FORECASTING TECHNIQUES FOR A NEEDLE MANUFACTURER

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ABSTRACT

Currently, one of the most significant activities in supply chain management is inventory management, so various theories and concepts have been illustrated on how to get a well-managed inventory. The purpose of this research is to optimize the inventory level and suggest procurement planning to know the demand forecast and a proper replenishment quantity of consumable stock, ABC Analysis model based on dollar value has been applied to prioritize significance of the stock for the company to pay attention to. Forecasting techniques use historical data of actual consumption to average demand. Moving Average Forecasting (MVA) and Single Exponential Smoothing forecasts (SES) help to predict demand in the next period. Forecast error measurement such as Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE) could support to find which of the forecast techniques is more accurate. Reorder Point (ROP) and Safety Stock (SS) can be recommended to compute an optimum stock during replenishment cycle to maintain customer service level. These methods can save over 2 million baht of inventory cost.

Keywords: *Forecasting technique, reorder point, safety stock, customer service level*

บทคัดย่อ

งานวิจัยนี้เป็นกรณีศึกษาของโรงงานผลิตเข็ม มีวัตถุประสงค์เพื่อแก้ปัญหาเกี่ยวกับการวางแผนการสั่งซื้อเพื่อเติมสต๊อกวัสดุสิ้นเปลืองที่ใช้สำหรับการผลิต โดยการใช้ทฤษฎีการวิเคราะห์จัดกลุ่มด้วยระบบ ABC การพยากรณ์ความต้องการของสินค้า การหาจุดสั่งซื้อซ้ำและสินค้าคงคลังขั้นต่ำเป็นเครื่องมือในงานวิจัยนี้ เพื่อพัฒนากระบวนการเติมเต็มสินค้าคงคลัง โดยการวิเคราะห์ทางตัวเลขและคำนวณจากฐานข้อมูลเก่าของบริษัท สรุปข้อสังเกตจากการวิเคราะห์และคำนวณหาจุดสั่งซื้อซ้ำที่ปริมาณสินค้า คงคลังขั้นต่ำที่เหมาะสมว่าแตกต่างจะปริมาณสินค้าคงคลังขั้นต่ำที่บริษัทกำหนดไว้อย่างไร โดยพิจารณาร่วมกับตัวชี้วัดระดับความพึงพอใจของลูกค้าตามนโยบายของบริษัท จากนั้นเลือกวิธีการพยากรณ์ที่แม่นยำ ง่ายและเหมาะสมที่สุดกับบริษัท เพื่อพัฒนาปรับใช้กับการพยากรณ์และการหาจุดสั่งซื้อซ้ำที่ปริมาณสินค้าคงคลังขั้นต่ำอื่น ๆ ซึ่งบริษัทได้รับประโยชน์จากงานวิจัยนี้ในการลดปริมาณสินค้าคงคลังขั้นต่ำ ทำให้ลดต้นทุนการถือสินค้าคงคลังได้มากกว่า 2 ล้านบาท

คำสำคัญ: เทคนิคการพยากรณ์ จุดสั่งซื้อซ้ำ สินค้าคงคลังขั้นต่ำ ระดับความพึงพอใจของลูกค้า

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INTRODUCTION

Needle Manu is a needle manufacturing company, which its parent company was established in Europe. The company's inventories are separated into two main kinds. One is the main raw material stainless steel and semi-final needles in the stock called RM stock and the other is called consumable stock which is subdivided into three categories as Main consumable stock which use directly affects the needle, Other consumable stock for indirect supply products, and Spare part consumable stock.

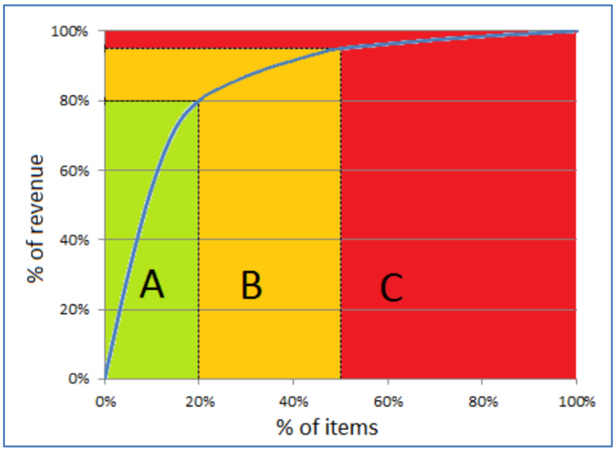
This research aims to manage and improve efficiency of replenishment process of procurement planning from the identified problems about inefficient procurement planning from lack of inventory management, and lack of forecast technique to predict future demand forecast. Inappropriate inventory caused the company to carry high stock cost due to overstock. Needle Manu has been concerned with customer service level equal to 95%, so the shortage stock is unacceptable. How can Needle Manu improve its procurement planning performance for replenishment process and control optimum inventory level? It was the question that the researcher needed to find the correct answer.

REVIEW OF RELATED LITERATURE

ABC Analysis

Applying ABC analysis to inventory optimization, a significant aim of supply chain analysis is achieved. It is widely applied in order to prioritize and determine an essential inventory category according to the Pareto principle also known as the rule of 80:20, as about 20% of elements contribute 80% of the costs (Stojanović & Regodić, 2017) (Figure 1). It can be applied to find the important service level for each item determination of each class assigned to its own service level as top 20% is class A for critical with high service level = 96-98%, next 20-30% is class B for interclass with medium service level = 91-95% and last 50-60% is class C for trivial- many with lower service level = 85-90% (Radasanu, 2016).

Figure 1: The Sample of ABC Analysis Curve



Source: Stojanović & Regodić (2017)

Moving Average Forecasting (MVA)

One of the simple forecasting technique methods is Moving average forecasting model for "n" period, usually applies for forecasting the next period's demand by computing the simple average of the "n" previous periods and "n" remains constant (Souza, Wanke, & Correa, 2019). Singh et al. (2015) also mentioned that Moving average forecasting method is a simple forecasting method, which is concerned with the calculation of the average of observations from historical data and then using those averages to predict the next demand. The average highly relies on the number of elements selected (n), as the formula below:

$$F_{t+1} = \frac{(Y_t + Y_{t-1} + Y_{t-2} + \ldots\ldots + Y_{t-n+1})}{n}$$

Where:
F_{t+1} = the forecast value for the next period,
Y_t= the actual value at period t,
n = the number of term in the moving average.

Simple (Single) Exponential Smoothing Method (SES)

The simplest type of exponential smoothing is simple exponential smoothing or single exponential smoothing (SES). This forecast method weighs the observed time series unequally. Heavier weight is given to recent observations than the remote observations. It is appropriate that a random moving of data is above and below a constant mean. The movement of the data has no trend and no seasonal patterns (Ostertagova & Ostertag, 2012).

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

Where:
F_{t+1} = the new smoothing value or the forecast value for the next period,
α= the smoothing constant ($0 < \alpha < 1$),
Y_t= the new observation or actual value of the series in period t,
F_t= the old smoothed value or forecast for period t.

Mean Absolute Deviation (MAD)

Sahu and Kumar (2014) stated that the MAD is a common measurement method, which can be applied for overall forecast error. Heizer and Rendor (2001) also said that this equation is calculated by dividing the sum of values of the single forecast error by the number of forecast elements as the formulation below:

$$\text{MAD} = \sum_{t=1}^{n} \left(\frac{Yt - Ft}{n} \right)$$

Mean Absolute Percentage Error (MAPE)

The mean absolute percentage error (MAPE) is a simple scale-free metric most widely used to compare error in business forecasting since it is very easy to interpret. Its scale is independent since it has been divided by the actual value. Sometimes it can be a bit misleading of making you understand that it always stays between 0 and 100%, but it can be above 100% (Mello, 2020). It is computed by the average of forecast error divided by the number of forecast elements (Callegaro, 2010).

$$\text{MAPE} = \sum_{t=1}^{n} \left(\frac{((Yt - Ft) \div Yt).\,100}{n} \right)$$

Reorder Point (ROP)

Reorder point (ROP) can help the company reduce risk as it will get to know the best point to repeat order for replenishment and a proper buffer stock to prevent uncertainty demand (Jiraruttrakul, 2016). In deciding the reorder point, there are three factors that need to be provided demand of inventory used daily, lead time between an order is placed until its receipt, and safety stock for buffering unexpected demand (Gonzalez & González, 2010).

The demand and the lead time are variable:

$$ROP = \bar{d}L + Z(\sqrt{L\sigma^2_d + \bar{d}^2\sigma^2_L})$$

When a safety stock is maintained:

$$ROP = \bar{d}L + SS$$

Where:

$\bar{d}$ = Average daily demand

σ_d = Standard deviation of daily demand

L = Lead time in days

Z = Service level

SS = Safety Stock

Safety Stock (SS)

Safety stocks have to be used in order to maintain delivery performance. However, they relate to the company’s capital. Inventory control has an efficient relation between customer’s service level and amount of capital in safety stocks. Simple safety stocks are calculated by average demand per day and safety time margin during replenishment (Jonsson & Mattsson, 2019). The inherent differentiation of the safety stock calculated from a demand fill-rate service level is as below:

$$SS = k \cdot \sigma \cdot \sqrt{Lt},$$

Where:

SS = safety stock

k = safety factor (service level)

Lt = lead time in days

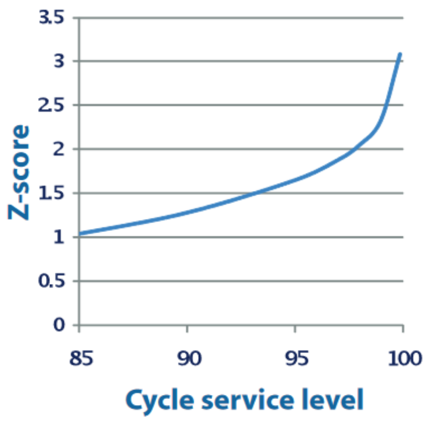
σ = standard deviation for the demand per day

Service Level (Z-score)

Lowson (2002) highlighted that the significance of safety stock can be maintained by the customer service level. The cost of poor service is also necessary to be determined in terms of impact on the cost of poor service level as well, a common demand forecasting is that forecasts will consistently contain a degree of error. The scale of this error will determine the nature of the tradeoff between customer service level and safety stock (Catt, Barbour, & Robb, 2008). Figure 2 presents the service level percentage converted to a service factor (Z-score). Higher service level requires higher service factor and higher safety stock. For example, if the company desires a service level of 95 percent and the inventory reaches reorder point during lead time, the expected customer’s fulfilment is 95% and stock running out which is not greater than 5% of order during the lead time that the company could expect. However, safety stock will be balanced on the conflicting goals of optimization inventory level and maximization of customer service level (King, 2011).

Figure 2: Service Level (Z-score)

Desired cycle service level	Z-score
84	1
85	1.04
90	1.28
95	1.65
97	1.88
98	2.05
99	2.33
99.9	3.09



Source: King (2011)

RESEARCH METHODOLOGY

ABC Analysis

To classify and determine an essential item which can generate a large number of inventory cost and find the most attended category for other proposed model in the next step by using the following steps:

1) Sorted the list of inventory item according to the value of annual consumption in descending order
2) Calculated the percentage of each item per total annual consumption value, then calculated the accumulated percentage
3) Segregated the inventory into three classes following the criteria below and determined each item into categories A, B and C respectively
4) Generated ABC analysis chart by giving the cumulative percentage in the vertical axis and the annual consumption in the vertical axis

Figure 3: ABC Analysis Chart of Actual Demand 2019

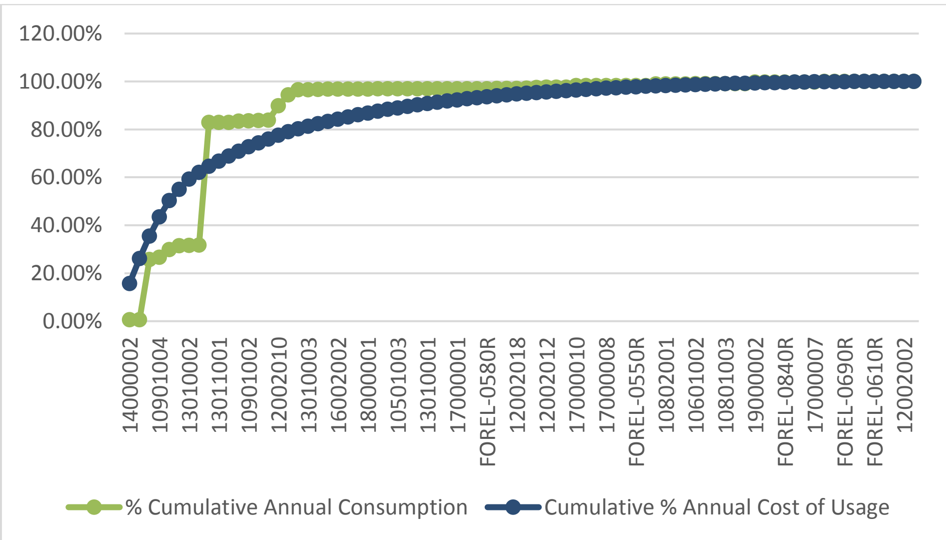


Table 1: Number of ABC Analysis of Main Consumable Stock

Class	ABC Analysis (Items)	% of Item
Class A	17	21%
Class B	23	29%
Class C	40	50%
Total	**80**	**100%**

In ranking the results of the ABC analysis to conduct key item of main consumable stock of Needle Manu, the researcher determined the stock in three classes. The classes were Class A with 17 items, Class B with 23 items, and Class C with 40 items. Therefore, the first priority of main consumable stock which Needle Manu had to pay attention to was the 17 items in Class A. However, the second priority was the 23 items in Class B had to be focused as well because they were also the cause of high usage cost. The researcher decided to implement forecasting methods and evaluate performance by using forecast error measurement.

The accuracy of forecasting methods between the Moving average forecasting (MVA) and Single exponential smoothing forecast was compared, the result of forecast error measurement showed that MAD and MAPE of the moving average forecasting was equal to 32.83 and 25% respectively. Both results were lower than the results of single exponential smoothing forecast which were 67.19 (MAD) and 26.7% (MAPE). It means that MVA is more accurate by comparing the result of forecast error measurement. Moreover, MVA is a simple forecasting method that could be applied to Needle Manu easier than Single Exponential Smoothing.

Table 2: The Result of MAD and MAPE

Forecast method	Forecast error measurement method	
	MAD	MAPE
Moving average	32.83	25.0%
Single exponential smoothing	67.19	26.7%

To determine the optimum stock which the Needle Manu should hold during replacement cycle, this research also implemented reorder point. The reorder point is concerned with safety stock in order to find the point that procurement planning should reorder for stock fulfilment by complying with the proper stock level to avoid customer dissatisfaction from stock out while the company does not lose its working capital to carry high inventory, the researcher calculated safety stock based on the company's policy that needs to control optimum inventory level with high service level at 95%. As figure 2 examined the service level which classified as 95% service level or Z score of 1.65. Table 3 shows the estimated inventory cost reduction of 2,382,957 baht from the reorder point calculation.

Table 3: Total Stock Cost Comparison between Optimum Stock and Existing Minimum Stock

						Forecasting methods Jan-May 2020		Reorder point (ROP) and Safety Stock (SS)				Estimate demand during lead time	Comparing ROP with Existing Min.stock			Total stock cost comparison	
No.	**ABC Analysis**	**Item Code**	**Annual consumption 2019**	**Actual consumption Jan-May 2020**	**Lead time**	**Moving Avg. (MAV)**	**Single Exponential smooting α = 0.5**	**Z = 1.65 (95%)**	**SS**	**ROP = $\bar{d}L + Z(\sigma d\sqrt{L})$**	**Optimum stock ROP + SS**	**Demand FC (MAV*LT)**	**Existing Min.Stoc k**	**ROP cover Demand FC**	**Difference Min.stock vs. ROP+SS**	**Unit cost (THB)**	**Reduce inventory cost (THB)**
1	A	14000002	2,850	425	60	83	94	1.65	19	251	271	167	1,200	Cover	929	410	492,000
2	A	16000001	164	153	120	38	20	1.65	31	198	230	151	78	Cover	(152)	4,750	370,500
3	A	17000004	120,380	41,860	30	9,187	9,792	1.65	852	12,269	13,121	9,187	20,800	Cover	7,679	6	120,224
4	A	10901004	4,025	1,225	21	233	218	1.65	33	267	300	163	350	Cover	50	147	51,300
5	A	12002013	15,803	4,700	90	1,017	1,024	1.65	85	3,930	4,015	3,050	4,000	Cover	(15)	32	128,040
6	A	12002017	7,470	3,050	120	633	609	1.65	68	3,395	3,462	2,533	1,400	Cover	(2,062)	48	66,500
7	A	13010002	310	103	7	20	20	1.65	1	7	8	5	30	Cover	22	998	29,941
8	A	10801004	1,040	208	75	69	65	1.65	60	202	263	173	208	Cover	(55)	210	43,680
9	A	17000002	244,800	83,200	30	18,133	19,250	1.65	1,714	24,405	26,119	18,133	44,800	Cover	18,681	1	33,600
10	A	13011001	32	16	7	5	5	1.65	1	2	2	1	5	Cover	3	5,011	25,053
11	A	16001001	332	136	21	29	29	1.65	2	27	29	21	64	Cover	35	468	29,920
12	A	14002001	2,508	1,254	15	279	217	1.65	79	250	329	139	418	Cover	89	62	25,800
13	A	10901002	725	225	120	58	48	1.65	30	276	306	233	450	Cover	144	182	81,870
14	A	19000001	246	83	60	18	18	1.65	2	47	49	36	140	Cover	91	495	69,300
15	A	12002020	850	100	7	17	34	1.65	5	12	17	4	100	Cover	83	143	14,258
16	A	12002010	29,000	8,750	14	1,917	1,960	1.65	86	1,200	1,285	894	2,250	Cover	965	4	9,000
17	A	16001002	21,500	7,500	7	1,667	1,822	1.65	99	576	676	389	2,000	Cover	1,324	5	10,184
18	B	17000011	10,300	3,500	30	733	792	1.65	65	1,019	1,084	733	4,000	Cover	2,916	9	36,280
19	B	13010003	65	18	7	4	4	1.65	0	1	2	1	30	Cover	28	1,222	36,662
20	B	FOREL-0400R	246	231	120	50	54	1.65	15	267	281	201	300	Cover	19	311	93,412

Table 3: Total Stock Cost Comparison between Optimum Stock and Existing Minimum Stock (Continued)

						Forecasting methods Jan-May 2020		Reorder point (ROP) and Safety Stock (SS)				Estimate demand during lead time	Comparing ROP with Existing Min.stock			Total stock cost comparison	
No.	ABC Analysis	Item Code	Annual consumption 2019	Actual consumption Jan-May 2020	Lead time	Moving Avg. (MAV)	Single Exponential smooting $\alpha = 0.5$	Z = 1.65 (95%)	SS	ROP = $\bar{d}L + Z(\sigma d\sqrt{L})$	Optimum stock ROP + SS	Demand FC (MAV*LT)	Existing Min.Stoc k	ROP cover Demand FC	Difference Min.stock vs. ROP+SS	Unit cost (THB)	Reduce inventory cost (THB)
21	B	14002002	600	400	15	67	69	1.65	32	86	118	33	200	Cover	82	123	24,500
22	B	16002002	388	128	21	25	26	1.65	1	25	26	18	32	Cover	6	188	6,000
23	B	10501002	2	-	7	-	0	1.65	-	-	-	-	2	Not enough	2	33,489	66,978
24	B	11502004	35	3	14	1	1	1.65	0	1	1	0	6	Cover	5	1,800	10,800
25	B	18000001	165	59	30	12	13	1.65	1	17	19	12	30	Cover	11	351	10,523
26	B	17000003	116	40	14	9	9	1.65	1	6	6	4	24	Cover	18	490	11,760
27	B	12001001	8	2	60	1	1	1.65	0	1	2	1	3	Cover	1	6,728	20,184
28	B	10501003	2	-	7	-	0	1.65	-	-	-	-	1	Not enough	1	24,119	24,119
29	B	11502001	80	-	7	-	1	1.65	-	-	-	-	60	Not enough	60	588	35,257
30	B	12002003	39	-	30	-	0	1.65	-	-	-	-	8	Not enough	8	1,200	9,600
31	B	13010001	50	14	7	3	4	1.65	0	1	1	1	10	Cover	9	845	8,453
32	B	13011003	12	4	7	1	1	1.65	0	0	0	0	5	Cover	5	3,225	16,125
33	B	FORCT-BIG34	37	105	120	25	20	1.65	7	122	129	100	200	Cover	71	1,030	206,000
34	B	17000001	142	44	14	10	11	1.65	1	6	7	5	12	Cover	5	250	3,000
35	B	FOREL-0440R	74	74	120	16	17	1.65	6	86	92	65	150	Cover	58	439	65,843
36	B	FOREL-0500R	41	30	7	6	7	1.65	1	2	3	1	20	Cover	17	789	15,785
37	B	FOREL-0580R	41	31	7	8	8	1.65	1	3	5	2	20	Cover	15	789	15,785
38	B	12002019	320	50	7	17	12	1.65	3	6	9	4	100	Cover	91	98	9,811
39	B	10501001	2	3	7	1	1	1.65	0	0	0	0	3	Cover	3	15,159	45,478
40	B	12002018	200	-	60	-	4	1.65	-	-	-	-	80	Not enough	80	118	9,434
													Total Inventory Cost Reduction				**2,382,957**

FINDINGS AND CONCLUSIONS

Based on the results of this research, after implementing ABC analysis to main consumable stock, the 17 items are classified as Class A, 23 items as Class B, and 40 items as Class C. The total amount is 7,438,986 baht, and of which, 5,875,996 baht or 79% is for items in Class A, while the rest of the annual cost of 1,562,990 baht or 21% is Class B and Class C. After that, the researcher has applied two forecasting methods and selected the moving average forecasting method, which is the most accurate from lowest MAD and MAPE results. The company has to review and set up new minimum stock level at the optimum quantity, which is recommended by using reorder point and safety stock calculation. After comparing the reorder point including the safety stock and the existing minimum stock, the simulation of the reorder point plus safety stock can cover demand forecast during replacement cycle lead time can save inventory cost 2,382,957 baht. For future research, the factors that affect forecasting performance and inventory should be considered for calculation, especially demand and lead time which can be variant or constant during the replenishment cycle. Therefore, the next research is for anyone who is interested in this subject to explore more other variables and conditions affecting the performance of the inventory management.

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