

## OPTIMIZING CAPACITY TO MEET PRODUCTION PLANNING AND IMPLEMENTING BLUE ECONOMY PRACTICES AT THE POPCORN FACTORY IN SURABAYA



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### Abstract

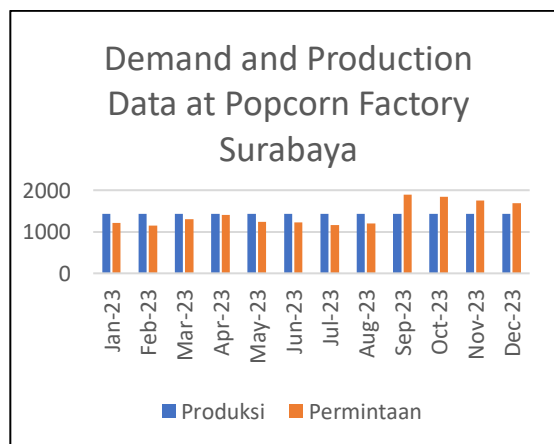
Production planning is the process of organizing and controlling the flow of materials in and out of the production system to meet consumer needs with the right quantity and timing while keeping production costs low. Based on the analysis, the popcorn factory in Surabaya has not maximized capacity management, as evidenced by the occurrence of surplus and deficit in available capacity (CA) during certain periods. The Surabaya popcorn factory does not fully utilize capacity management because the company produces either more or fewer products than the demand. Overproduction can lead to warehouse overstocking, while underproduction prevents the company from meeting consumer needs. The purpose of this research is to analyze and evaluate the capacity of resources and production equipment using forecasting techniques with minimum MSE (Mean Squared Error) to obtain an optimal production capacity plan and make appropriate capacity planning recommendations to ensure all consumer demands are met.

**Keywords:** Time Series; Linear Regression; and Demand Forecasting

## INTRODUCTION

Production planning management is very important to measure and evaluate the quantity of capacity both needed and available from various aspects of production resources owned by each company, including Popcorn Factory in Surabaya. Popcorn Factory in Surabaya is a business entity that focuses on the production of snacks in the form of various flavors of popcorn, this business has been operating since 2010 and is located in Surabaya. Popcorn is produced every working day with the raw materials that are used for the production. obtained from the purchase of imported corn kernels. However, since the outbreak of COVID-19 in 2019, consumer purchasing power is still low, and this has an impact on the Popcorn Surabaya factory, although the food and beverage industry has gradually begun to return to its original condition, Popcorn Surabaya factory needs to pay attention to production planning considering that consumer purchasing power is still low and tends to fluctuate. The imbalance between capacity requirements or what is commonly referred to as Capacity Requirement (CR) and Capacity Available (CA) often results in inefficient overcapacity. A good company can plan its production capacity appropriately (Bersabie et al., 2022).

The master production schedule (MPS) reflects the capacity that has been adjusted to the level of demand fluctuations (Hidayat et al., 2023) The following are demand data and production data at Popcorn Factory Surabaya.



The data shows consistent production of 1,430 kg per month, while market demand fluctuates. This imbalance is due to the use of the same forecasting every year without updates, despite fluctuating market demand. This situation signals the need for a production

planning strategy that is more responsive to changes in market demand to avoid over- or under-production and to optimize operational efficiency. If the company does not change its production planning, products may be held in warehouses, incurring additional storage costs, as well as increasing the risk of product damage due to prolonged storage, conversely, if the company produces below the demand rate, the company is unable to meet customer demand. To overcome this problem, good and appropriate production planning is needed, such as the use of TSR (Time Series Regression) forecasting techniques and appropriate production planning methods

Sustainable development is a pattern of development that pays attention to the balance of nature. Understanding that waste generated from the production process has economic value is a new paradigm in development. Waste is no longer seen as something to be avoided or managed secretly, but can have economic value.

In the case study of a popcorn factory in Surabaya, capacity management has not been fully utilized by considering CA and CR when determining the amount of production required. The uncertainty of consumer needs and the company's failure to predict the level of purchases over a certain period resulted in the existence of remaining production orders where the company produced more products than demand.

This excess inventory expands inventory, This excess inventory leads to warehouse overruns, expired products, and returns, resulting in losses and waste treatment costs. The application of Blue Economy concepts, such as proper production planning, defective product waste management, and technology utilization, can help companies overcome these negative impacts and improve business sustainability.

Based on the interview with the manager, it was estimated that the number of defective products reached 0.5% of the total production each month. On an annual basis, defects total 51.48, a significant amount that requires further processing. This large number of defects can cause financial losses if waste treatment is not appropriate. In the popcorn factory that was the object of the study, defective products that do not meet quality standards are usually discarded.

Researchers are interested in applying the Blue Economy concept by converting popcorn that does not meet quality standards into organic fertilizer that is environmentally

friendly and beneficial for plants. The RCCP (Rough-Cut Capacity Planning) method in production planning can help reduce the production of popcorn that does not meet quality standards, thereby reducing waste and increasing the sustainability of the popcorn industry. Through this research, it is expected that the use of the Blue Economy concept and the RCCP method in the process of recycling popcorn into fertilizer can generate economic and environmental benefits. Therefore, this research is titled "Capacity Optimization to Meet Production Planning and Blue Economy Implementation".

## **REVIEW OF LITERATURE**

### **Forecasting**

Forecasting is a key component in many types of integrated operating systems, such as supply chain management, customer relationship management, and revenue management systems. (Sutisna & Hendy, 2019). According to (Soeltanong & Sasongko, 2021). Demand forecasting is information that will be used as the basis for production planning, master production scheduling, resource requirement planning, and inventory control.

### **Quantitative Forecasting Methods**

#### **1. Naïve Approach**

This approach is a forecasting method that analogizes the demand of the next period to the demand of the current period. This method involves using the last value of the time series as a prediction for the next (Darmawan et al., 2023).

#### **2. Moving Average**

According to (Agustian & Wibowo, 2019) moving average is a method of calculating the average of the movement of several data. sequentially over some time, on a group of time series data.

#### **3. Smoothing Exponential**

The exponential smoothing method is a procedure that repeats calculations continuously in forecasting against the latest data (Mirdaolivia & Amelia, 2021).

#### **4. Trend projection**

According to (Samosir et al., 2022) Trend Projection is a time series forecasting method that matches a trend line with a series of past data which is then projected into the future for medium and long-term forecasting.

## 5. Linear Regression

Linear regression method is one of the methods to predict the calculation mathematically using two or more variables, namely predictor variables and criterion variables (Oktaviani et al., 2021).

### Accuracy of Forecasting Results

#### 1. Mean Absolute Deviation MAD

(Pratama et al., 2020) Systematically, MAD is formulated as follows

$$MAD = \sum \left| \frac{D_t - F_t}{n} \right|$$

#### 2. Mean Squared Error MSE

(Wardah & Iskandar, 2017) Systematically MSE is formulated as follows

$$MSE = \sum \frac{(A_t - f_t)^2}{n}$$

#### 3. Mean Forecast Error MFE

(Wardah & Iskandar, 2017) Systematically MFE is expressed as follows

$$MFE = \sum \frac{(A_t - f_t)}{n}$$

#### 4. Mean Absolute Percentage error MAPE

(Wardah & Iskandar, 2017) Systematically MAPE is expressed as follows

$$MAPE = \left( \frac{100}{n} \right) \sum \left| A_t - \frac{F_t}{A_t} \right|$$

Where it is the actual demand in period-t,  $F_t$  is the demand forecast in period-t, and  $n$  is the number of forecasting periods involved.

### Forecasting Verification

It is important to use the moving range chart (MRC) in the verification process. According to (Aditya Permana et al., 2023) MR prices are obtained from the calculations they describe. The use of MRC helps to ensure that demand patterns remain under control and enables early detection in case of instability or anomalies in the forecasting system.

$$MR = |(Y' t - Yt) - (Y' t-1 - Yt-1)|$$

$$MR = \frac{\sum MR}{n-1}$$

The control limits are:

Upper Control Limit

$$(BKA) = 2.66 \times MR$$

Lower Control Limit

$$(BKB) = -2.66 \times MR$$

The escape condition can be checked using the following four rules: a) One-point rule: If there is a distribution point  $Y_t - Y_{t-1}$  outside the upper control limit (BKA) and lower control limit (BKB); b) Three-point rule: If there are three consecutive points on a edge, then two of them are in the area of A; c) Five Point Rule: If there are 5 consecutive points on a side, 4 of them are in area B; d) 8-point rule: If there are 8 consecutive points in area C on one side.

## RESEARCH METHOD

This research uses a quantitative descriptive approach. According to (Sitorus et al., 2022), descriptive research aims to find information related to existing symptoms, set clear objectives, plan approaches, and collect various data to make reports. Quantitative methods rely on numerical data and exact science to test hypotheses or analyze data, which are then used as a basis for making conclusions. The object of this research is the production capacity of popcorn, a snack food produced in large quantities at a popcorn factory in Surabaya. This research aims to understand how this factory manages production capacity, identify challenges faced, and find solutions to improve production efficiency and performance.

Data collected through Literature Research by utilizing relevant theories and literature, including books, magazines, the internet, and company data. Field Research by collecting primary data through direct observation and interviews with employees. The data taken includes a description of production, total demand, operating time, setup time, working days, working hours, number of machines/workstations, and total labor. Demand Forecasting Data Analysis Techniques such as Simple Average, Moving Average, Weighted Moving Average, Single Exponential Smoothing, Double Exponential Smoothing, and Linear Regression with Time methods, with the help of the WinQSB program.

Through this approach, this study aims to improve the efficiency and sustainability of production in a popcorn factory, by applying Blue Economy concepts to manage waste and increase the added value of defective products.

## RESULTS AND DISCUSSION

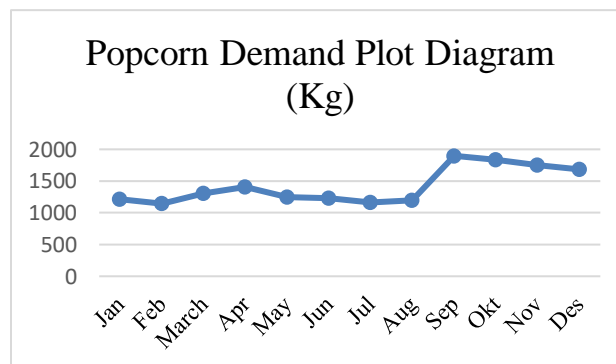
### Data Analysis Results

The process of estimating or predicting future demand by analyzing consumer demand for a product is called forecasting. The purpose of this forecasting is to project the amount of demand for popcorn products for the next year, starting from the January 2023 period. The following is a table of 2023 popcorn demand data.

**Table 1**  
**Popcorn Demand Data**

Period	Demand
January 2023	1212,5
February 2023	1144
March 2023	1308,4
April 2023	1410,4
May 2023	1242,9
June 2023	1227,6
July 2023	1166,9
August 2023	1194
September 2023	1898
October 2023	1835,6
November 2023	1750,4
December 2023	1688
Total	17.078,7

Based on the popcorn demand data table at the Surabaya Popcorn Factory in 2023 above, the following plot diagram can be visualized:



Prediction or forecasting is done to project possible future demand. After the six forecasting methods are calculated, the best method is selected based on the MSE (Mean Squared Error) criteria. Based on the results of forecasting calculations using the WinQSB program, the forecasting error value of the previous year's demand data is obtained, as shown in the table below:

Forecasting g Model	Fault Accuracy	Value
Simple Average	MAD (Mean Absolute Deviation)	222,7502
	MSE (Mean Squared Error)	92095,4
	MAPE (Mean Absolute Percentage Error)	13,53696
Moving Average (MA 3)	MAD (Mean Absolute Deviation)	204,1111
	MSE (Mean Squared Error)	84432,23
	MAPE (Mean Absolute Percentage Error)	12,34046
Weighted Moving Average (WMA 3)	MAD (Mean Absolute Deviation)	204,1111
	MSE (Mean Squared Error)	84432,23
	MAPE (Mean Absolute Percentage Error)	235,01
Single Exponential Smoothing (0,99)	MAD (Mean Absolute Deviation)	137,7989
	MSE (Mean Squared Error)	53189,79
	MAPE (Mean Absolute Percentage Error)	8,808172
Double Exponential Smoothing (0,33)	MAD (Mean Absolute Deviation)	209,3484
	MSE (Mean Squared Error)	87557,88
	MAPE (Mean Absolute Percentage Error)	12,62779
Linear Regression with Time	MAD (Mean Absolute Deviation)	155,6818
	MSE (Mean Squared Error)	34615,37
	MAPE (Mean Absolute Percentage Error)	11,20859

Based on this figure, the smallest MSE value is in the linear regression with time method with values 34615,37. Next, a verification test is carried out from the results of the forecasting method to check whether the data is in the right place. Within the limit that is determined by the moving Range Chart). Based on the least squares analysis, the upper control limit (BKA/UCL) of 468.87 and the lower control limit (BKB/LCL) are obtained.

(BKB/LCL) amounting to -468,87. Based on the results of the analysis, it can be concluded that the control map does not violate the 4 MRC rules. That way, the Linear Regression method is feasible or can be applied. Based on the prediction results of the selected method, namely using the Linear Regression method through the WinQsb program in Windows version 5.3, the researcher can see the results of the forecasting prediction as follows.

<b>Periode (t)</b>	<b>Demand (Y)</b>	<b>Demand (Y) after rounding</b>	<b>Forecast (Y')</b>
Jan	1212.5	1212	1103
Feb	1144	1144	1161
Mar	1308.4	1308	1219
Apr	1410.4	1410	1277
Mei	1242.9	1242	1335
Juni	1227.6	1227	1393
Jul	1166.9	1166	1451
Aug	1194	1194	1509
Sep	1898	1898	1568
Oct	1835.6	1835	1626
Nov	1750.4	1750	1684
Des	1688	1688	1742

Based on the forecasting results above, an RCCP Rough Cut Capacity Planning report can then be made by comparing CR and CA in the form of a table as follows.

Work Station- 1 Cook

<b>Capacity Available (Hours)</b>	<b>Capacity Requirement (Hours)</b>	<b>Varians (Hours)</b>	<b>Load Percentage (%)</b>
96,95	81,63	-15,32	84%
89,49	85,35	-4,14	95%
96,95	89,75	-7,2	93%
85,76	93,3	7,54	109%
96,95	97,87	0,92	101%
93,22	101,76	8,54	109%
100,68	106,16	5,48	105%
100,68	110,22	9,54	109%

93,22	114,01	20,79	122%
100,68	118,41	17,73	118%
96,95	122,3	25,35	126%
93,22	126,19	32,97	135%

Work Station-2 Packaging

Capacity Available (Hours)	Capacity Requirement (Hours)	Varians (Hours)	Load Percentage (%)
133,54	82,41	-51,13	62%
123,26	86,07	-37,19	70%
133,54	90,53	-43,01	68%
118,13	93,99	-24,14	80%
133,54	98,65	-34,89	74%
128,4	102,51	-25,89	80%
138,67	106,97	-31,7	77%
138,67	111,03	-27,64	80%
128,4	114,76	-13,64	89%
138,67	119,22	-19,45	86%
133,54	123,08	-10,46	92%
128,4	126,94	-1,46	99%

Based on the RCCP report, researchers can see which workstations lack capacity and excess capacity. Based on the table above, it is known that WS 1-Cooking is experiencing a capacity shortage problem. The following are the labor hours needed to overcome the lack of capacity.

Working Station	Period	Capacity Shortage (Hours)	Number of Machines (Unit)	Total Working Hours (Hours)
Pemasakan SK-1	Jan-24	-	1	-
	Feb-24	-	1	-
	Mar-24	-	1	-
	Apr-24	7,54	1	8

	Mei-24	0,92	1	1
	Jun-24	8,54	1	9
	Jul-24	5,48	1	5
	Agu-24	9,54	1	10
	Sep-24	20,79	1	21
	Oct-24	17,73	1	18
	Nov-24	25,35	1	25
	Des-24	32,97	1	33

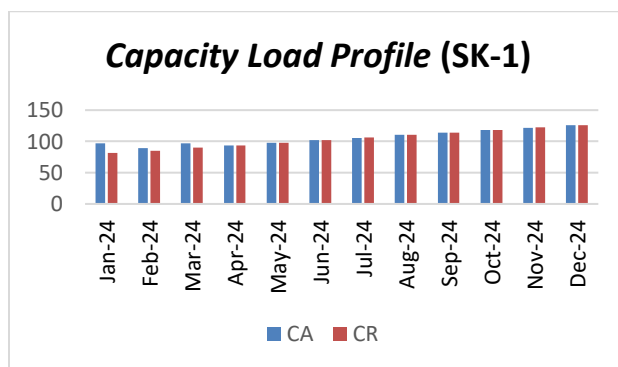
After knowing the need for the required number of hours, it is necessary to compare alternative solution options to get the best solution. The following are alternative options for adding 1 new machine.

Peri ode	Initial Capacity	Undercapacity /overcapacity (Hours)	Available Capacity Addition 1 New Machine (Hours)	Undercapacit y/overcapacit y (Hours)
Jan-24	96,95	-15,32	96,95	112,27
Feb-24	89,49	-4,14	89,49	93,63
Mar-24	96,95	-7,2	96,95	104,15
Apr-24	85,76	7,54	85,76	78,22
May-24	96,95	0,92	96,95	96,03
Jun-24	93,22	8,54	93,22	84,68
Jul-24	100,68	5,48	100,68	95,2
Aug-24	100,68	9,54	100,68	91,14
Sep-24	93,22	20,79	93,22	72,43
Oct-24	100,68	17,73	100,68	82,95
Nov-24	96,95	25,35	96,95	71,6
Des-24	93,22	32,97	93,22	60,25

Here are some solution options for adding overtime working hours.

Period	Number of Overtime Work Hours (Hours)	Overtime Cost	Total Cost of Overtime Work Hours (Rp)
Jan-24	-	Rp8.670	-
Feb-24	-	Rp8.670	-
Mar-24	-	Rp8.670	-
Apr-24	8	Rp8.670	Rp69.360
Mei-24	1	Rp8.670	Rp8.670
Jun-24	9	Rp8.670	Rp78.030
Jul-24	5	Rp8.670	Rp43.350
Agu-24	10	Rp8.670	Rp86.700
Sep-24	21	Rp8.670	Rp182.070
Oct-24	18	Rp8.670	Rp156.060
Nov-24	25	Rp8.670	Rp216.750
Des-24	33	Rp8.670	Rp286.110
Total(year)/Tenaga Kerja			Rp1.127.100
Total (year) x 5 Tenaga Kerja			Rp. 5.635.500

Thus, it can be seen that the selected proposal, namely the addition of overtime incurs the smallest cost to fulfill its capacity. The following is the load profile of the cooking process workstation after the addition of overtime working hours.



### Implementation of Blue Economy with My Second Product Creation

The new paradigm in development recognizes that production process waste has economic value that can be utilized. For example, a popcorn factory in Surabaya does not have full control over its production capacity, especially the balance between available capacity and the capacity needed to fulfill target orders. Uncertainty about the number and

timing of input and output orders resulted in production order backlogs, excess inventory, product expirations, and returns, as well as losses and waste disposal costs.

However, with the application of Blue Economy concepts, such as proper production planning, waste treatment of defective products, and utilization of technology, companies can overcome these negative impacts and improve the sustainability of their business.

In addition, a concrete step that can be taken is to utilize the waste of defective products, such as corn kernels that fail to bloom, into compost. This process not only helps reduce waste but also provides significant economic and environmental benefits. Compost from corn waste can fertilize the soil, prevent erosion, and reduce soil cracks, thus helping in building soil fertility in the long run. This is in line with the spirit of agricultural sustainability and reduced reliance on chemical fertilizers. For example, in Wellulang Village, Amali Sub-district, training in making compost from maize waste has helped farmers meet their fertilizer needs and reduce reliance on chemical fertilizers, demonstrating the real potential of this new paradigm in creating sustainable and economically beneficial solutions (Aden et al., 2023). Here are the steps in making compost fertilizer from corn waste:

#### **Raw Material Preparation**

Corn waste in the form of corn kernels that fail to bloom is prepared as the main raw material. To make compost from corn harvest, the corn waste must be crushed and mixed with manure, and sprayed with EM4 as a weathering agent.

#### **Raw Material Refining**

Raw materials are pulverized by reducing their size, such as chopping corn stalks or other corn waste.

#### **Material Mixing**

Mix the crushed corn stalks with other ingredients such as manure, bran, or animal manure in an appropriate ratio. Make sure the mixing is done evenly to get a nutritionally balanced compost.

#### **Stack Formation**

Form piles of the mixed materials in layers. Each layer of the stack should be carefully arranged, taking into the proportions of the ingredients used.

#### **Composting**

Let the pile undergo the composting process for a few weeks until it turns into mature compost. Make sure to monitor the temperature and humidity of the pile regularly during the composting process.

### **Processing and Maturation**

Once the composting process is complete, the resulting compost should be separated from the coarse parts and left to mature for some time. Make sure to sift the compost to get the final product smooth and ready to be used as fertilizer

### **Storage and Use**

Store the compost in a suitable container to maintain its quality. Use this compost to enrich the soil in your garden, vegetable garden, or other agricultural areas as an environmentally friendly organic fertilizer.

Through the above steps, corn waste that was originally worthless can be turned into compost that is valuable and beneficial to plants and the environment as a whole.

## **CONCLUSION**

As explained in the previous chapter, based on the results of data analysis conducted at Papabrik Popcorn Surabaya, the following conclusions are obtained: 1) The production plan is prepared based on the results of product demand forecasting estimates with the Linear Regression with Time method as the method with the smallest error of other methods. Based on the results of the analysis of production capacity planning with the Rough-Cut Capacity Planning (RCCP) method, the comparison between the required capacity and the available capacity shows that the production plan in some periods is not feasible because there is still a lack of capacity in some periods at the cooking process workstation (WS-1); 2) Capacity planning with Rough Cut Capacity Planning (RCCP) technique is one of the alternative recommendations for designing optimal strategies that can be implemented by the company by increasing working hours and increasing the capacity of the cooking process workstation (WS-1) that we provide.

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