Production Planning and Inventory Control Using Artificial Neural Network Forecasting for Furniture Industry 4.0 Custom Production

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Abstract

The raw materials are stored in PT. Skala Maxima Griya Workshop 1 warehouse is too much. Therefore, it's essential to recalculate raw material requirements using PPIC methods so that raw materials don't accumulate and become damaged in the warehouse. This research requires demand data from January 2017 to 2019 and other supporting data to perform forecasting methods for SMA, DMA, WMA, SES, DES, Cyclic, Linear, Quadratic, Decomposition, and ANN, then continued with the aggregate Shift, overtime, and mix. Rough Cut Capacity Planning CPOF, BOLA, and RPA, safety stock material requirement planning EOQ, POQ, LFL, LUC, AWW, and Silver Meal, ending with capacity requirement planning. The best forecasting calculations are using ANN, aggregate planning in the form of a mixed shift. An Overtime alternative scheduling with a total of Rp 1,297,061,500 with an average capacity of 9,655 minutes, an average RCCP capacity of 251,030 minutes. No shortage of resources in material requirement planning using the Silver Meal method of Rp 17,484,000 for ten materials during the period 2020. There CRP capacity is smaller than RCCP, which is 226,555 minutes, but still meets production needs. The savings for PT. Skala Maxima Griya is 68%.

Keywords
Aggregate, ANN, CRP, RCCP, Silver Meal

1. Introduction
This increasingly tight business competition makes industries more careful in making decisions. One of the decisions that must be taken appropriately is the supply of raw materials. The supply of raw materials must be fast and precise to support the smooth production process. The Inventory Control section plays an essential role in determining the quantity and time of ordering raw materials. **(Hoswari, Gozali, Marie, & Sukania, 2020)** Determining the quantity and time of order will not interfere with the smooth production and minimize the total inventory cost
Until now, PT. Skala Maxima Griya has not paid attention to PPIC science and uses production planning software and raw material control to carry out production activities and purchase raw materials. Because of this problem then some raw materials pile up and be damaged in the warehouse. Therefore this research was conducted to help the head of the warehouse and the purchasing department solve this problem.

1.1 Objectives
The objectives to be achieved in this research are troubleshooting raw material overstock at PT. Sakala Maxima Griya Workshop 1, determine the appropriate forecasting method, determine the production capacity at PT. Skala Maxima Griya Workshop 1, and determine the appropriate method of planning raw materials at PT. Skala Maxima Griya Workshop 1.

2. Literature Review (12 font)

Data processing is a step taken to solve problems in research. The steps are:

a. Forecasting product demand

Forecasting is an objective calculation and using past data to determine something in the future (Samuel, Lefta, Indahsari, & Gozali, 2020)

(1) SMA (Single Moving Average)

$$Ft + m = \frac{\sum_{i=1}^{t-N+1} Xi}{N} \quad (1)$$

Information:

Xi : observation data for period t
N : serial length of time
Ft + m : is the forecast value for the period t + m

(2) DMA (Double Moving Average)

$$F_{t+m} = a_t + b_m \quad (2)$$

$$a_t = S'_t + (S'_t - S''_t) \quad (3)$$

$$b_t = \frac{2}{N-1}(S'_t - S''_t) \quad (4)$$

Information:

Ft + m : forecast data for m The period ahead
S't : Value of smoothing single exponential
S" t : Smoothing value double exponential
M : The number of periods ahead the foreseen

(3) WMA (Weighted Moving Average)

$$F_{t+1} = \frac{W_t.X_t + W_{t-1}.X_{t-1} + \ldots + W_{t-N+1}.X_{t-N+1}}{W_t + W_{t-1} + \ldots + W_{t-N+1}} \quad (5)$$

Information:

Wt : weight for period t

(4) SES (Single Exponential Smoothing)

$$F_{t+1} = a \,.\, x_t + (1-a) \quad (6)$$

Information:

A : Smoothing constant
Xt : Actual data for period T
Ft : Forecasting in Period T
Ft + 1 : Forecasting in the period T + 1

(5) DES (Double Exponential Smoothing)

$$F_{t+m} = a_t + b_t \,.\, m \quad (7)$$

$$S'_t = \alpha \,.\, x_t + (1-\alpha) \,.\, S'_{t-1} \quad (8)$$

$$S''_t = \alpha \,.\, x_t + (1-\alpha) \,.\, S''_{t-1} \quad (9)$$

$$a_t = 2 \,.\, S'_t - S''_t \quad (10)$$

$$b_t = [\alpha(S'_t - S''_t)]/(1-\alpha) \quad (11)$$

Information:

Ft + m : forecast data for m The period ahead
S't : Value of smoothing single exponential
S ”t : Smoothing value double exponential
M : The number of periods ahead the foreseen

(6) Linear Regression

$$Y = a + bx \quad (12)$$

In here a is called the intercept and b is the direction coefficient or beta coefficient.

(7) Quadratic Regression

$$Y = a + bt + ct^2 \quad \text{.....(13)}$$

(8) Cyclic

$$Y = a + b \sin[(2\pi t)/n] + c \cos[(2\pi t)/n] \quad \text{.....(14)}$$

(9) Decomposition

The decomposition method assumes that the existing data is a combination of several components, which is illustrated as follows (Makridakis, Spyros, Wheelwright, & McGee, 1999).

Data = Pattern + *error*

$$Y\_x = f(T\_x, S\_x, C\_x, I\_x) \quad \text{.....(15)}$$

(10) ANN

An artificial neural network is an information processing system with similar characteristics to biological neural networks (siang, 2005) (Wijaya, 2020).

b. Comparing some of the forecasting techniques used based on the value of the smallest Mean Square Error (MSE), the smallest Mean Absolute Deviation (MAD) (Gasperz & Vincent, 2004) MAPE (Mean Absolute Percent Error). In testing forecasting, the equation is as follows:

(1) *Mean Square Error* (MSE)

$$MSE = \sum_{I=1}^{N} \frac{(XI-FI)^2}{N} \quad \text{.....(16)}$$

(2) *Mean Absolute Deviation* (MAD)

$$MAD = \sum_{I=1}^{N} \frac{|XI-FI|}{N} \quad \text{.....(17)}$$

(3) *Standard Deviation of Error* (SDE)

$$SDE = \sum_{I=1}^{N} \frac{(XI-FI)^2}{N-1} \quad \text{.....(18)}$$

(4) *Mean Absolute Percent Error* (MAPE)

$$MAPE = \frac{100 \sum_{1=1}^{N} \frac{|XI-FI|}{XI}}{N} \quad \text{.....(19)}$$

(5) *Mean Percent Error* (MPE)

$$MPE = \frac{100 \sum_{I=1}^{N} \frac{(XI-FI)}{XI}}{N} \quad \text{.....(20)}$$

c. Aggregate Planning

Aggregate planning is a method used in production planning to adjust production capabilities in the face of uncertain and timeless consumer demand by optimizing available resources (equipment and labor) to reduce the company's operational costs. In aggregate planning, facilities are considered fixed and cannot be expanded. (Lefta, Gozali, & Marie, 2020) (Gozali, et al.).

d. Master Production Schedule

According to Sirait et al. (Sirait, Sinulingga, & Ishak, 2013) Master Production Schedule is a detailed plan of what and how many companies plan to produce each final product in each period for the next few months.

e. Rough Cut Capacity Planning

RCCP uses the definition of unit product loads, which are known product-load profiles, bills of capacity, bills of resources, or bill of labor. Suppose the RCCP process indicates that the MPS is feasible. In that case, the MPS will be forwarded to the MRP process to determine raw materials or materials, components, and subassemblies, which are four steps needed to carry out RCCP, namely:

(1) Obtain information about the production plan from MPS.
(2) Obtain information about product structure and lead times.
(3) Determine the bill of resources.
(4) Calculate specific resource requirements and generate RCCP reports.

f. Calculating Safety Stock

Safety Stock is calculated to anticipate probabilistic demand.

$$\textit{Safety stock} = Z \times \sqrt{(PC/T)} \times \Sigma d \quad \text{.....(21)}$$

Information:

Z : safety factor
PC : performance cycle
Σd : standard deviation of demand
Q : cycle of demand period

g. Creating Material Requirements Planning (MRP)

MRP is a concept in production management that discusses the proper way of planning goods' needs in the production process. (Gasperz V. , 2005)(Gozali, 2020)(Christifan,2020)

(1) EOQ

A method based on the ideal number of ordering units with the formula:

$$EOQ = \sqrt{\frac{2DS}{H}} \quad (22)$$

Information:
D : Request
S : Ordering Fee
H : Storage Costs

(2) POQ

This method is similar to EOQ but has a modification so it is used for discrete period requests.

$$\mathrm{EOI} = \frac{\mathrm{EOQ}}{\mathrm{R}} \quad (23)$$

Information:
R : Demand/month

(3) LFL

The lot for lot (LFL) method or the minimal inventory method is based on providing inventory (producing) by what is needed at that time. So the costs that arise are only in the form of ordering costs.

(4) LUC

A method that is considers as a cost of the inventory per unit.

$$L) = \frac{s+(h\sum_{t=T}^{L}[(t-dT)dt]}{J} \quad (24)$$

Information:
S : labor costs
H : saving costs
Dt : needs in period t
Q : the initial period in which cumulative lots are calculated
L : cumulative lots per period

(5) Silver Meal

This method is based on the period of cost. Determination of the average cost per period is the number of periods when the addition of orders increases.

$$\frac{\mathrm{TRC(T)}}{\mathrm{T}} = \frac{\mathrm{C+Ph}\sum(\mathrm{K}-1)Rk}{\mathrm{T}} \quad (25)$$

Information:
C : booking fee per period
H : percentage of cost per period
P : purchase cost per unit
Ph : Save cost per period
Q : is the total relevant costs in period T
Rk : is the average demand in period k

(6) AWW

This technique uses an optimization procedure based on a dynamic program model. The aim is to get the optimal ordering strategy for the entire clean needs schedule by minimizing the total cost of procurement and storage costs. The possible technique test to meet each period's needs on the planning horizon always provides optimal answers. (Gozali, andres, & Handika, 2013).

3. Methods

The research methodology can be seen in Figure 1. The steps taken in conducting this research are

A. Study of literature

Some of the literature studied is about forecasting, safety stock, lot sizing EOQ, and scheduling.

B. Field Study

The field study conducted was an observation regarding the company's inventory system, starting from forecasting, determining safety stock, and calculating the lot-sizing technique.

C. Identification of problems

After analyzing the purchasing, warehouse, and production departments by directly observing inventory management problems, the process continues with smoothing production and maintaining the quality of the raw materials used to produce products.

D. Formulation of the problem

In the formulation of the problem, the researcher must formulate what problems will be studied to facilitate the research process.

E. Goal Setting

Determination of objectives is intended so that researchers can focus on the problem to be studied. Research can be carried out systematically and not deviating from the problem to be studied. Also, the research objectives are intended to measure the success of the research.

F. Data collection

Data collection is carried out to collect data needed in research either directly, through interviews, or data available at the research site.

G. Data Processing

Data processing is a step taken to solve problems in research. The techniques used in carrying out data processing can be seen in the literature study section above.

H. Calculating the total inventory cost

The total inventory cost is calculated based on the order cost and storage cost, which is carried out by the calculation results using the selected lot-sizing technique.

I. Analysis

An analysis of the results of data processing is carried out at this stage, then provide appropriate recommendations for problems previously encountered. In this study, a comparative analysis was carried out between the MRP system using the lot sizing EOQ technique and the company's system.

J. Conclusion Stage

At this stage, conclusions are drawn from the research that has been carried out and suggestions for further research related to this research.

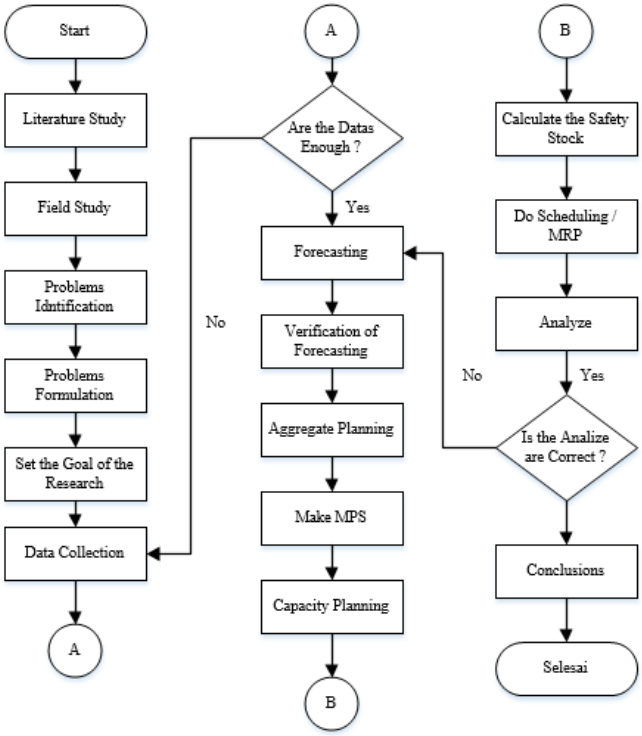

Figure 1. Flowchart of Research Methodology

4. Data Collection

The data needed for this research, such as:

A. Production cycle time
B. Product demand data
C. Product lead time data
D. Data on raw material prices
E. Bill of Material (BOM)

Not all raw materials are stocked; only the certain and fast raw materials are stocked. The reason for providing this raw material is that the company is engaged in furniture production where each consumer has different specifications for each item ordered. Materials that are often used in making TV cabinets can be seen in Figure 2 in the form of a BOM Tree.

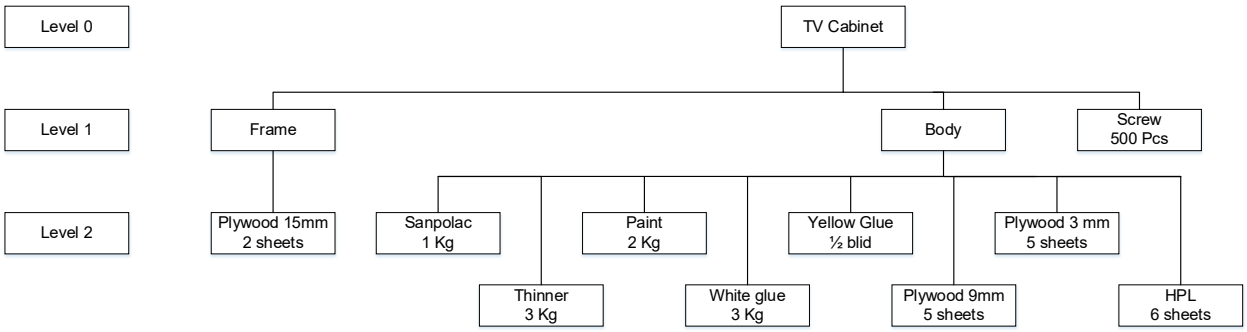

Figure 2. Bill of Material

5. Results and Discussion

5.1 Numerical Results

A. Forecasting

The data used in forecasting is the demand of TV Cabinet products for the last 3 years. The more data used in forecasting, the more accurate the forecasting results will be. This forecast is calculated using three sets of product demand data, namely data for 2017, 2018 and 2019. Forecasting results can be seen in table 1.

Table 1. Error Results

Method	MAD	MSE	SDE	MAPE	MAP
SMA 3	0.79	0.97	1.00	30.56	5.81
SMA 4	0.56	0.56	0.76	24.22	13.28
SMA 5	0.68	0.94	0.98	24.19	1.61
SMA 6	0.53	0.67	0.83	21.39	8.61
SMA 7	0.59	0.72	0.87	22.70	4.89
SMA 8	0.71	0.86	0.94	28.87	10.42
DMA 3	1.01	1.42	1.21	43.22	27.39
DMA 4	0.91	1.15	1.09	38.52	22.68
DMA 5	0.79	0.89	0.96	32.95	15.84
DMA 6	0.66	0.66	0.83	27.00	11.67
DMA 7	0.65	0.57	0.77	26.83	13.78
DMA 8	0.87	1.00	1.02	35.98	6.28
WMA 3	0.70	0.82	0.92	27.78	8.59
WMA 4	0.78	0.97	1.00	29.95	4.43

Continued in Table 1. Error Results

Method	MAD	MSE	SDE	MAPE	MAP
WMA 5	0.77	0.97	1.00	29.30	2.96
WMA 6	0.73	0.87	0.95	28.61	4.72
WMA 7	0.69	0.83	0.93	26.72	4.31
SES 0,1	1.40	2.43	1.58	65.00	63.57
SES 0,2	1.40	2.43	1.58	65.00	63.57
SES 0,3	1.40	2.43	1.58	65.00	63.57
SES 0,4	1.40	2.43	1.58	65.00	63.57
SES 0,5	0.86	1.03	1.03	39.05	33.33
SES 0,6	0.86	1.03	1.03	39.05	33.33
SES 0,7	0.86	1.03	1.03	39.05	33.33
SES 0,8	0.86	1.03	1.03	39.05	33.33
SES 0,9	0.86	1.03	1.03	39.05	33.33
DES 0,1	0.74	0.74	0.87	33.82	27.94
DES 0,2	0.74	0.74	0.87	33.82	27.94
DES 0,3	0.74	0.74	0.87	33.82	27.94
DES 0,4	0.74	0.74	0.87	33.82	27.94
DES 0,5	1.47	2.59	1.63	58.33	27.94
DES 0,6	0.56	0.68	0.83	20.59	1.96
DES 0,7	0.56	0.68	0.83	20.59	1.96
DES 0,8	0.62	0.79	0.90	23.04	4.41
DES 0,9	0.62	0.79	0.90	23.04	4.41
Cyclic	0.69	0.69	0.85	31.94	26.39
Linear Regression	0.61	0.46	0.69	23.90	6.37
Quadratic Regression	0.74	0.74	0.87	33.82	27.94
Decomposition	0.13	0.06	0.21	5.27	0.70
ANN	0.04421687	0.022145	0.155430	1.379343	1.273037

The table above shows that the ANN method error value is better than other methods. The smallest error value is found in the ANN method, so this method was chosen to forecast product demand. The smaller the error value makes the forecasting results able to describe the actual conditions more actually The forecasting demand for TV Cabinet products in 2020 and used as MPS can be seen in table 2.

Table 2. Forecasting Results

Month	1	2	3	4	5	6
Unit	2	2	3	2	4	4
Month	7	8	9	10	11	12
Unit	2	2	4	2	4	4

B. Aggregate Planning

This planning functions to regulate the amount of production required by looking at the smallest expenditure of production costs to be incurred. The production costs are in the form of inventory costs, salaries, and overtime pay. The aggregate planning method is compared into three types, namely Shift, overtime, and mixed Shift

overtime. After calculating with existing data, the selected one with the smallest cost is a mixture of Shift and overtime. The following are the results of the mixed aggregate can be seen in table 3.

Table 3. Results of Aggregate Planning Mixed Method

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	0.02	20	2	165	2	3	1	0	0	3	6	Rp -	Rp 108,000,000	Rp 32,500	Rp 108,032,500
2	0.02	19	5	158	2	3	2	0	0	3	3	Rp -	Rp 108,000,000	Rp 61,500	Rp 108,061,500
3	0.02	21	4	167	3	3	3	0	0	5	3	Rp -	Rp 108,000,000	Rp 70,000	Rp 108,070,000
4	0.02	21	4	167	4	3	2	0	0	5	3	Rp -	Rp 108,000,000	Rp 53,500	Rp 108,053,500
5	0.02	12	5	109	4	2	0	0	0	4	2	Rp -	Rp 108,000,000	Rp 8,000	Rp 108,008,000
6	0.02	21	4	167	2	3	2	0	0	2	3	Rp -	Rp 108,000,000	Rp 41,500	Rp 108,041,500
7	0.02	22	4	174	2	3	3	0	0	4	3	Rp -	Rp 108,000,000	Rp 78,500	Rp 108,078,500
8	0.02	18	5	151	2	3	4	0	0	5	3	Rp -	Rp 108,000,000	Rp 104,000	Rp 108,104,000
9	0.02	22	4	174	2	3	6	0	0	5	3	Rp -	Rp 108,000,000	Rp 141,000	Rp 108,141,000
10	0.02	20	5	165	2	3	7	0	0	6	3	Rp -	Rp 108,000,000	Rp 173,500	Rp 108,173,500
11	0.02	21	4	167	4	3	6	0	0	6	3	Rp -	Rp 108,000,000	Rp 157,000	Rp 108,157,000
12	0.02	21	4	167	4	3	6	0	0	5	3	Rp -	Rp 108,000,000	Rp 140,500	Rp 108,140,500
JUMLAH												Rp -	Rp 1,296,000,000	Rp 1,321,500	Rp 1,297,061,500

Information:
A: Month
B: Average Production/hour
C: Number of Production Days (Monday-Friday)
D: Number of Production Days (Saturday)
E: Total Production Hours
F: Demand Forecasting (Unit)
G: Regular Production Time (Unit)
H: Initial Inventory
I: Overtime time
A: Overtime Production (Unit)
K: Final Inventory
L: Production RT + OT (Unit)
M: Overtime Fee
N: Employee Salary
O: Inventory Costs
P: Total Cost

C. Rough Cut Capacity Planning

The results of the calculation of rough capacity requirements can be seen in Table 4.

Table 4. Results of Calculation of Gross Capacity Needs for the Future Period in Units of Minutes

Machine	*Historical Proportion*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jigsaw	0.192982456	346.5	346.5	231	346.5	346.5	577.5	231	231	346.5	346.5	346.5	462
Sanding	0.210526316	378	378	252	378	378	630	252	252	378	378	378	504
Cutter	0.070175439	126	126	84	126	126	210	84	84	126	126	126	168
Compressor	0.105263158	189	189	126	189	189	315	126	126	189	189	189	252
Air Brush	0.105263158	189	189	126	189	189	315	126	126	189	189	189	252
Brush	0.157894737	283.5	283.5	189	283.5	283.5	472.5	189	189	283.5	283.5	283.5	378
Drill	0.157894737	283.5	283.5	189	283.5	283.5	472.5	189	189	283.5	283.5	283.5	378
Total Capacity Req	1	1795.5	1795.5	1197	1795.5	1795.5	2992.5	1197	1197	1795.5	1795.5	1795.5	2394

After knowing the sufficient time available for each machine, each machine's working time is calculated based on the total number of production and available time. The following is the machine working time capacity can be seen in table 4.

Table 5. Machine Uptime Capacity Available for Future Period in Minutes

Machine	Qty. of Machine	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
Jigsaw	6	108000	56880	60120	60120	39240	60120	62640	54360	62640	59400	60120	60120
Sanding	3	54000	28440	30060	30060	19620	30060	31320	27180	31320	29700	30060	30060
Cutter	4	72000	37920	40080	40080	26160	40080	41760	36240	41760	39600	40080	40080
Compressor	2	36000	18960	20040	20040	13080	20040	20880	18120	20880	19800	20040	20040
Air Brush	2	36000	18960	20040	20040	13080	20040	20880	18120	20880	19800	20040	20040
Brush	4	72000	37920	40080	40080	26160	40080	41760	36240	41760	39600	40080	40080
Drill	5	378000	199080	210420	210420	137340	210420	219240	190260	219240	207900	210420	210420
Total Capacity Req.	26	756000	398160	420840	420840	274680	420840	438480	380520	438480	415800	420840	420840

From the RCCP calculation above, it can be seen that PT. Skala Maxima Griya Workshop 1 can meet consumer demand with the resources it has.

D. Master Production Schedule

At this stage, a monthly raw material request will be made. The demand for raw materials can be obtained by multiplying the forecast results with the Bill of Materials requirements. Demand for raw materials can be seen in table 6.

Table 6. TV Cabinet Production Raw Material Requirements in 2020

A	Raw Material of Cabinet TV									
	B	C	D	E	F	G	H	I	J	K
1	4	10	10	12	6	15	2	4	6	1000
2	4	10	10	12	6	15	2	4	6	1000
3	6	15	15	18	9	22.5	3	6	9	1500
4	4	10	10	12	6	15	2	4	6	1000
5	8	20	20	24	12	30	4	8	12	2000
6	8	20	20	24	12	30	4	8	12	2000
7	4	10	10	12	6	15	2	4	6	1000
8	4	10	10	12	6	15	2	4	6	1000
9	6	15	15	18	9	22.5	3	6	9	1500
10	4	10	10	12	6	15	2	4	6	1000
11	8	20	20	24	12	30	4	8	12	2000
12	8	20	20	24	12	30	4	8	12	2000
L	68	170	170	204	102	255	34	68	102	17000

Information:
A : Raw Material
B : Plywood 15 mm/sheet
C : Plywood 9 mm/sheet
D : Plywood 3 mm/sheet
E : HPL / Sheet
F : White Glue/kg
G : Yellow Glue/kg
H : San Polac/kg
I : Paint/kg
J : Thinner/kg
K : Screw 4 cm/pcs
L : Total

E. Safety Stock

In table 7, the results of the calculation of safety stock for each raw material will be displayed.

Table 7. Safety Stock Calculation

A	B	C	D	E	F	G
1	1.28	1	0.03	5.5	2	1

Continued in Table 7. Safety Stock Calculation

A	B	C	D	E	F	G
1	1.28	1	0.03	5.67	2	1
2		1	0.03	14.17	5	2
3		1	0.03	14.17	5	2
4		1	0.03	17	5.62	2
5		1	0.03	8.5	2.81	1
6		1	0.03	21.25	7.03	2
7		1	0.03	2.83	0.94	1
8		1	0.03	5.67	1.87	1
9		1	0.03	8.5	2.81	1
10		1	0.03	1416.67	468.72	1000

Information:
A: Raw Material
B: Safety Factor (90%)
C: Lead Time/day
D: Lead Time/month
E: Average Demand
F: Standard Deviation of Request
G: Safety Stock
1: Plywood 15 mm/sheet
2: Plywood 9 mm/sheet
3: Plywood 3 mm/sheet
4: HPL / Sheet
5: White Glue/kg
6: Yellow Glue/kg
7: San Polac/kg
8: Paint/kg
9: Thinner/kg
10: Screws 4cm/pcs

Table 7 above shows the results of the calculation of safety stock for each raw material. The calculation value shows good results where the majority of the value, if rounded up, is 1. This calculation makes the company not need to spend too much money on preparing safety stock.

F. Capacity Requirement Planning

CRP pays more attention to detail, namely, engine efficiency, utilization, and leeway. The following is a table of requirements, and time availability can be seen in table 8.

Table 8. Time Needs and Availability in Minutes

Work Center		Jan	Feb	Mar	Apr	May	Jun
Jigsaw	Needs	251	251	366.5	482	482	251
	Availability	53608.5	51334.2	54258.3	54258.3	35414.1	54258.3
Sanding	Needs	253	253	379	505	505	253
	Availability	26804.25	25667.1	27129.15	27129.15	17707.05	27129.15
Cutter	Needs	84	84	126	168	168	84
	Availability	35739	34222.8	36172.2	36172.2	23609.4	36172.2
Compressor	Needs	131	131	194	257	257	131
	Availability	17869.5	17111.4	18086.1	18086.1	11804.7	18086.1
Paint	Needs	126	126	189	252	252	126
	Availability	17869.5	17111.4	18086.1	18086.1	11804.7	18086.1
Drill	Needs	199	189	283.5	378	378	189
	Availability	44673.75	42778.5	45215.25	45215.25	29511.75	45215.25

Continued in Table 8. Time Needs and Availability in Minutes

Work Center		Jul	Aug	Sep	Oct	Nov	Dec
Jigsaw	Needs	251	251	251	251	482	482
	Availability	56532.6	49059.9	56532.6	53608.5	54258.3	54258.3
Sanding	Needs	253	253	253	253	505	505
	Availability	28266.3	24529.95	28266.3	26804.25	27129.15	27129.15
Cutter	Needs	84	84	84	84	168	168
	Availability	37688.4	32706.6	37688.4	35739	36172.2	36172.2
Compressor	Needs	131	131	131	131	257	257
	Availability	18844.2	16353.3	18844.2	17869.5	18086.1	18086.1
Paint	Needs	126	126	126	126	252	252
	Availability	18844.2	16353.3	18844.2	17869.5	18086.1	18086.1
Drill	Needs	189	189	189	189	378	378
	Availability	47110.5	40883.25	47110.5	44673.75	45215.25	45215.25

The table above shows that the capacity/availability is greater than the need. This calculation shows that PT. Skala Maxima Griya Workshop 1 can meet the demand in 2020 with the resources it has.

5.2 Proposed Improvements

A. Material Requirement Planning

The following result is the summary of the costs needed to be incurred from each method for each type of item can be seen in Table 9.

Table 9. Comparison of Total Costs

Raw Material	Raw Material Procurement Costs for PT. Skala Maxima Griya in 2019	Raw Material Procurement with Lot Sizing EOQ	Raw Material Procurement with Lot Sizing POQ	Raw Material Procurement with Lot Sizing LFL	Raw Material Procurement with Lot Sizing Silver Meal	Raw Material Procurement with Lot Sizing LUC	Raw Material Procurement with Lot Sizing AWW
Plywood 15 mm	Rp 7,580,000.00	Rp 4,630,000.00	Rp 4,510,000.00	Rp 4,320,000.00	Rp 2,280,000.00	Rp 3,040,000.00	Rp 2,830,000.00
Plywood 9 mm	Rp 6,820,000.00	Rp 6,230,000.00	Rp 5,540,000.00	Rp 2,940,000.00	Rp 2,540,000.00	Rp 2,770,000.00	Rp 2,990,000.00
Plywood 3 mm	Rp 4,985,000.00	Rp 3,860,000.00	Rp 2,995,000.00	Rp 1,260,000.00	Rp 1,260,000.00	Rp 1,260,000.00	Rp 1,260,000.00
HPL	Rp 9,580,000.00	Rp 10,650,000.00	Rp 4,440,000.00	Rp 3,480,000.00	Rp 3,160,000.00	Rp 3,480,000.00	Rp 3,620,000.00
White Glue	Rp 4,429,000.00	Rp 3,785,000.00	Rp 2,798,000.00	Rp 2,256,000.00	Rp 1,472,000.00	Rp 1,855,000.00	Rp 2,034,000.00
Yellow Glue	Rp 13,504,000.00	Rp 9,939,000.00	Rp 7,657,000.00	Rp 6,672,000.00	Rp 4,121,000.00	Rp 5,222,000.00	Rp 5,668,000.00
Screws	Rp 977,000.00	Rp 498,000.00	Rp 343,000.00	Rp 980,000.00	Rp 140,000.00	Rp 266,000.00	Rp 535,500.00
San Polac	Rp 1,112,000.00	Rp 1,215,000.00	Rp 543,000.00	Rp 1,059,000.00	Rp 483,000.00	Rp 604,000.00	Rp 826,000.00
Paint	Rp 1,404,000.00	Rp 1,286,000.00	Rp 902,000.00	Rp 840,000.00	Rp 508,000.00	Rp 680,000.00	Rp 749,000.00
Thinner	Rp 4,280,000.00	Rp 3,254,000.00	Rp 2,726,000.00	Rp 3,096,000.00	Rp 1,520,000.00	Rp 2,062,000.00	Rp 2,080,000.00
Total Cost	Rp 54,671,000.00	Rp 45,347,000.00	Rp 32,454,000.00	Rp 26,903,000.00	Rp 17,484,000.00	Rp 21,239,000.00	Rp 22,592,500.00

The comparison table shows a significant difference in the total cost of supplying raw materials. The silver meal method can provide the smallest raw material cost. The savings for this company occur for 68%.

B. Software

Created software that aims to assist the purchasing and warehouse in planning raw material requirements. Software created using the C # programming language. This software contains all calculation phases, but only uses the selected method for each step. Because forecasting uses the ANN method which requires the help of Matlab software, this program is created and designed to be connected with the Matlab software version R2017B. The software can be seen in Figure 3.

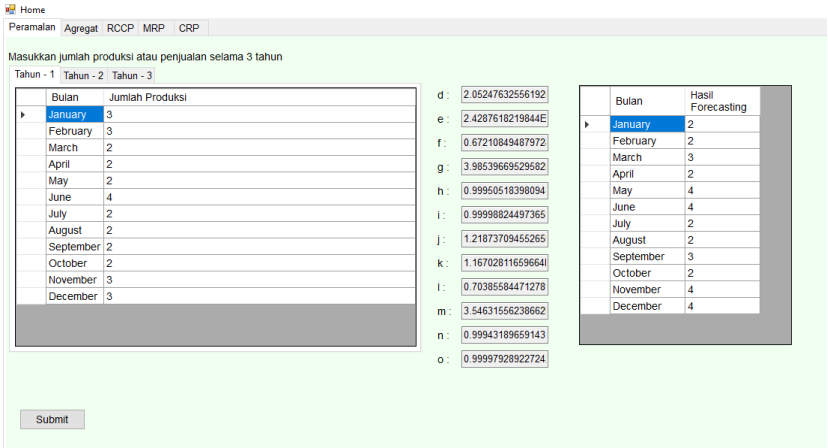

Figure 3. Software

6. Conclusion

The forecasting has been done using many methods carried out on ten types of products at PT. Skala Maxima Griya Workshop 1. The ANN method is the most appropriate because it has the smallest error value than other methods. The selected aggregate planning is a mixture of Shift and overtime because the costs incurred are the smallest compared to the aggregate Shift and overtime. The total cost incurred was Rp 1,405,321,500.00. The results of the calculation of the RCCP capacity with the CRP are different. The average monthly capacity of the RCCP method is 251.030 minutes, while the CRP calculation results show a smaller average capacity of 226.555 minutes.

In contrast, the RCCP method does not take these two things into account. However, there is a difference in the average capacity of the two methods, PT. Skala Maxima Griya is still able to produce the demand for TV cabinets with its resources.

After calculating material requirements planning calculated using the MRP method with lot sizing LFL, EOQ, POQ, LUC, AWW, and Silver Meal for ten types of raw materials, the silver meal method was the most suitable to be used because it produced the cheapest total cost of Rp. 17,068,500.00. The savings for this improvement for PT. Skala Maxima Griya Workshop was 74% of the total cost in 2019. Based on the analysis that has been carried out, the cause of excessive raw materials is due to the absence of experts who know and master PPIC knowledge at PT. Skala Maxima Griya. The absence of the expert cause purchases problems with raw materials.

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Biography

Andre Jonathan Christifan is a final year student at Universitas Tarumanagara, Jakarta. He is active in various campus activities and has won the favorite industrial engineering research category at the XVIII Student Scientific Work Competition organized by the Faculty of Engineering, Universitas Tarumanagara. The research he did when he was undergoing an internship at PT. Skala Maxima Griya as an inventory analyzer.

Lina Gozali is a lecturer in the Industrial Engineering Department at Universitas Tarumangara since 2006 and a free-lance lecturer at Universitas Trisakti since 1995. She got her Bachelor's degree at Trisakti University, Jakarta - Indonesia, then she graduated Master's Degree at STIE IBII, Jakarta – Indonesia, and graduated with her Ph.D. at Universiti Teknologi Malaysia, Kuala Lumpur – Malaysia in 2018. Her apprentice college experience was in paper at Kertas Bekasi Teguh, shoe at PT Jaya Harapan Barutama, automotive chain drive industry at Federal Superior Chain Manufacturing. She teaches Production System and Supply Chain Management Subjects and her Ph.D. research about Indonesian Business Incubator. She actively writes for almost 40 publications since 2008 in the Industrial Engineering research sector, such as Production Scheduling, Plant Lay Out, Maintenance, Line Balancing, Supply Chain Management, Production Planning, and Inventory Control. She had been worked at PT. Astra Otoparts Tbk as International.

Lamto Widodo is a lecturer at Tarumanagara University Jakarta since 1994, joining the Mechanical Engineering Department.; he is involved as a team for the Industrial Engineering Department opening in 2004-2005. He was starting in 2005 as a lecturer in the Industrial Engineering Department. Obtained a Bachelor's degree at the Sepuluh Nopember Institute of Technology Surabaya (ITS), then completed a Master's degree at the University of Indonesia (UI) and graduated with the title Dr. at the Bogor Agricultural Institute (IPB). He is engaged in research and publication in Product Design and Ergonomics, Production Systems, and Engineering Economics and teaches at many universities in Jakarta. He has published nearly 30 publications in the field of Industrial Engineering research both nationally and internationally. Active in various professional organizations, especially in the field of Ergonomics (IEA), and active in the organization of the Indonesian Industrial Engineering Higher Education Cooperation Agency (BKSTI).

Frans Jusuf Daywin was born in Makasar, Indonesia on 24th November 1942. is a lecturer in the Department of Agricultural Engineering at Faculty of Agricultural Technology Bogor Agricultural University since 1964 conducted teaching, research, and extension work in the field of farm power and machinery and become a professor in Internal Combustion Engine and Farm Power directing and supervising undergraduate and graduate students thesis and dissertation and retired as a professor in 2007. In 1994 up to present as a professor in Internal Combustion Engine and Farm Power at Mechanical Engineering Program Study and Industrial Engineering Program Study Universitas Tarumanagara, directing and supervising undergraduate student's theses in Agricultural Engineering and Food Engineering Desain. In 2016 up to present teaching undergraduate courses of the introduction of concept technology, research methodology, and seminar, writing a scientific paper and scientific communication, and directing and supervising undergraduate student's theses in Industrial Engineering Program Study at the Faculty of Engineering Universitas Tarumanagara. He got his Ir degree in Agricultural Engineering, Bogor Agricultural University Indonesia in 1966, and finished the Master of Science in Agricultural Engineering at the University of Philippines, Los Banos, the Philippines 1981, and got the Doctor in Agricultural Engineering, Bogor Agricultural University Indonesia in 1991. He joined 4-month farm machinery training at ISEKI CO, AOTS, Japan in 1969 and 14 days agricultural engineering training at IRRI, Los Banos the Philippines, in March 1980. He received the honors "SATYA LANCANA

KARYA SATYA XXX TAHUN" from the President of the Republic of Indonesia, April 22nd, 2006, and received appreciation as Team Jury from the Government of Indonesia Minister of Industry in Industry Start-Up 2008. He did several research and survey in the field of farm machinery, farm mechanization, agricultural engineering feasibility study in-field performance and cost analysis, land clearing and soil preparation in secondary forest and alang-alang field farm 1966 up to 1998. Up till now he is still doing research in designing food processing engineering in agriculture products. Up to the present he already elaborated as a conceptor of about 20 Indonesia National Standard (SNI) in the field of machinery and equipment. He joins the Professional Societies as a member: Indonesia Society of Agricultural Engineers (PERTETA); Indonesia Society of Engineers (PII); member of BKM-PII, and member of Majelis Penilai Insinyur Profesional BKM-PII.

Carla Olyvia Doaly is a lecturer in the Industrial Engineering Department at Universitas Tarumanagara graduated with my bachelor's degree from Institut Teknologi Nasional Malang, which study the Industrial Engineering program, then continued my Master Degree at Institut Teknologi Bandung majoring in Industrial engineering and management and a special field of Enterprise Engineering. I am very interested in studying industrial engineering by doing research related to System Design and Engineering, Supply Chain Management, Operations Research and Analysis, Information System Management, Occupational Health and Safety, Facilities Engineering, Quality and Reliability Engineering