Jurnal Teknik Industri Vol. 14 No. 1, March 2024: 17-34
https://doi.org/10.25105/jti.v14i1.19855
Received: 2023-08-31 Revised: 2024-07-19 Accepted: 2024-08-02
p-ISSN 1411-6340 e-ISSN 2622-5131

Planning Daily Bread Production Using Forecasting Method and Heuristic Aggregate Method on CV. Delia Bakery

Kayla Shawafira Nasha[a], Syarif Hidayat[a], Nunung Nurhasanah[a*]

[a] Department of Industrial Engineering, University of Al-Azhar Indonesia, Komplek Masjid Agung Al-Azhar, Jalan Sisingamangaraja, 12110 South Jakarta, Indonesia.

kylshwfrnsh@gmail.com; syarifsyahida@gmail.com; nunungamindradjat@gmail.com

ABSTRACT

CV. Delia Bakery is a home-based bakery factory located in Jatinegara, East Jakarta. It produces bread every period and currently has 30 salesmen. The amount of bread produced every period depends on the requests of each salesperson, who only asks what their target wants without any clear basis. This results in inefficient daily production levels and suboptimal profits for the company, highlighting the necessity for a well-thought-out production plan. Hence, bread production demand is predicted using the Double Moving Average forecast for 3 and 6 periods and Double Exponential Smoothing by Brown with α = 0.1. Production planning involves heuristic aggregate planning with two strategies, workforce control, and overtime control, aiming for cost-effective results. Based on the results of forecasting calculations that have been carried out using data from May and June 2023, a total of 53 periods were analyzed, revealing that the Double Exponential Smoothing by Brown method with α=0.1 achieved the lowest MAPE of 9.91%. The forecasted values for the 54th period are 9510 pcs, 55th period 9502 pcs, 56th period 9494 pcs, 57th period 9486, 58th period 9478, and 59th period 9470. The heuristic aggregate method showed that workforce control is the most cost-efficient production control strategy, costing Rp 4,800,000 over six forecasting periods.

Keywords:

Demand forecasting; Exponential Smoothing; Moving average; Overtime Control Strategy; Production Planning; Workforce control strategy.

Introduction

CV. Delia Bakery is a bakery that produces 14 different bread flavors at the same price and with the exact ingredients. The distribution of its products, CV. Delia Bakery was assisted by 30 third-party salesmen who worked with the company to distribute the bread produced to various cluster stores around Jakarta using their respective routes. Work collaboration between CV. Delia Bakery and the salesman caused the problem of not maximizing the profits obtained by the CV. This can happen because the amount of daily bread production is entirely controlled at the request of each salesman. When making a request, the salesmen only requested according to the wishes of their target without any apparent basis. This makes the daily production of bread excessive according to demand, and the use of raw materials flour (bags) must follow the plurality that each bag of flour can produce 900 pieces of bread so that the production is not optimal or exceeds every period. The profit obtained by either

cannot be maximized. Production planning involves volume determination, timing accuracy, capacity utility, and load planning. Production plans, in this case, must be coordinated with company planning [1]. So, the main issue facing CV. Delia Bakery is that there is no good production plan for some period ahead, so employment is difficult to predict. To maximize the market demand, production planning must be done. Therefore, mature production planning is required to optimize production.

Forecasting is a process to estimate how much future needs are covered in terms of quantity, quality, time and location required to meet the demand for goods or services. The marketing field can do the predictive activity and the outcome of the prediction is often referred to as demand prediction [2]. The reason the company does the forecast is to control the management of inventory for future planning and to minimize the raw material problem in the company [3]. In a prediction, it is necessary to minimize possible errors; to minimize the error level, it would be better if the prediction was in some form of mathematical model [4]. Predictions are useful as guidance for decisions relating to future capacity predictions, marketing, planning and development [5]. Predictions are not needed if demand in the market is stable because demand changes are relatively small. However, prediction will be essential if market demand conditions are complex and dynamic [1]. Forecasting is a way to increase the value of a product and increase the quantity of production by predicting orders that will occur in the future [6].

Forecasting is the prediction of something that has not happened, so it is necessary to determine the method of prediction that is most suitable for a problem or situation that is occurring [7]. Prediction is the initial part of a decision-making process. Before making a prediction, it is necessary to know first the real issue in the decision-making process [8]. Companies have been using forecasting methods to plan for the next period. The prediction method used depends on the type of historical data pattern. The data pattern consists of four types: horizontal or stationary data patterns, trend, seasonal, and cyclical [9]. The smoothing method is a predictive technique that takes the mean values of some past period to estimate the value of a future period [10]. The smoothing method is divided into the average and exponential smoothing methods [11].

Moving Average is a prediction method performed by taking observational values and looking for those averages as predictions for future periods [12]. The Double Moving Average (DMA) method is a variation of the moving average procedure that can better address trends for short- and medium-term forecasts [13]. Double Moving Average is a method of predicting moving averages. However, the difference in this method is that predictions are made in two stages, namely, the initial prediction and then recalculated from the result of its decline to obtain a new prediction value [14]. Double Moving Average is one way to predict a time series with a linear trend [15].

The Double Exponential Smoothing by Brown method is used to complete non-approved direct double finishing unless finishing is done with a parameter different from the parameter used in the original data finishing [16]. The essential thinking of double exponential smoothing methods is that the finishing value will be present before the actual data when the data contains a trend component. Therefore, a duplicate fining value must be added for single finishing values to adjust the trend [16]. The Exponential Smooting by Brown technique is a prediction that can be used for unstable and volatile data patterns. The Exponential Smoothing by Brown technique is a prediction that can be used for unstable data patterns. The exponential smoothing method uses a finishing constant (α) with values between 0 and 1 in its calculation. A value of α close to 1 means that the actual data pattern is unstable, whereas α is close to 0 when the actual data model is stable [17]. If the historical data pattern is unstable, the value chosen is close to 1 because it will respond more to demand fluctuation [18].

Brown's double exponential smoothing method starts by determining the size of α by trial and repeating the calculation error using the latest data [19].

The Deviation Error Test compares the prediction results with the actual data. The smaller the error value, the higher the level of prediction accuracy [20]. The deviation test can determine the degree of difference between the prediction result and the demand based on the smallest deviation value. So, it functions to know what is wrong with the forecasting [2]. One of the accuracy tests is the Mean Absolute Percentage Error (MAPE), which indicates the mean value of the absolute deviation of the percentage of error of the result of the prediction against the actual demand for a given period [21]. MAPE is obtained from the average absolute error over the past period multiplied by 100%, resulting in the predicted variable measure determining the precision of the forecast [20].

Aggregate planning can suppress the production costs that will be spent if seen from the calculations of the selected forecast [22]. Aggregate planning is part of a more extensive production planning system, which can determine the amount and time of allocation of some resources that are not fixed in nature, like workforce and supplies, to meet consumer demand for the medium term [23]. Aggregate planning provides a comprehensive overview of a company's ability to produce, considering cost-effectiveness, i.e., minimizing costs during the planning period, reducing workforce problems, suppressing supply levels, and fulfilling services [24]. Aggregated planning can be the best alternative to meeting predicted demand with data on production value, workforce level, supply level, overtime, subcontract rate, and other controllable variables [25].

The Workforce Control Strategy affects production capacity so that output levels follow demand patterns and maintain a steady inventory. Companies can hire and lay off employees based on production alignment with demand. Overtime control is part of this strategy; when demand exceeds production capacity, the company will increase working hours or implement overtime to meet demand. The Workforce Control Strategy optimizes staffing levels and composition to match demand. At the same time, the Overtime Control Strategy emphasizes managing and minimizing overtime costs and ensuring compliance with labor regulations [26].

Another case study titled "Production Planning and Control of Bread using Heuristic Aggregate Planning Method at CV. Family Bakery" utilized data over a 12-month period and applied forecasting using linear regression, resulting in a MAPE of 2.22%. The overtime control aggregate planning method in this study yielded a minimum production cost of Rp. 1,069,040,000 per year.

The study aims to calculate production demand forecasts and analyze production planning using heuristic aggregate methods to identify strategies that provide the lowest cost to optimize workforce usage and meet market demand daily.

Methods

Research methodology is a scientifically structured phase carried out when the research follows the plan.

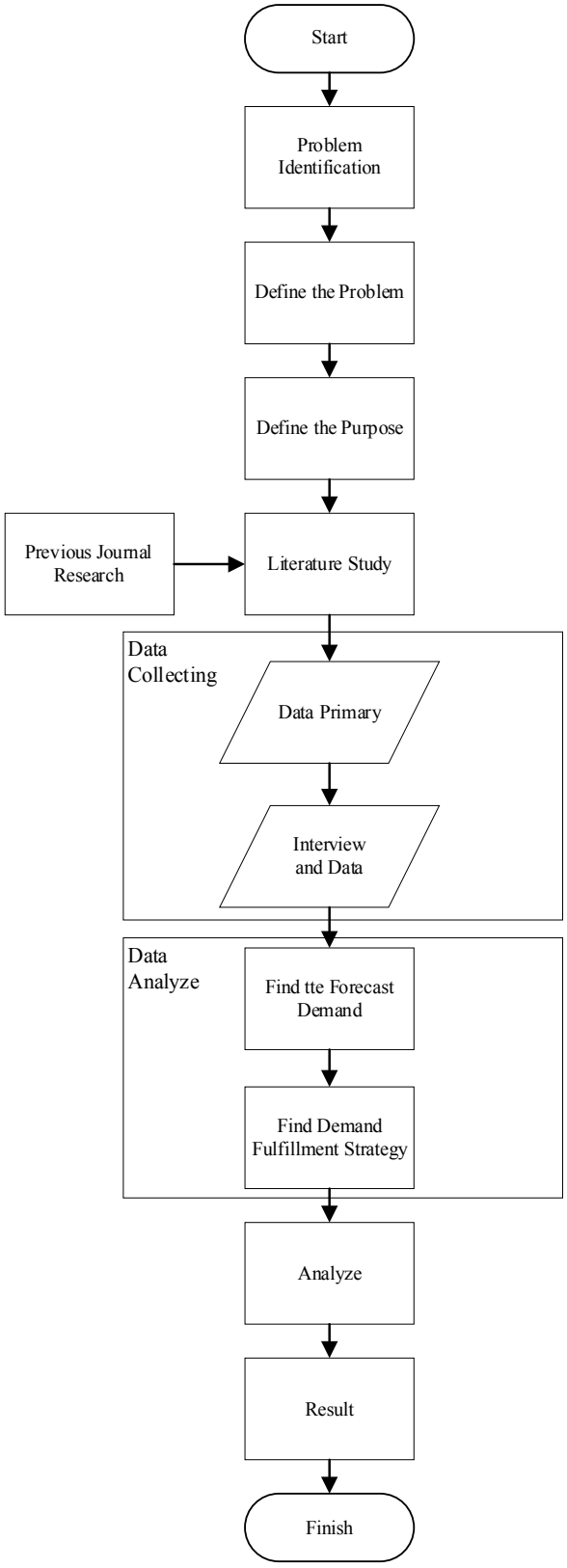

Figure 1. Flowchart of the Research

Figure 1. shows that starting from the problem identification involved interviewing the owner, who has not been forecasting the production quantity because they have relied solely on salesmen's demand. As a result, the daily production quantity needs to be more consistent, which affects the availability of raw materials and the existing workforce. The problem found relates to production planning and demand quantity determination. Production planning begins with forecasting demand based on historical data using double moving averages and double exponential smoothing to predict future demand quantities. Subsequently, aggregate planning will determine whether variations in workforce quantity or overtime hours are necessary. Data collection and analysis are then conducted following flowchart 2 to flowchart 4.

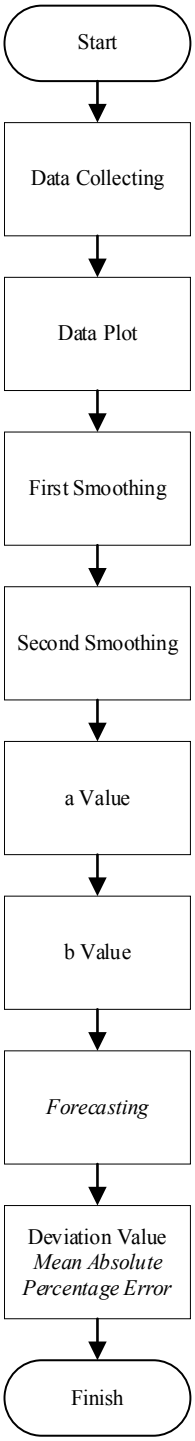

Figure 2. Flowchart of Double Moving Average

Figure 2. shows that processing forecast data using different methods will serve as a comparison for better prediction results. A smaller deviation value will be considered as the best forecast outcome. In double moving averages, a forecast with a 3-day period is used based on a bread expiration time, and a 6-day period is based on weekdays within a week.

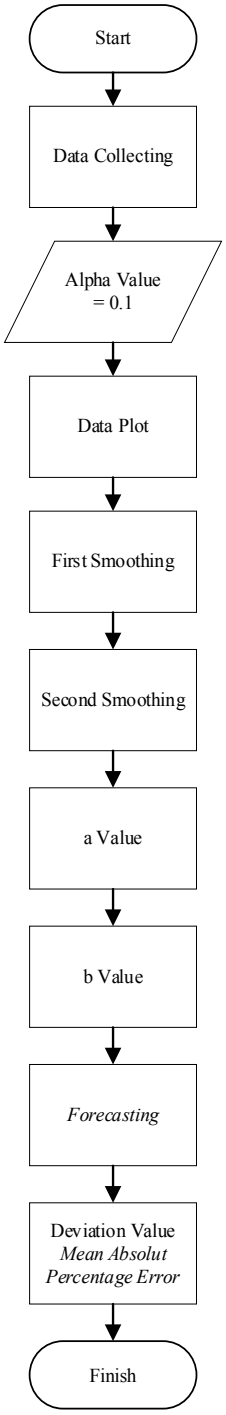

Figure 3. Flowchart of Double Exponential Smoothing

Figure 3 shows that the alpha value is used for double exponential smoothing. The alpha value used results from the researcher's trial and error test before determining the smallest resulting value, alpha = 0.1.

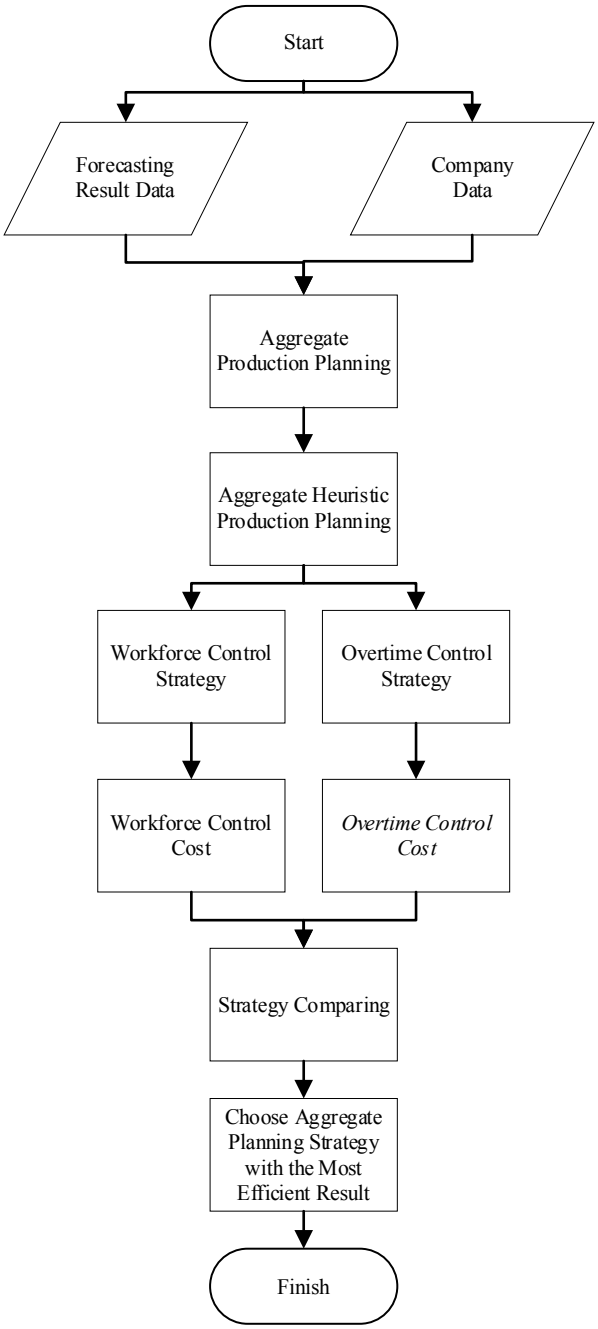

Figure 4. Flowchart of Aggregate Planning

Figure 4. In aggregate planning, workforce control and overtime control will be compared to the best strategy to be implemented.

Results and Discussion

Data was collected from interviews with company owners and data on daily bread demands for two months, May and June 2023, for 53 periods. The Variety of bread, which is the flavor, does not affect the demand because the bread's main ingredients are the same.

Table 1. Daily bread demand data May to June 2023

May 2023			June 2023		
Date	**Period (daily) (t)**	**Demand (pcs) (Xt)**	**Date**	**Period (daily) (t)**	**Demand (pcs) (Xt)**
1	1	10840	1	28	10310
2	2	12469	2	29	12545
3	3	8135	4	30	7790
4	4	8815	5	31	11250
5	5	8930	6	32	9057
7	6	11865	7	33	11660
8	7	9290	8	34	9590
9	8	10490	9	35	11110
10	9	9595	11	36	9460
11	10	9540	12	37	9435
12	11	10310	13	38	9075
14	12	9260	14	39	9200
15	13	10200	15	40	10186
16	14	9670	16	41	9385
17	15	9045	18	42	10360
18	16	10185	19	43	11680
19	17	10410	20	44	8560
21	18	8560	21	45	8380
22	19	9118	22	46	8930
23	20	9956	23	47	9666
24	21	9430	25	48	10223
25	22	9012	26	49	8189
26	23	8018	27	50	10519
28	24	8795	28	51	10495
29	25	8769	29	52	9200
30	26	8176	30	53	9066
31	27	7425			

Table 1 shows the daily bread demand data for May 2023 and June 2023. The data will determine the demand forecast for the following six periods.

Table 2. Additional Data

Description	**Total**	**Unit**
Total of Workforce	8	Workforce
Work hours per period	10	Hour
Workperiods per week	6	Period
Fixed production capacity per period	7200	Pcs
Workforce fee per period	Rp 100.000	/Workforce
Overtime cost per hour	Rp 15.000	/Workforce

Maximum overtime	1	Hour

Table 2. is the supporting data for finding aggregate planning obtained from the results of interviews with the owner of the company.

A. Double Moving Average

The data was requested for every period in the last two months and then tested with periods 3 and 6. From each forecast period, the deviation with the Mean Absolute Percentage Error (MAPE) will be calculated to determine the error rate of the prediction.

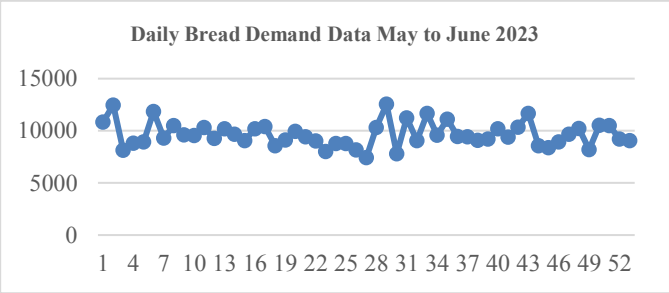

Figure 5. Data Plot of Double Moving Average

Figure 5. is a data plot diagram showing the daily bread production demand of the double moving average method.

1) 3 Period Forecast

Table 3. Double Moving Average 3 period Forecast

t	Xt	S't	S"t	at	bt	Ft	Error (%)
1	10840						
2	12469						
3	8135	10481					
4	8815	9806					
5	8930	8627	9638	7615	-1011		
6	11865	9870	9434	10306	436	6604	44,34
7	9290	10028	9508	10548	520	10741	15,62
8	10490	10548	10149	10948	399	11068	5,51
9	9595	9792	10123	9461	-331	11347	18,26
10	9540	9875	10072	9678	-197	9129	4,30
11	10310	9815	9827	9803	-12	9482	8,03
12	9260	9703	9798	9609	-94	9791	5,73
13	10200	9923	9814	10033	109	9514	6,72
14	9670	9710	9779	9641	-69	10142	4,88
15	9045	9638	9757	9519	-119	9572	5,83
16	10185	9633	9661	9606	-27	9401	7,70
17	10410	9880	9717	10043	163	9579	7,98

t	Xt	S't	S"t	at	bt	Ft	Error (%)
18	8560	9718	9744	9693	-26	10206	19,22
19	9118	9363	9654	9072	-291	9667	6,02
20	9956	9211	9431	8992	-219	8781	11,81
21	9430	9501	9358	9644	143	8772	6,97
22	9012	9466	9393	9539	73	9787	8,60
23	8018	8820	9262	8378	-442	9612	19,88
24	8795	8608	8965	8252	-356	7935	9,78
25	8769	8527	8652	8403	-125	7895	9,96
26	8176	8580	8572	8588	8	8278	1,25
27	7425	8123	8410	7836	-287	8596	15,77
28	10310	8637	8447	8827	190	7550	26,77
29	12545	10093	8951	11235	1142	9017	28,12
30	7790	10215	9648	10782	567	12378	58,89
31	11250	10528	10279	10778	249	11348	0,87
32	9057	9366	10036	8695	-671	11027	21,75
33	11660	10656	10183	11128	472	8024	31,18
34	9590	10102	10041	10163	61	11601	20,97
35	11110	10787	10515	11058	272	10225	7,97
36	9460	10053	10314	9793	-261	11330	19,77
37	9435	10002	10281	9723	-279	9532	1,03
38	9075	9323	9793	8854	-469	9444	4,06
39	9200	9237	9521	8953	-284	8384	8,86
40	10186	9487	9349	9625	138	8669	14,89
41	9385	9590	9438	9743	152	9763	4,03
42	10360	9977	9685	10269	292	9895	4,49
43	11680	10475	10014	10936	461	10561	9,58
44	8560	10200	10217	10183	-17	11397	33,14
45	8380	9540	10072	9008	-532	10165	21,30

46	8930	8623	9454	7792	-831	8477	5,08
47	9666	8992	9052	8932	-60	6961	27,98
48	10223	9606	9074	10139	532	8872	13,21
49	8189	9359	9319	9399	40	10671	30,31
50	10519	9644	9536	9751	107	9440	10,26
51	10495	9734	9579	9890	155	9858	6,07
52	9200	10071	9816	10326	255	10045	9,18
53	9066	9587	9798	9376	-211	10581	16,71
54						9166	
55						8955	
56						8745	
57						8534	
58						8324	
59						8113	
				MAPE			14,18

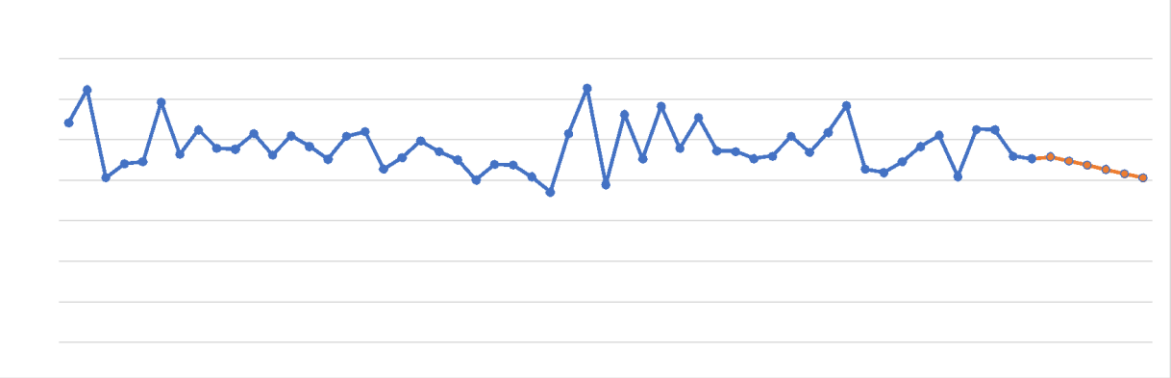

Figure 6. Data and Forecast Plot Data Double Moving Average 3 period

In Table 3, forecasts using the Double Moving Average method of three-period forecast obtained a deviation of 14.18% with forecasting the total production of the predictions in the 54th period of 9166 pcs, the 55th period 8955 pcs, the 56th period 8745 pcs 57, the 57th period 8534, the 58th period 8324, and the 59th period 8,113. Figure 6 shows the pattern of data and forecast, the data color is blue and the forecast is orange.

2) 6 Period Forecast

Table 4. Double Moving Average 6 period Forecast

t	Xt	S't	S"t	at	bt	Ft	Error (%)
1	10840						
2	12469						
3	8135						
4	8815						
5	8930						
6	11865	10176					
7	9290	9917					
8	10490	9588					
9	9595	9831					
10	9540	9952					
11	10310	10182	9941	10423	96		
12	9260	9748	9960	9535	-85	10519	13,60
13	10200	9899	9943	9856	-17	9450	7,36
14	9670	9763	9803	9722	-16	9838	1,74
15	9045	9671	9778	9564	-43	9706	7,30
16	10185	9778	9737	9819	16	9522	6,51
17	10410	9795	9748	9842	19	9836	5,51
18	8560	9678	9751	9606	-29	9861	15,20
19	9118	9498	9657	9339	-64	9577	5,04
20	9956	9546	9574	9517	-11	9275	6,84
21	9430	9610	9551	9669	23	9506	0,81
22	9012	9414	9523	9305	-44	9692	7,55
23	8018	9016	9347	8685	-132	9262	15,51
24	8795	9055	9162	8948	-43	8552	2,76
25	8769	8997	9022	8971	-10	8905	1,55
26	8176	8700	8917	8483	-87	8961	9,60
27	7425	8366	8688	8044	-129	8396	13,08
28	10310	8582	8549	8615	13	7916	23,23
29	12545	9337	8762	9912	230	8628	31,22
30	7790	9169	9029	9309	56	10142	30,19

t	Xt	S't	S"t	at	bt	Ft	Error (%)
31	11250	9583	9363	9803	88	9365	16,76
32	9057	9730	9494	9965	94	9890	9,20
33	11660	10435	9916	10955	208	10060	13,73
34	9590	10315	10160	10471	62	11163	16,40
35	11110	10076	10276	9877	-80	10533	5,20
36	9460	10355	10249	10460	42	9797	3,56
37	9435	10052	10161	9943	-44	10503	11,32
38	9075	10055	10154	9956	-40	9900	9,09
39	9200	9645	9917	9373	-109	9917	7,79
40	10186	9744	9815	9674	-28	9264	9,05
41	9385	9457	9615	9298	-63	9646	2,78
42	10360	9607	9603	9611	2	9235	10,86
43	11680	9981	9682	10280	120	9613	17,70
44	8560	9895	9828	9963	27	10400	21,50
45	8380	9759	9878	9639	-48	9990	19,21
46	8930	9549	9734	9364	-74	9591	7,40
47	9666	9596	9635	9557	-15	9290	3,89
48	10223	9573	9573	9574	0	9542	6,66
49	8189	8991	9387	8596	-158	9574	16,91
50	10519	9318	9294	9342	9	8438	19,79
51	10495	9670	9327	10014	138	9351	10,90
52	9200	9715	9568	9863	59	10152	10,34
53	9066	9615	9667	9564	-21	9922	9,44
54						9543	
55						9522	
56						9502	
57						9481	
58						9460	

59		9440	
	MAPE		11,05

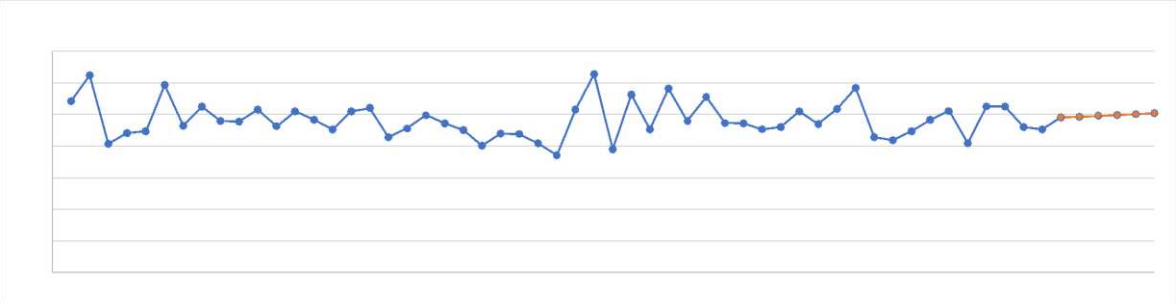

Figure 7. Data and Forecast Plot Data Double Moving Average 6 period

Table 4. shows predictions using the Double Moving Average method of the six-period prediction obtained a deviation of 11.40% with the prediction of the total output of the forecast in the 54th period of 9804 pcs, the 55th period 9858 pcs, the 56th period 9912 pcs 9966, the 58th period 10020, and the 59th period 1074 pcs. Figure 7 shows the pattern of data and forecast, the data color is blue and the forecast is orange.

B. Double Exponential Smoothing

Double Exponential Smoothing was tested with an alpha value parameter. The α value used is a trial-and-error result between 0.1 and 1. The selected α value is 0.1 because it gives the lowest error value when calculating the deviation with the Mean Absolute Percentage Error (MAPE) to determine the error rate of the prediction by trial-and-error test.

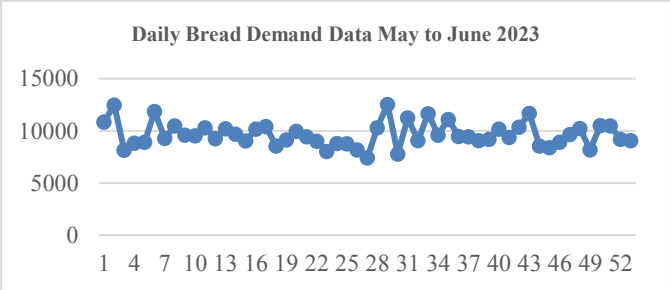

Figure 8. Data Plot of Double Exponential Smoothing

Figure 8 is a plot diagram of daily bread demand data for the months of May and June 2023.

Table 5. Double Exponential Smoothing (α = 0.1)

t	Xt	S't	S"t	at	bt	Ft	Error (%)
1	10840	10840	10840	10840	1155		
2	12469	11003	10856	11150	16,3	11995	3,81
3	8135	10716	10842	10590	-14,0	11166	37,26

4	8815	10526	10811	10241	-31,6	10576	19,98
5	8930	10366	10766	9967	-44,4	10210	14,33
6	11865	10516	10741	10291	-25,0	9922	16,37
7	9290	10394	10706	10081	-34,8	10266	10,51
8	10490	10403	10676	10130	-30,3	10046	4,23
9	9595	10322	10641	10004	-35,4	10100	5,26
10	9540	10244	10601	9887	-39,7	9969	4,49
11	10310	10251	10566	9935	-35,0	9848	4,48
12	9260	10152	10525	9779	-41,4	9900	6,92
13	10200	10157	10488	9825	-36,8	9737	4,54
14	9670	10108	10450	9766	-38,0	9788	1,22
15	9045	10002	10405	9598	-44,8	9728	7,55
16	10185	10020	10367	9673	-38,5	9553	6,20
17	10410	10059	10336	9782	-30,8	9635	7,45
18	8560	9909	10293	9525	-42,7	9751	13,92
19	9118	9830	10247	9413	-46,3	9482	4,00
20	9956	9843	10206	9479	-40,4	9367	5,92
21	9430	9801	10166	9437	-40,5	9438	0,09
22	9012	9722	10121	9323	-44,3	9396	4,26
23	8018	9552	10065	9039	-57,0	9279	15,73
24	8795	9476	10006	8947	-58,8	8982	2,13
25	8769	9406	9946	8865	-60,0	8888	1,36
26	8176	9283	9879	8686	-66,3	8805	7,70
27	7425	9097	9801	8392	-78,3	8619	16,09
28	10310	9218	9743	8693	-58,3	8314	19,36
29	12545	9551	9724	9378	-19,2	8635	31,17
30	7790	9375	9689	9061	-34,9	9359	20,14
31	11250	9562	9676	9448	-12,6	9026	19,77
32	9057	9512	9660	9364	-16,4	9436	4,18
33	11660	9727	9666	9787	6,7	9347	19,83

34	9590	9713	9671	9755	4,7	9793	2,12
35	11110	9853	9689	10016	18,2	9759	12,16
36	9460	9813	9702	9925	12,4	10034	6,07
37	9435	9776	9709	9842	7,4	9938	5,33
38	9075	9705	9709	9702	-0,4	9849	8,53
39	9200	9655	9703	9607	-5,4	9702	5,46
40	10186	9708	9704	9712	0,5	9601	5,74
41	9385	9676	9701	9651	-2,8	9713	3,49
42	10360	9744	9705	9783	4,3	9648	6,88
43	11680	9938	9728	10147	23,2	9787	16,20
44	8560	9800	9736	9864	7,1	10170	18,81
45	8380	9658	9728	9588	-7,8	9871	17,80
46	8930	9585	9714	9457	-14,3	9580	7,28
47	9666	9593	9702	9485	-12,0	9442	2,31
48	10223	9656	9697	9615	-4,5	9473	7,34
49	8189	9510	9678	9341	-18,8	9611	17,36
50	10519	9610	9671	9549	-6,8	9322	11,38
51	10495	9699	9674	9724	2,7	9543	9,07
52	9200	9649	9672	9626	-2,5	9726	5,72
53	9066	9591	9664	9518	-8,1	9624	6,15
54							9510
55							9502
56							9494
57							9486
58							9478
59							9470
				MAPE			9,91

Figure 9. Data and Forecast Plot Data Double Exponential Smoothing

able 5 forecasts using the Double Exponential Smoothing method with a value of α=0.1 obtained a deviation of 9.91% and forecast for the 54th period 9510 pcs, the 55th period 9502 pcs, the 56th period 9494 pcs, the 57th period 9486 pcs, the 58th period 9478 pcs, and the 59th period 9470 pcs. Figure 9 shows the pattern of data and forecast, the data color is blue and the forecast is orange.

Table 6. Forecast Recapitulation

Metod	MAPE	Forecast Period					
		1	2	3	4	5	6
DMA 3 period forecast	14,18	9166	8955	8745	8534	8324	8113
DMA 6 period forecast	11,40	9804	9858	9912	9966	10020	10074
DES α=0.1	9,91	9510	9502	9494	9486	9478	9470

Table 6 is a summary of the value of the deviation and the sum of the output of the production forecast for the following six periods. The minimum deviation is found in the Double Exponential Smoothing method with an alpha value of 0.1, which is 9.91% obtaining the predicted results of the 54th period of 9510 pcs, the 55th period 9502 pcs, the 56th period 9494 pcs, and the 57th period 9486 pcs, the 58th period 9478 pcs, and the 59th period 9470 pcs. The data validation process was conducted using the face validation method, where the forecasting results were handed over to the company for evaluation and verification against company conditions. The validation results indicated that the company could apply the forecast data.

C. Aggregate Heuristic Planning

In aggregate planning, two alternatives will be counted: workforce control and overtime control. It does not have inventory; thus, no holding costs are needed. In addition to the supporting data in Table 7, which has already been obtained from the results of interviews with the owner of the CV. Delia Bakery, the data of the outcome of the forecast request is also required as data of production parameters.

Table 7. Additional Data

Description	Total	Units
Total of Workforce	8	Workforce
Work hours per period	10	Hour
Total Work periods per week	6	Period
Fixed production capacity per period	7200	Pcs
Workforce fee per period	Rp 100.000	/Workforce

Description	Total	Units
Overtime cost per hour	Rp 15.000	/Workforce
Maximum overtime	1	Hour

1) Workforce Control Strategy :
   Workforce control strategies can be used when production rates are adjusted to monthly demand levels. This strategy does not apply to hiring cost and firing cost because the company does not issue both costs. Total production is assumed from data obtained over 53 periods because the company has been able to meet demand. Here is the calculation of average production parameters:

- Total production in 2 months (53 Periods) = 511.629 pcs
- Average production per period = $\frac{511.629}{53} = 9.653{,}37 = 9.654$ pcs/period
- Average production per hour = $\frac{9.654}{10} = 965{,}4 = 966$ pcs/hour
- Workforce output per hour = $\frac{966}{8} = 120{,}75 = 121$ pcs/labour/hour
- Workforce output per period = $\frac{9.654}{8} = 1.206{,}75 = 1.207$ pcs/period

Workforce control results on data requests for forecast results. Here are the calculations in the workforce control strategy at period 1 on table 9.

- Workforce needs = $\frac{Period\ demand}{Labour\ Output\ per\ Day} = \frac{9510}{1207} = 7{,}879 = 8\ labour$
- Production Rate = $Workforce\ output\ per\ day \times Workforce\ needs = 1207 \times 8 = 9.654\ pcs/day$
- Workforce Cost = $Labour\ needs \times Labour\ fees\ per\ day = 8 \times 100.0000 = Rp.800.000$
- Total Cost = $Labour\ Cost + Hiring\ Cost + Firing\ Cost = Rp.800.000 + 0 + 0 = Rp\ 800.000$

Table 8. Workforce Control Strategy

Period	Demand	Inventory	Holding Cost	Workforce Needs	Rounded Workforce Needs	Workforce Cost Needs	Total Cost
1	9510	0	0	7,879	8	Rp 800.000	Rp 800.000
2	9502	0	0	7,872	8	Rp 800.000	Rp 800.000
3	9494	0	0	7,866	8	Rp 800.000	Rp 800.000
4	9486	0	0	7,859	8	Rp 800.000	Rp 800.000
5	9478	0	0	7,853	8	Rp 800.000	Rp 800.000
6	9470	0	0	7,846	8	Rp 800.000	Rp 800.000
					Total Cost		Rp 4.800.000

In table 9. From the calculation of the heuristic aggregate planning with the strategy of control of workforce for 6 planning periods obtained the total cost of production of Rp 4,800,000.

2) Overtime Control Strategy:
   The overtime control strategy of the production rate of each period is fixed constantly based on the lowest demand outcome of the forecast because the lower demand is a measure that to produce a few lowest capacity companies do not need overtime. Forecast results in 6 periods with the lowest demand value of 9470. The company have limits of the maximum overtime production time 1 hour per period with an overtime cost per worker per hour of Rp 15,000. The following is the calculation of parameters for overtime control:

- Total Production in 2 months (53 Period) = 511.629 pcs
- Production Rate = $\frac{511.629}{53} = 9.653{,}37 = 9.654$ pcs/period
- Average production per hour = $\frac{9.654}{10} = 965{,}4 = 966$ pcs/hour
- Workforce output per hour = $\frac{966}{8} = 120{,}75 = 121$ pcs/workforce/hour

- Workforce output per period = $\frac{9.654}{8} = 1.206{,}75 = 1.207$ pcs/period
- Workforce = $\frac{production\ level}{production\ output\ per\ day} = \frac{9470}{1207} = 7{,}85 = 8$ workforce
- Overtime capacity per hour = OT workforce per hour = $\frac{production\ level}{work\ time\ per\ day} = \frac{9470}{10} = 947$ pcs/hour

Table 9. Overtime Control Parameter

Descriptiom	Total	Unit
Total production in 6 periods	511.629	Pcs
Average production per period	9.654	pcs/period
Average production per hour	966	pcs/hour
Workforce output per hour	121	pcs/workforce/hour
Workforce output per period	1.207	pcs/period
Workforce fees per period	Rp 100.000	Rp/period
Overtime cost	Rp 15.000	/hour/workforce
Lowest Production Level	9470	Pcs
Overtime capacity per hour	947	pcs/hour
Workforce output per hour	947	pcs/hour
Workforce	8	Workforce

Here are the calculations in overtime control strategy at period 1 in table 11.

- Demand differentiate = $Demand - Production\ Level = 9510 - 9470 = 40\ pcs$
- Overtime needs = 1 hour
- Overtime cost = $Labour \times Bovertime\ cost\ per\ hour = 8 \times 15.000 = Rp.120.000$
- Workforce cost = $labour\ needs \times labour\ fees\ per\ day = 8 \times 100.0000 = Rp.800.000$
- Total cost = $Labour\ cost + overtime\ cost = Rp.800.000 + Rp\ 120.000 = Rp\ 920.000$

Table 10. Overtime Control Strategy

Period	Demand	Lowest Production Level	Demand differentiate	Overtime Capacity/hour	Overtime needs	Workforce	Overtime cost	Workforce fee	Total Cost
1	9510	9470	40	947	1	8	Rp 120.000	Rp 800.000	Rp 920.000
2	9502	9470	32	947	1	8	Rp 120.000	Rp 800.000	Rp 920.000
3	9494	9470	24	947	1	8	Rp 120.000	Rp 800.000	Rp 920.000
4	9486	9470	16	947	1	8	Rp 120.000	Rp 800.000	Rp 920.000
5	9478	9470	8	947	1	8	Rp 120.000	Rp 800.000	Rp 920.000
6	9470	9470	0	947	0	8	Rp -	Rp 800.000	Rp 800.000
				Total Cost					Rp 5.400.000

In table 11. From the calculations of heuristic aggregate planning with overtime control strategies for 6 planning periods, the total cost of production amounted to Rp 5,400,000.

Table 11. Aggregate Planning Recapitulation

Strategy	Cost
Workforce Control	Rp 4.800.000
Overtime Control	Rp 5.400.000

Based on the results of calculations and analysis of production planning and control using heuristic methods of aggregate planning, it is known that using the method of workforce control generates a

total production cost of Rp 4,800,000 and using overtime control strategies generate a total cost of Rp 5,400,000. So between these two strategies the most optimal is the strategy of workforce control with lower production costs of Rp 4,800,000. Workforce control can be implemented by considering the current conditions of the company, where demand can still be met with the existing workforce

Conclusion

The company's observation data for May and June 2023, analyzed using 3 different methods, showed that Double Exponential Smoothing with α=0.1 had the lowest deviation (MAPE) at 9.91%. Predicted results for the following 6 periods were the 54th period of 9510 pcs, the 55th period 9502 pcs, the 56th period 9494 pcs, the 57th period 9486 pcs, the 58th period 9478 pcs, and the 59th period 9470 pcs. Production control strategies used were workforce control and overtime control, which were more cost-efficient, saving Rp 4,800,000 over 6 forecast periods. Utilizing predictive analysis and comprehensive planning allows for achieving cost reductions. However, it is crucial to regularly monitor and calculate prediction variables to improve accuracy as prediction accuracy diminishes over time. The limitation of the forecasting method is that forecast values tend to fluctuate continuously, necessitating periodic forecasting using actual data to maintain the stability of forecast results.

Acknowledgments

Reference

[1] M. Fitri and G. Jauhari, "Analisis Perencanaan Produksi Roti Untuk Memenuhi Permintaan di UD. Bunga Bakery," *Saintek*, vol. 2, no. 2, pp. 89–96, 2018, [Online]. Available: https://doi.org/10.32524/saintek.v2i2.138.

[2] N. Nurhasanah, C. A. Nurpraja, S. Himawan, and A. Ramadanti, *Metode Peramalan Deret Waktu : Teori dan Aplikasinya*. Penerbit KBM Indonesia, 2022.

[3] R. Satyarini, "Menentukan Metode Peramalan yang Tepat," *Jurnal Ilmiah Fakultas Ekonomi Universitas Katolik Parahyangan*, vol. 11, no. 1. Bandung, 2007, [Online]. Available: https://media.neliti.com/media/publications/27539-ID-menentukan-metode-peramalan-yang-tepat.pdf.

[4] R. Ambarwati and Supardi, *Buku Ajar Manajemen Operasional Dan Implementasi Dalam Industri*. Sidoarjo: UMSIDA Press, 2020.

[5] N. Savitri, "Penerapan Peramalan Penjualan (Sales Forecast) Roti Sebagai Dasar Penyusunan Perencanaan Produksi Pada Ciwawa Cake and Bakery," Universitas Psundan, 2016.

[6] D. R. Indah and E. Rahmadani, "Sistem Forecasting Perencanaan Produksi dengan Metode Single Eksponensial Smoothing pada Keripik Singkong Srikandi Di Kota Langsa," *J. Penelit. Ekon. Akunt.*, vol. 2, no. 1, pp. 10–18, 2019, [Online]. Available: https://ejurnalunsam.id/index.php/jensi/article/view/930.

[7] M. Hilmy, Badie'ah, and H. Munawar, "Implementasi Metode Double Exponential Smoothing untuk Memprediksi Kebutuhan Produksi pada CV. Pusaka Indah Furniture Jepara," *Pros. Semin. Nas. Konstelasi Ilm. Mhs. UNISSULA 5 (KIMU 5)*, vol. 5, no. Kimu 5, pp. 86–96, 2021.

[8] R. Fanisya, "Penerapan Double Exponential Smoothing Dan Trend Analysis Dalam Peramalan Permintaan Kemasan Maintenance Box Di PT XYZ," *Proceeding Semin. Nas. Teknol. Cetak Dan Media Kreat.*, vol. 1, no. 2, pp. 446–454, 2022, [Online]. Available: https://prosiding-old.pnj.ac.id/index.php/TETRAMEKRAF/article/view/4830.

[9] P. M. Tampubolon, *Manajemen Operasi dan Rantai Pemasok Edisi Revisi*, no. November 2019. Mitra Wacana Media, 2018.

[10] E. Pujiati, D. Yuniarti, and R. Goejantoro, "Peramalan Dengan Menggunakan Metode Double Exponential Smoothing Dari Brown (Studi Kasus : Indeks Harga Konsumen (IHK) Kota Samarinda)," *J. EKSPONENSIAL*, vol. 7, no. 1, pp. 33–40, 2016, [Online]. Available: http://jurnal.fmipa.unmul.ac.id/index.php/exponensial/article/view/23.

[11] R. Ariyanto, D. Puspitasari, and F. Ericawati, "Penerapan Metode Double Exponential Smoothing Pada Peramalan Produksi Tanaman Pangan," *J. Inform. Polinema*, vol. 4, no. 1, pp. 57–62, 2017, doi: 10.33795/jip.v4i1.145.

[12] R. Rachman, "Penerapan Metode Moving Average Dan Exponential Smoothing Pada Peramalan Produksi Industri Garment," *J. Inform.*, vol. 5, no. 2, 2018, doi: 10.31311/ji.v5i2.3309.

[13] C. V. Hudiyanti, F. A. Bachtiar, and B. D. Setiawan, "Perbandingan Double Moving Average dan Double Exponential Smoothing untuk Peramalan Jumlah Kedatangan Wisatawan Mancanegara di Bandara Ngurah Rai," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 3, no. 3, pp. 2667–2672, 2019.

[14] A. Nurlifa and S. Kusumadewi, "Sistem Peramalan Jumlah Penjualan Menggunakan Metode Moving Average Pada Rumah Jilbab Zaky," *INOVTEK Polbeng - Seri Inform.*, vol. 2, no. 1, p. 18, 2017, doi: 10.35314/isi.v2i1.112.

[15] R. Mustapa, M. Latief, and M. Rohandi, "Double moving average method for predicting the number of patients with dengue fever in Gorontalo City," *Sci. Technol.*, vol. 2, pp. 332–337, 2019, [Online]. Available: https://series.gci.or.id.

[16] C. Baktiar, A. Wibowo, and R. Adipranata, "Pembuatan Sistem Peramalan Penjualan Dengan Metode Weighted Moving Average dan Double Exponential Smoothing Pada UD Y," *J. Ilm.*, vol. vol 7, no. global, pp. 1–5, 2013, [Online]. Available: https://media.neliti.com/media/publications/103445-ID-pembuatan-sistem-peramalan-penjualan-den.pdf.

[17] T. P. Modul, "Chapter 2 : Forecasting," 2017.

[18] Muhammad Nurdin and Fauzi widyawati, "Analysis of Forecasting and Control of Calcium Carbide and Flour Spar Inventories (Case Study: PT. XYZ Southeast Sulawesi)," *J. Tek. Ind.*, vol. 12, no. 3, pp. 258–264, 2022, doi: 10.25105/jti.v12i3.15658.

[19] M. Layakana and S. Iskandar, "Penerapan Metode Double Moving Average dan Double Eksponential Smoothing dalam Meramalkan Jumlah Produksi Crude Palm Oil (CPO) Pada PT. Perkebunan Nusantara IV Unit Dolok Sinumbah," *Karismatika*, vol. 6, no. 1, pp. 44–53, 2020, [Online]. Available: https://jurnal.unimed.ac.id/2012/index.php/jmk/article/download/19309/13924.

[20] A. Lusiana and P. Yuliarty, "PENERAPAN METODE PERAMALAN (FORECASTING) PADA PERMINTAAN ATAP di PT X," *Ind. Inov. J. Tek. Ind.*, vol. 10, no. 1, pp. 11–20, 2020, doi: 10.36040/industri.v10i1.2530.

[21] U. Khair, H. Fahmi, S. Al Hakim, and R. Rahim, "Forecasting Error Calculation with Mean Absolute Deviation and Mean Absolute Percentage Error," *J. Phys. Conf. Ser.*, vol. 930, no. 1, 2017, doi: 10.1088/1742-6596/930/1/012002.

[22] F. A. Reicita, "Analisis Perencanaan Produksi Pada Pt. Armstrong Industri Indonesia Dengan Metode Forecasting Dan Agregat Planning," *J. Ilm. Tek. Ind.*, vol. 7, no. 3, pp. 160–168, 2020, doi: 10.24912/jitiuntar.v7i3.6340.

[23] E. Noegraheni and H. Nuradli, "Aggregate Planning to Minimize Cost of Production in Manufacturing Company," *Binus Bus. Rev.*, vol. 7, no. 1, p. 39, 2016, doi:10.21512/bbr.v7i1.1448.

[24] S. T. Wahyuni, "OPTIMALISASI PRODUKSI PADA PERUSAHAAN ROTI 'DONNA JAYA BAROKAH' JEMBER MELALUI PENDEKATAN GOAL PROGRAMING," Universitas Jember, Jember, 2015.

[25] A. K. Nisa and T. Y. T. Kusuma, "Perencanaan dan Pengendalian Produksi Dengan Metode Aggrate Planning Di C-Maxi Alloycast," *Integr. Lab J.*, vol. 5, no. 2, pp. 51–62, 2017, [Online]. Available: https://ejournal.uin-suka.ac.id/pusat/integratedlab/article/view/1553.

[26] Reynaldo, "Analisa Perencanaan Agregat untuk Meminimalisasi Biaya Produksi Nippe 2000 pada PT Nippon Paint," Universitas Multimedia Nusantara, 2018.