
7	SVP07	12	12	12	12	12	12	12	12	12	12	12	12
8	SVP08	11	11	11	11	11	11	11	11	11	11	11	11
9	SVP09	11	11	11	11	11	11	11	11	11	11	11	11
10	DIC01	11	11	11	11	11	11	11	11	11	11	11	11
11	DIC02	12	12	12	12	12	12	12	12	12	12	12	12
12	DIC03	11	11	11	11	11	11	11	11	11	11	11	11
13	DIC04	13	13	13	13	13	13	13	13	13	13	13	13
14	DIC05	13	13	13	13	13	13	13	13	13	13	13	13
15	DIC06	11	11	11	11	11	11	11	11	11	11	11	11
16	DIC07	15	15	15	15	15	15	15	15	15	15	15	15
17	DIC08	11	11	11	11	11	11	11	11	11	11	11	11

B. The current inventory orders

According to the actual orders of all items in 2017 as shown in TABLE V.

TABLE V. THE ACTUAL ORDERS OF ALL ITEMS IN 2017

Product		Acutal Demand in 2017 (pcs/month)											
Item	Model	1	2	3	4	5	6	7	8	9	10	11	12
1	SVP01	11	8	14	12	14	10	9	15	10	10	11	7
2	SVP02	9	15	12	7	10	11	9	14	8	10	12	10
3	SVP03	15	10	7	12	10	15	9	11	12	8	9	10
4	SVP04	10	15	16	8	12	10	14	11	6	11	10	0
5	SVP05	12	11	9	7	10	8	9	14	16	11	10	5
6	SVP06	5	15	10	11	9	7	12	10	9	13	10	11
7	SVP07	10	12	9	14	11	8	9	12	10	13	10	7
8	SVP08	5	14	10	14	12	11	8	15	9	8	11	6
9	SVP09	7	9	12	12	10	8	14	11	10	7	18	8
10	DIC01	0	12	8	15	10	12	11	7	13	12	9	4
11	DIC02	11	9	10	14	15	9	12	12	14	10	11	8
12	DIC03	10	15	11	9	10	11	12	10	14	11	7	5
13	DIC04	10	12	14	14	11	8	12	10	11	14	18	9
14	DIC05	7	12	10	13	15	9	12	12	10	13	11	0
15	DIC06	5	16	11	9	14	10	11	15	20	12	14	8
16	DIC07	7	14	16	10	12	12	15	10	11	16	8	14
17	DIC08	5	15	12	11	16	14	10	11	20	12	9	10

The details of cost or amount spare parts in the current as shown in TABLE VI.

Example of 2 items that is model SVP01 and model SVP02. Model SVP01, the unit cost is at 26,240 baht per unit, the ordering cost is at 9,500 baht per order, the holding cost is at 656 baht of the unit cost per month (the holding cost is at 30% of the unit cost per year in the company is calculated for the inventory price) and the average shortage costs is at 150,000 baht per time from delayed delivery, lack of confidence and other. The safety stock is 0 pc and the maximum inventory storage is 25 pieces per month.

And model SVP02, the unit cost is at 22,600 baht per unit, the ordering cost is at 9,500 baht per order, the holding cost is at 565 baht of the unit cost per month. The safety stock is 0 pc and the maximum inventory storage is 25 pieces per month.

TABLE VI. THE DETAILS OF ALL ITEMS IN THE CURRENT

Unit : Baht

Item	Model	2016					
		SS	Max	Inv Begin.	Unit Cost	Ordering Cost	Holding Cost
1	SVP01	0 pcs	25 pcs	25 pcs	26,240.00	9,500.00	656.00
2	SVP02	0 pcs	25 pcs	20 pcs	22,600.00	9,500.00	565.00
3	SVP03	0 pcs	25 pcs	22 pcs	22,360.00	9,500.00	559.00
4	SVP04	0 pcs	25 pcs	24 pcs	22,350.00	9,500.00	558.75
5	SVP05	0 pcs	25 pcs	22 pcs	21,600.00	9,500.00	540.00
6	SVP06	0 pcs	25 pcs	20 pcs	20,650.00	9,500.00	516.25
7	SVP07	0 pcs	25 pcs	22 pcs	20,395.00	9,500.00	509.88
8	SVP08	0 pcs	25 pcs	24 pcs	18,600.00	9,500.00	465.00
9	SVP09	0 pcs	25 pcs	25 pcs	18,250.00	9,500.00	456.25
10	DIC01	0 pcs	35 pcs	32 pcs	13,360.00	7,750.00	222.67
11	DIC02	0 pcs	35 pcs	30 pcs	15,815.00	7,750.00	263.58
12	DIC03	0 pcs	35 pcs	28 pcs	14,600.00	7,750.00	243.33
13	DIC04	0 pcs	35 pcs	30 pcs	15,250.00	7,750.00	254.17
14	DIC05	0 pcs	35 pcs	35 pcs	13,200.00	7,750.00	220.00
15	DIC06	0 pcs	35 pcs	25 pcs	11,750.00	7,750.00	195.83
16	DIC07	0 pcs	35 pcs	26 pcs	11,670.00	7,750.00	194.50
17	DIC08	0 pcs	35 pcs	34 pcs	10,350.00	7,750.00	172.50

*** Holding cost parameter was used this research, The cost that represents all the costs associated with the storage of the inventory unit it is sold or used that is at 30% of the unit cost per year in the company is calculated for the inventory price.

*** Shortage costs is at 150,000 baht per time from delayed delivery, lack of confidence and other.

But this research has calculate new safety stock level for 17 items when the demand is unstable but the lead time is constant at the fixed confidence level (CI=95%) of equation (15) and equation (16) as shown in Fig. 6, it was found that the new safety stock of all items. That model SVP01 is 9 pieces and model SVP02 is 8 pieces. So, The details of all items as shown in TABLE VII.

Fig. 6 New safety stock for all items

TABLE VII. THE DETAILS OF ALL ITEMS FOR NEW PURCHASING PLANNING

Unit : Baht

Item	Model	2017					
		SS	Max	Inv Begin.	Unit Cost	Ordering Cost	Holding Cost
1	SVP01	9 pcs	25 pcs	25 pcs	26,240.00	9,500.00	656.00
2	SVP02	8 pcs	25 pcs	20 pcs	22,600.00	9,500.00	565.00
3	SVP03	7 pcs	25 pcs	22 pcs	22,360.00	9,500.00	559.00
4	SVP04	6 pcs	25 pcs	24 pcs	22,350.00	9,500.00	558.75
5	SVP05	8 pcs	25 pcs	22 pcs	21,600.00	9,500.00	540.00
6	SVP06	8 pcs	25 pcs	20 pcs	20,650.00	9,500.00	516.25
7	SVP07	8 pcs	25 pcs	22 pcs	20,395.00	9,500.00	509.88
8	SVP08	6 pcs	25 pcs	24 pcs	18,600.00	9,500.00	465.00
9	SVP09	5 pcs	25 pcs	25 pcs	18,250.00	9,500.00	456.25
10	DIC01	8 pcs	35 pcs	32 pcs	13,360.00	7,750.00	222.67
11	DIC02	7 pcs	35 pcs	30 pcs	15,815.00	7,750.00	263.58
12	DIC03	6 pcs	35 pcs	28 pcs	14,600.00	7,750.00	243.33
13	DIC04	6 pcs	35 pcs	30 pcs	15,250.00	7,750.00	254.17
14	DIC05	6 pcs	35 pcs	35 pcs	13,200.00	7,750.00	220.00
15	DIC06	9 pcs	35 pcs	25 pcs	11,750.00	7,750.00	195.83
16	DIC07	7 pcs	35 pcs	26 pcs	11,670.00	7,750.00	194.50
17	DIC08	8 pcs	35 pcs	34 pcs	10,350.00	7,750.00	172.50

This research analyzes spare parts all 17 items but this paper will show the process experiment of spare parts 2 items that is model SVP01 and model SVP02. Those are samples because they were most valuable of all expired spare parts and other 15 items were experiment as same as model SVP01 and model SVP02.

The inventory purchase of model SVP01 in the current year 2017 reveals the real purchasing demand, as presented in the D_t column in TABLE VIII. The total cost of this inventory order is 3,952,112 baht: 38,000 baht of ordering cost, 3,253,760 baht of item cost, 60,352 baht of holding cost, and 600,000 baht of 4 shortage costs.

TABLE VIII. PURCHASING OF MODEL SVP01 IN THE CURRENT

Model 1	SVP01	Unit cost	26,240										
		Ordering cost	9,500										
		Holding cost	656	h	0.3								

Month	Dt	Xt	Rt	Yi	M	It	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	11	0	0	0	0	14	0	25	0	0	9,184	0	9,184
2	8	0	0	0	0	6	0	25	0	0	3,936	0	3,936
3	14	33	0	1	100000	-8	0	25	9,500	865,920	0	150,000	1,025,420
4	12	0	33	0	0	13	0	25	0	0	8,528	0	8,528
5	14	26	0	1	100000	-1	0	25	9,500	682,240	0	150,000	841,740
6	10	0	26	0	0	15	0	25	0	0	9,840	0	9,840
7	9	0	0	0	0	6	0	25	0	0	3,936	0	3,936
8	15	34	0	1	100000	-9	0	25	9,500	892,160	0	150,000	1,051,660
9	10	0	34	0	0	15	0	25	0	0	9,840	0	9,840
10	10	0	0	0	0	5	0	25	0	0	3,280	0	3,280
11	11	31	0	1	100000	-6	0	25	9,500	813,440	0	150,000	972,940
12	7	0	31	0	0	18	0	25	0	0	11,808	0	11,808
									38,000	3,253,760	60,352	600,000	3,952,112
									Grand Total				

And the inventory purchase of model SVP02 in the current year 2017 reveals the real purchasing demand, as presented in the D_t column in TABLE IX. The total cost of this inventory order is 3,444,920 baht: 38,000 baht of ordering cost, 2,757,200 baht of item cost, 49,720 baht of holding cost, and 600,000 baht of 4 shortage costs

TABLE IX. PURCHASING OF MODEL SVP02 IN THE CURRENT

Model 2	SVP02	Unit cost	22,600										
		Ordering cost	9,500										
		Holding cost	565	h	0.3								

Month	Dt	Xt	Rt	Yi	M	It	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	9	0	0	0	0	11	0	25	0	0	6,215	0	6,215
2	15	29	0	1	100000	-4	0	25	9,500	655,400	0	150,000	814,900
3	12	0	29	0	0	13	0	25	0	0	7,345	0	7,345
4	7	0	0	0	0	6	0	25	0	0	3,390	0	3,390
5	10	29	0	1	100000	-4	0	25	9,500	655,400	0	150,000	814,900
6	11	0	29	0	0	14	0	25	0	0	7,910	0	7,910
7	9	0	0	0	0	5	0	25	0	0	2,825	0	2,825
8	14	34	0	1	100000	-9	0	25	9,500	768,400	0	150,000	927,900
9	8	0	34	0	0	17	0	25	0	0	9,605	0	9,605
10	10	0	0	0	0	7	0	25	0	0	3,955	0	3,955
11	12	30	0	1	100000	-5	0	25	9,500	678,000	0	150,000	837,500
12	10	0	30	0	0	15	0	25	0	0	8,475	0	8,475
									38,000	2,757,200	49,720	600,000	3,444,920
									Grand Total				

C. *Inventory purchase planning*

1) Inventory purchase planning with a mathematical model where the new safety stock = 9 (SS = 9) and the forecasting demand of spare parts in 2017 for model SVP01.

According to TABLE X, the beginning inventory is 25 pieces (I_0) whereas the inventory demand in the first month (D_1) is 11 pieces. As a result from the mathematical model, the inventory purchasing is 17 pieces ($X_1 = 17$) and $Y_1 = 1$ is the purchasing demand. Therefore, the inventory in the first month ($I_1 = I_0 + R_1 - D_1$) is 14 pieces, the ordering cost is $S \times Y_1 = 9,500 \times 1 = 9,500$ baht, the item cost is $U \times X_1 = 26,240 \times 17 = 446,080$ baht, and the holding cost is $H \times I_1 = 656 \times 14 = 9,184$ baht.

The inventory demand in the second month (D_2) is 11 pieces. As a result from the mathematical model, the inventory purchasing is 0 piece ($X_2 = 0$), $Y_2 = 0$ which means no order, and the inventory transferred from the previous order in the first month (R_2) is 17 pieces. Therefore, the inventory ($I_2 = I_1 + R_2 - D_2$) in the second month is 20 pieces. The second month inventory is more than the safety stock (*SS*), leading to no order in this month. The ordering cost is $S \times Y_2 = 9,500 \times 0 = 0$ baht, the item cost is $U \times X_2 = 26,240 \times 0 = 0$ baht, and the holding cost is $H \times I_2 = 656 \times 20 = 13,120$ baht.

As a result from the model in 2017; the ordering cost is 57,000 baht, the item cost is 3,043,840 baht, the holding cost is 110,208 baht, and the shortage cost is 0 baht. The total cost is 3,211,048 baht.

TABLE X. PURCHASING PLANNING WITH A MATHEMATICAL MODEL WHERE SAFETY STOCK = 9 *(SS=9)*

Model 1	SVP01	Unit cost	26,240										
		Ordering cost	9,500										
		Holding cost	656	h	0.3								

Month	Dt	Xt	Rt	Yi	M	It	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	11	17	0	1	100000	14	9	25	9,500	446,080	9,184	0	464,764
2	11	0	17	0	0	20	9	25	0	0	13,120	0	13,120
3	11	22	0	1	100000	9	9	25	9,500	577,280	5,904	0	592,684
4	11	0	22	0	0	20	9	25	0	0	13,120	0	13,120
5	11	22	0	1	100000	9	9	25	9,500	577,280	5,904	0	592,684
6	11	0	22	0	0	20	9	25	0	0	13,120	0	13,120
7	11	22	0	1	100000	9	9	25	9,500	577,280	5,904	0	592,684
8	11	0	22	0	0	20	9	25	0	0	13,120	0	13,120
9	11	22	0	1	100000	9	9	25	9,500	577,280	5,904	0	592,684
10	11	0	22	0	0	20	9	25	0	0	13,120	0	13,120
11	11	11	0	1	100000	9	9	25	9,500	288,640	5,904	0	304,044
12	11	0	11	0	0	9	9	25	0	0	5,904	0	5,904
									57,000	3,043,840	110,208	0	3,211,048
									Grand Total				

The decision variables (X_t, Y_t), resulting from the mathematical model in TABLE IX, were applied with the 2017 inventory demand as presented in D_t column TABLE XI. The decision variables were simulated in real situations, with the recalculation of new safety stock (SS) at 9 pieces. When the real inventory demand is higher than the estimated forecasting demand, the inventory has reduced shortage costs, leading to the total cost of the inventory at 3,197,928 baht. As a result, it reduces the current total cost to 19.08%.

TABLE XI. SIMULATION OF USING DECISION VARIABLES IN REAL SIMULATION *(SS=9)*

Model 1	SVP01	Unit cost	26,240										
		Ordering cost	9,500										
		Holding cost	656	h	0.3								

Month	Dt	Xt	Rt	Yi	M	It	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	11	17	0	1	100000	14	9	25	9,500	446,080	9,184	0	464,764
2	8	0	17	0	0	23	9	25	0	0	15,088	0	15,088
3	14	22	0	1	100000	9	9	25	9,500	577,280	5,904	0	592,684
4	12	0	22	0	0	19	9	25	0	0	12,464	0	12,464
5	14	22	0	1	100000	5	9	25	9,500	577,280	3,280	0	590,060
6	10	0	22	0	0	17	9	25	0	0	11,152	0	11,152
7	9	22	0	1	100000	8	9	25	9,500	577,280	5,248	0	592,028
8	15	0	22	0	0	15	9	25	0	0	9,840	0	9,840
9	10	22	0	1	100000	5	9	25	9,500	577,280	3,280	0	590,060
10	10	0	22	0	0	17	9	25	0	0	11,152	0	11,152
11	11	11	0	1	100000	6	9	25	9,500	288,640	3,936	0	302,076
12	7	0	11	0	0	10	9	25	0	0	6,560	0	6,560
									57,000	3,043,840	97,088	0	3,197,928
									Grand Total				

The summary of the comparative results from SVP01 purchasing planning is illustrated in TABLE XII.

TABLE XII. RESULTS OF THE PURCHASING PLANNING WITH THE MATHEMATICAL MODEL FOR MODEL SVP01

Unit : Baht

Model : SVP01	Current Order (SS = 0)	New Purchasing (SS = 9)
Ordering Cost	38,000	57,000
Item Cost	3,253,760	3,043,840
Holding Cost	60,352	97,088
Shortage Cost	600,000	0
Total	**3,952,112**	**3,197,928**

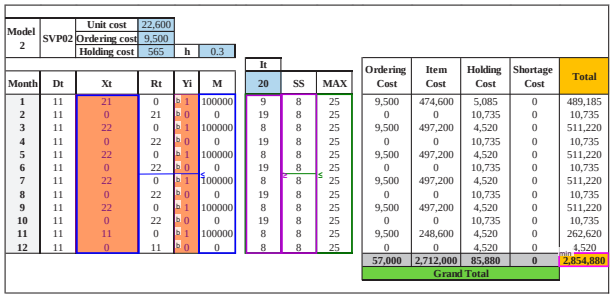
2) Inventory purchase planning with a mathematical model where the new safety stock = 8 (SS = 8) and the forecasting demand of spare parts in 2017 for model SVP02.

According to TABLE XIII, the beginning inventory is 20 pieces (I_0) whereas the inventory demand in the first month (D_1) is 11 pieces. As a result from the mathematical model, the inventory purchasing is 21 pieces ($X_1 = 21$) and $Y_1 = 1$ is the purchasing demand. Therefore, the inventory in the first month ($I_1 = I_0 + R_1 - D_1$) is 9 pieces, the ordering cost is $S \times Y_1 = 9,500 \times 1 = 9,500$ baht, the item cost is $U \times X_1 = 26,240 \times 21 = 474,600$ baht, and the holding cost is $H \times I_1 = 565 \times 9 = 5,085$ baht.

The inventory demand in the second month (D_2) is 11 pieces. As a result from the mathematical model, the inventory purchasing is 0 piece ($X_2 = 0$), $Y_2 = 0$ which means no order, and the inventory transferred from the previous order in the first month (R_2) is 21 pieces. Therefore, the inventory ($I_2 = I_1 + R_2 - D_2$) in the second month is 19 pieces. The second month inventory is more than the safety stock (*SS*), leading to no order in this month. The ordering cost is $S \times Y_2 = 9,500 \times 0 = 0$ baht, the item cost is $U \times X_2 = 26,240 \times 0 = 0$ baht, and the holding cost is $H \times I_2 = 565 \times 19 = 10,735$ baht.

As a result from the model in 2017; the ordering cost is 57,000 baht, the item cost is 2,712,000 baht, the holding cost is 85,880 baht, and the shortage cost is 0 baht. The total cost is 2,854,880 baht.

TABLE XIII. PURCHASING PLANNING WITH A MATHEMATICAL MODEL WHERE SAFETY STOCK = 8 *(SS=8)*

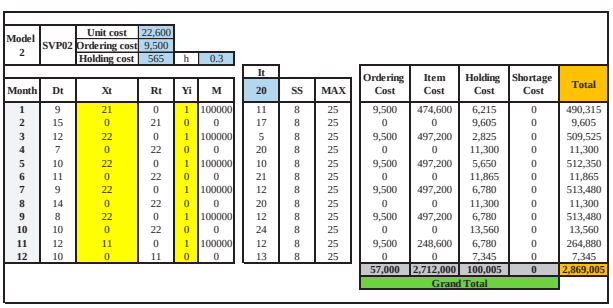


Model 2	SVP02	Unit cost	22,600		
		Ordering cost	9,500		
		Holding cost	565	h	0.3

Month	Dt	Xt	Rt	Yi	M	It 20	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	11	21	0	1	100000	9	8	25	9,500	474,600	5,085	0	489,185
2	11	0	21	0	0	19	8	25	0	0	10,735	0	10,735
3	11	22	0	1	100000	8	8	25	9,500	497,200	4,520	0	511,220
4	11	0	22	0	0	19	8	25	0	0	10,735	0	10,735
5	11	22	0	1	100000	8	8	25	9,500	497,200	4,520	0	511,220
6	11	0	22	0	0	19	8	25	0	0	10,735	0	10,735
7	11	22	0	1	100000	8	8	25	9,500	497,200	4,520	0	511,220
8	11	0	22	0	0	19	8	25	0	0	10,735	0	10,735
9	11	22	0	1	100000	8	8	25	9,500	497,200	4,520	0	511,220
10	11	0	22	0	0	19	8	25	0	0	10,735	0	10,735
11	11	11	0	1	100000	8	8	25	9,500	248,600	4,520	0	262,620
12	11	0	11	0	0	8	8	25	0	0	4,520	0	4,520
									57,000	2,712,000	85,880	0	2,854,880
									Grand Total				

The decision variables (X_t, Y_t), resulting from the mathematical model in TABLE XIV, were applied with the 2017 inventory demand as presented in D_t column TABLE XIV. The decision variables were simulated in real situations, with the recalculation of new safety stock (SS) at 8 pieces. When the real inventory demand is higher than the estimated forecasting demand, the inventory has reduced shortage costs, leading to the total cost of the inventory at 2,869,005 baht. As a result, it reduces the current total cost to 16.72%.

TABLE XIV. SIMULATION OF USING DECISION VARIABLES IN REAL SIMULATION *(SS=8)*



Model 2	SVP02	Unit cost	22,600		
		Ordering cost	9,500		
		Holding cost	565	h	0.3

Month	Dt	Xt	Rt	Yi	M	It 20	SS	MAX	Ordering Cost	Item Cost	Holding Cost	Shortage Cost	Total
1	9	21	0	1	100000	11	8	25	9,500	474,600	6,215	0	490,315
2	15	0	21	0	0	17	8	25	0	0	9,605	0	9,605
3	12	22	0	1	100000	5	8	25	9,500	497,200	2,825	0	509,525
4	7	0	22	0	0	20	8	25	0	0	11,300	0	11,300
5	10	22	0	1	100000	10	8	25	9,500	497,200	5,650	0	512,350
6	11	0	22	0	0	21	8	25	0	0	11,865	0	11,865
7	9	22	0	1	100000	12	8	25	9,500	497,200	6,780	0	513,480
8	14	0	22	0	0	20	8	25	0	0	11,300	0	11,300
9	8	22	0	1	100000	12	8	25	9,500	497,200	6,780	0	513,480
10	10	0	22	0	0	24	8	25	0	0	13,560	0	13,560
11	12	11	0	1	100000	12	8	25	9,500	248,600	6,780	0	264,880
12	10	0	11	0	0	13	8	25	0	0	7,345	0	7,345
									57,000	2,712,000	100,005	0	2,869,005
									Grand Total				

The summary of the comparative results from SVP01 purchasing planning is illustrated in TABLE XV.

TABLE XV. RESULTS OF THE PURCHASING PLANNING WITH THE MATHEMATICAL MODEL FOR MODEL SVP02

Unit : Baht

Model : SVP02	Present	Purchasing Planning (SS=8)
Ordering Cost	38,000	57,000
Item Cost	2,757,200	2,712,000
Holding Cost	49,720	100,005
Shortage Cost	600,000	0
Total	**3,444,920**	**2,869,005**

And other 15 items were experiment as same as model SVP01 and SVP02. So, those were shown in TABLE XVI.

TABLE XVI. RESULTS OF THE CURRENT ORDER WITH THE NEW PURCHASING PLANNING FOR ALL ITEMS

Unit : Baht

		Current Order		New Purchasing	
Item	Model	SS	Total Cost	New SS	Total Cost
1	SVP01	0 pc	3,952,112.00	9 pcs	3,197,928.00
2	SVP02	0 pc	3,444,920.00	8 pcs	2,869,005.00
3	SVP03	0 pc	3,385,485.00	7 pcs	2,750,821.00
4	SVP04	0 pc	3,460,805.00	6 pcs	3,110,726.00
5	SVP05	0 pc	3,064,760.00	8 pcs	2,720,280.00
6	SVP06	0 pc	3,293,590.00	8 pcs	2,367,219.00
7	SVP07	0 pc	3,277,623.00	8 pcs	2,841,937.00
8	SVP08	0 pc	2,878,370.00	6 pcs	2,516,850.00
9	SVP09	0 pc	2,970,350.00	5 pcs	2,188,144.00
10	DIC01	0 pc	2,053,515.00	8 pcs	1,548,251.00
11	DIC02	0 pc	2,421,658.00	7 pcs	2,012,198.00
12	DIC03	0 pc	2,391,203.00	6 pcs	1,783,943.00
13	DIC04	0 pc	2,623,614.00	6 pcs	2,323,988.00
14	DIC05	0 pc	2,143,490.00	6 pcs	1,785,770.00
15	DIC06	0 pc	2,059,108.00	9 pcs	1,730,621.00
16	DIC07	0 pc	2,041,309.00	7 pcs	1,688,918.00
17	DIC08	0 pc	1,812,023.00	8 pcs	1,453,113.00

TABLE XVII. RESULTS OF THE PURCHASING PLANNING WITH THE MATHEMATICAL MODEL FOR ALL ITEMS

Unit : Baht

		Current Order		New Purchasing		Result	
Item	Model	SS	Total Cost	New SS	Total Cost	Reduce Cost	% Reduce
1	SVP01	0 pc	3,952,112.00	9 pcs	3,197,928.00	754,184.00	19.08
2	SVP02	0 pc	3,444,920.00	8 pcs	2,869,005.00	575,915.00	16.72
3	SVP03	0 pc	3,385,485.00	7 pcs	2,750,821.00	634,664.00	18.75
4	SVP04	0 pc	3,460,805.00	6 pcs	3,110,726.00	350,079.00	10.12
5	SVP05	0 pc	3,064,760.00	8 pcs	2,720,280.00	344,480.00	11.24
6	SVP06	0 pc	3,293,590.00	8 pcs	2,367,219.00	926,371.00	28.13
7	SVP07	0 pc	3,277,623.00	8 pcs	2,841,937.00	435,686.00	13.29
8	SVP08	0 pc	2,878,370.00	6 pcs	2,516,850.00	361,520.00	12.56
9	SVP09	0 pc	2,970,350.00	5 pcs	2,188,144.00	782,206.00	26.33
10	DIC01	0 pc	2,053,515.00	8 pcs	1,548,251.00	505,264.00	24.60
11	DIC02	0 pc	2,421,658.00	7 pcs	2,012,198.00	409,460.00	16.91
12	DIC03	0 pc	2,391,203.00	6 pcs	1,783,943.00	607,260.00	25.40
13	DIC04	0 pc	2,623,614.00	6 pcs	2,323,988.00	299,626.00	11.42
14	DIC05	0 pc	2,143,490.00	6 pcs	1,785,770.00	357,720.00	16.69
15	DIC06	0 pc	2,059,108.00	9 pcs	1,730,621.00	328,487.00	15.95
16	DIC07	0 pc	2,041,309.00	7 pcs	1,688,918.00	352,391.00	17.26
17	DIC08	0 pc	1,812,023.00	8 pcs	1,453,113.00	358,910.00	19.81

V. CONCLUSION

The purposes of this research are to improve the inventory quantity to be suitable for customers' demand, to reduce holding cost and to minimize the total inventory cost from Demand Forecasting Methods with the lowest Mean Absolute Deviation (MAD), new safety stock at 95% confident level and new purchasing planning for Shelf Life-Limited Instrument Equipment Spare Parts those were applied a mathematical model for purchasing planning spare parts to minimize the total inventory cost

According to the findings from the current study, the results of forecasting were shown in TABLE III (page 5). After new safety stocks and those were used in the new purchasing planning by solver the problem with mathematical model. That can reduce the total inventory cost.

Therefore, the results of the ordering of 17 items were compared with the comparison of the current order and the new purchasing planning as shown in TABLE XVII. It is contain with Ordering Costs, Costs, and Shortage Costs, as well as item costs, Moreover, it can minimize the total inventory cost from the current purchases by 17.55%

Consequently, this research can minimize the total inventory costs. If your company want to reduce costs or your company needs to manage costs, you can use this method to analyze and manage your costs.

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