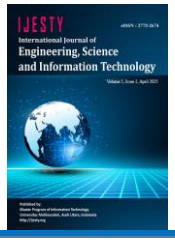
International Journal of Engineering, Science and Information Technology
Volume 5 No. 2 (2025) pp. 223-231
ISSN 2775-2674 (online)
Website: http://ijesty.org/index.php/ijesty
DOI: https://doi.org/10.52088/ijesty.v5i2.817
Research Paper, Short Communication, Review, Technical Paper



Forecasting the Inventory of Milled Dry Grain Using the Lot Sizing Method at Markom Rice Mill

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The manuscript was received on 21 June 2024, revised on 20 October 2024, and accepted on 22 February 2025, date of publication 6 April 2025

Abstract

Today's industrial activities are increasing with sophisticated technology, all applied to satisfy consumers in various services. One of the important parts of an industry is the inventory of goods. This is related to the continuity of the resulting production. In meeting the needs of consumers, a plan is needed in production so that there is no shortage of raw materials and the production process does not stop. Grain is an agricultural commodity whose demand and production levels occasionally increase. We can see that until now, our country, Indonesia, still imports rice from other countries, where rice is the main production product produced from grain. The problem can be solved with the Lot sizing method used in this study, which is used to determine the size of the order quantity. In the rice mill itself, grain storage has a limited capacity, so it cannot be directly stored with a large capacity when the price of grain is down. Applying this method as an application will make it easier to manage grain inventory at the rice mill and estimate inventory costs for the next 1 () year. The results of the lot sizing calculation (silver meal) show that for the next year, the smallest cost of procurement of dry milled grain (MDG) demand is obtained from the procurement of demand every month. In other words, procurement is more appropriate every month or period so that the costs incurred for grain inventory are smaller. The following data are the results of the silver meal lot sizing calculation: (1) 39015.4 kg, (2) 35871.2 kg, (3) 39536 kg, (4) 33894.8 kg, (5) 31402 kg, (6) 27982.5 kg, (7) 41461.9 kg, (8) 35336.7 kg, (9) 41305.6 kg, (10) 45717.5 kg, (11) 42007.9 kg, (12) 50828 kg. The cost incurred per order is Rp. 6,000,000.

***Keywords**: Forecasting, Milled Dry Grain, Lot Sizing, Agriculture.*

1. Introduction

Today's industrial activities are increasing with sophisticated technology, all applied to satisfy consumers in various services [1]. One of the essential parts of an industry is the inventory of goods; this relates to the continuity of the resulting production [2], [3]. Smooth production is a significant service so that goods or products are always available according to the needs of consumers [4].
In meeting the needs of consumers, a plan is needed in production so that there is no shortage of raw materials and the production process does not stop [5], [6]. Forecasting is a way to find out or estimate what will happen in the future and can provide an overview in determining future production planning [7], [8]. Forecasting is the initial part of a decision-making process to estimate the expected level of demand for a product or several products within a certain period in the future [9], [10]. Forecasting depends on sufficient historical data to be described statistically and on relatively stable market-forming factors.
Inventory is idle resources waiting for further processing. Inventory is goods stored for use or sale in the future or the future. Inventory consists of raw, semi-finished, and finished goods inventory. Inventories of finished and semi-finished goods are stored before they are used or put into production.

Grain is an agricultural commodity whose demand and production levels occasionally increase. This can be seen where, until now, our country, Indonesia, still imports rice from other countries, where rice is the main production product produced from grain. Milled dry grain (GKG) has undergone the drying process so that it is free from the moisture content contained in the grain and can be ground immediately without needing to dry again [11], [12].
Lot sizing is used to determine the order quantity size [13]. In the rice mill itself, grain storage has a limited capacity, so it cannot be directly stored with a large capacity when the price of grain is down. Applying this method as an application will make it easier to manage grain inventory at the rice mill and estimate inventory costs for the following year.

2. Literature Review

Forecasting is the initial part of a decision-making process to forecast the expected level of demand for a product or several products over some time in the future [14], [15]. Forecasting depends on the existence of sufficient historical data to be statistically decipherable and also depends on market-forming factors being relatively stable [16].
Inventory is an asset that includes goods owned by the company to be sold within a standard business period, inventory of goods that are still in the work/production process, or inventory of raw materials awaiting use in a production process [17].
Optimization is the result achieved as desired, so optimization is the achievement of results as expected effectively and efficiently [18].
Safety stock (persediaan pengaman) atau sering pula disebut sebagai persediaan besi (iron stock) adalah suatu persediaan yang dicadangkan sebagai pengaman dari kelangsungan proses produksi perusahaan [19].
The lot sizing technique is a technique to minimize the number of items to be ordered and minimize inventory costs [20].

3. Research Method

3.1. Data Processing and Analysis

In processing the existing data, we will use the following steps:
1. Forecasting
   Calculating the forecast of demand for milled dry grain raw materials for 12 (twelve) periods or 1 (one) year ahead using two forecasting methods, namely:
   a. Constant Forecasting Method
   b. Linear Forecasting Method
2. Determine the forecasting method with the smallest mean square error value.
3. Calculating safety stock.
4. Calculating the order size (lot)

This research uses the silver meal method to determine lot size.

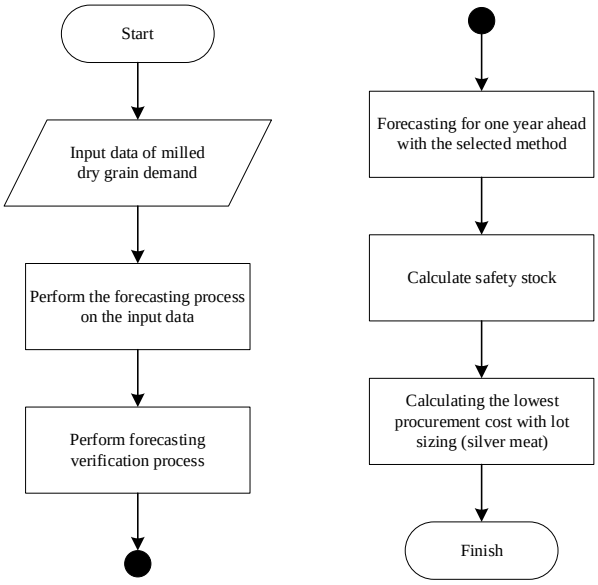

Fig 1. System Schematic

3.2. System Analysis

The system to be built will use forecasting methods and methods regarding optimization of a lot sizing. This forecasting uses data from the period and the needs or demands of the grain processing plant (rice refinery) for 60 periods (5 years) from 2011 to 2015. The comparison between these two forecasts must first find the value of the standard error of each forecast. The standard error measurement uses the MSE (Mean Square Error) method. After the MSE is obtained, calculations will be made for the next year using the selected forecasting method from the minor MSE results. The next stage of this system is to calculate the safety stock value. The forecasting results' standard deviation value is needed to find the safety stock value.
Calculation of lot sizing: here, in more detail, we use silver meal lot sizing. After the forecast for the next year is obtained, the lot-sizing value will be calculated. In calculating lot sizing, the data used are the shelf price, message price, period, and forecasting results for the following year. The storage price and message price use a benchmark from the price in the previous period or the price in the last year of the total five years of dry-milled grain demand data at the rice mill.

3.2.1. Demand Data for Milled Dry Grain (GKG)

The data is from the demand (needs) of each period (month) of the Markom rice refinery for five years, from 2011 to 2015. The following is data from the demand (needs) of the Markom rice refinery within five years (60 periods), which is summarized in Table 1:

Table 1. Five-year GKG demand data

Period	2011 (Kg)	2012 (Kg)	2013 (Kg)	2014 (Kg)	2015 (Kg)
1	32241	46501	33002	47311	53943
2	42079	36265	34831	39178	43480
3	54981	41522	34506	32015	52816
4	32254	40731	23190	38347	50521
5	30063	21094	61146	24100	35031
6	33676	43597	23114	27195	25184
7	58390	41141	48941	26409	51473
8	32764	37188	41757	37258	43948
9	40257	39866	47020	45670	52688
10	36605	57798	44938	48177	62069
11	50456	46030	33375	42282	57192
12	59679	46147	38969	69272	63420
Total	503445	497880	464789	477214	591765
Average	41953,75	46147	38732,42	39767,83	49313,75

From the data in Table 1, it is found that the average demand per month in each year is as follows: 41953.75 Kg, 46147 Kg, 38732.42 Kg, 39767.83 Kg, 49313.75 Kg. As for the average value per year, it is obtained at 42251.55 Kg. We can see the trend pattern of the demand for dry-milled grain needs in Figure 2 below.

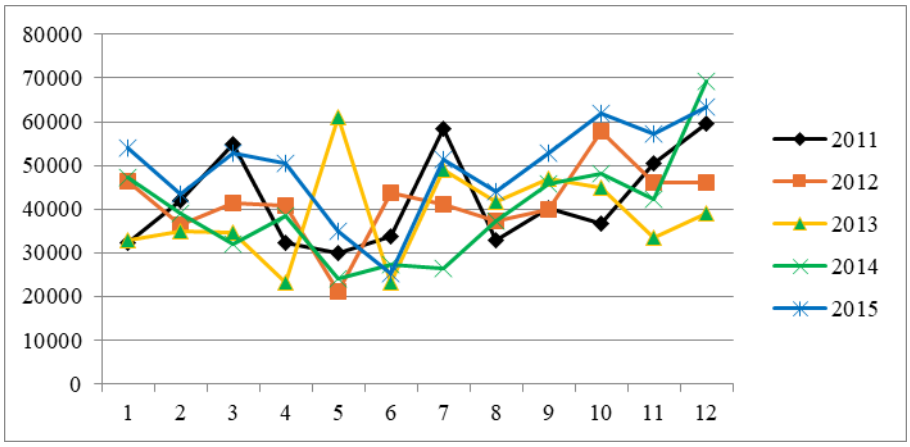

Fig 2. Five-year graph of demand for GKG

From the graph above, it can be seen that demand fluctuates between periods in one year.

3.2.2. Ordering Cost and Purchase Cost

The cost of ordering dry unhusked rice obtained from the results of interviews with the owner of the Markom rice mill is shown in Table 2 below:

Table 2. Order cost data

Description	Costs (Rp)
Cost per message	600.000
Number of orders per period	10
Total cost of the order	6000.000

As for the annual purchase cost is different and continues to increase yearly, with the increase being around Rp.100.00 per year. The data can be seen in Table 3 below:

Table 3. Purchase cost data

Costs per year	Price/kg (Rp)
2011	4400
2012	4500
2013	4600
2014	4700
2015	4800

The price of milled dry grain in 2015 can be seen in Table 4 below. Several factors, including market demand, harvest, and weather, influence the cost of grain itself. Here is a sample of prices in 2015.

Table 4. Sample of milled dry grain prices in 2015

Month	Price/kg (Rp)
1	5300
2	5300
3	5150
4	4900
5	4700
6	4700
7	4700
8	4700
9	4700
10	4500
11	4500
12	5300
Total	58450
Average	4870,83

3.2.3. Storage Cost

Storage costs are costs that the rice mill must incur to store dry-milled grain in the warehouse. The costs incurred based on the results of the interview obtained that the cost of storing in 1 ton is summarized in Table 5 below:

Table 5. Storage cost data

Information	Costs (Rp)
Cost in 1 ton GKG	348.000
Cost for 1 kg of GKG	348

3.2.4. Lead Time for Ordering GKG

Lead time is the time difference from the time of ordering until the goods are received. Based on the results of the interviews, the lead time for ordering GKG is seven days.

4. Result and Discussion

4.1. Forecasting the Demand for Milled Dry Grain (MDG)

Based on the raw material demand data for the period 2011-2015, it can be seen that the demand fluctuated, and for this forecast, constant and linear methods were used. Meanwhile, to choose which method is best for forecasting demand for the next year, the MSE (Mean Square Error) method will be used, where the technique that has the smallest error value will be chosen to forecast the results of the following year for the demand for milled dry grain (MDG) from the Markom rice mill.

1. Constant Forecasting

   The results of manual calculations for constant forecasting are as follows:

Table 6. Constant calculation

No.	Period	Requirement (Kg)	Constants	e	e^2	Period	Requirement (Kg)	Constants	e	e^2
1	1	32241	42251,55	-10011	100211111	31	48941	42251,55	6689	44748741
2	2	42079	42251,55	-173	29774	32	41757	42251,55	-495	244580
3	3	54981	42251,55	12729	162038897	33	47020	42251,55	4768	22738115
4	4	32254	42251,55	-9998	99951006	34	44938	42251,55	2686	7217014
5	5	30063	42251,55	-12189	148560751	35	33375	42251,55	-8877	78793140
6	6	33676	42251,55	-8576	73540058	36	38969	42251,55	-3283	10775135
7	7	58390	42251,55	16138	260449568	37	47311	42251,55	5059	25598034
8	8	32764	42251,55	-9488	90013605	38	39178	42251,55	-3074	9446710
9	9	40257	42251,55	-1995	3978230	39	32015	42251,55	-10237	104786956
10	10	36605	42251,55	-5647	31883527	40	38347	42251,55	-3905	15245511
11	11	50456	42251,55	8204	67313000	41	24100	42251,55	-18152	329478767
12	12	59679	42251,55	17427	303716014	42	27195	42251,55	-15057	226699698
13	13	46501	42251,55	4249	18057825	43	26409	42251,55	-15843	250986391
14	14	36265	42251,55	-5987	35838781	44	37258	42251,55	-4994	24935542
15	15	41522	42251,55	-730	532243	45	45670	42251,55	3418	11685800
16	16	40731	42251,55	-1521	2312072	46	48177	42251,55	5925	35110958
17	17	21094	42251,55	-21158	447641922	47	42282	42251,55	30	927
18	18	43597	42251,55	1345	1810236	48	69272	42251,55	27020	730104718
19	19	41141	42251,55	-1111	1233321	49	53943	42251,55	11691	136690003
20	20	37188	42251,55	-5064	25639539	50	43480	42251,55	1228	1509089
21	21	39866	42251,55	-2386	5690849	51	52816	42251,55	10564	111607604
22	22	57798	42251,55	15546	241692108	52	50521	42251,55	8269	68383803
23	23	46030	42251,55	3778	14276684	53	35031	42251,55	-7221	52136342

24	24	46147	42251,55	3895	15174531	54	25184	42251,55	-17068	291301263
25	25	33002	42251,55	-9250	85554175	55	51473	42251,55	9221	85035140
26	26	34831	42251,55	-7421	55064562	56	43948	42251,55	1696	2877943
27	27	34506	42251,55	-7746	59993545	57	52688	42251,55	10436	108919489
28	28	23190	42251,55	-19062	363342688	58	62069	42251,55	19817	392731325
29	29	61146	42251,55	18894	357000241	59	57192	42251,55	14940	223217046
30	30	23114	42251,55	-19138	366245820	60	63420	42251,55	21168	448103275
			Total			1830	2535093	2535093	0	7289895741

Information:
Constants: Constant forecasting calculation value
e: Error (constant-need)
e^2: Squared errors

2. Linear Forecasting

The results of the manual search for the linear forecasting method get the following results:

Table 7. Linear calculation of part one

No.	Period	Requirements (Kg)	ty	t^2	a	b	No.	Period	Requirements (Kg)	ty	t^2	a	b
1	1	32241	32241	1	37733,9	148,1196	31	31	48941	1517171	961	37733,9	148,1196
2	2	42079	84158	4	37733,9	148,1196	32	32	41757	1336224	1024	37733,9	148,1196
3	3	54981	164943	9	37733,9	148,1196	33	33	47020	1551660	1089	37733,9	148,1196
4	4	32254	129016	16	37733,9	148,1196	34	34	44938	1527892	1156	37733,9	148,1196
5	5	30063	150315	25	37733,9	148,1196	35	35	33375	1168125	1225	37733,9	148,1196
6	6	33676	202056	36	37733,9	148,1196	36	36	38969	1402884	1296	37733,9	148,1196
7	7	58390	408730	49	37733,9	148,1196	37	37	47311	1750507	1369	37733,9	148,1196
8	8	32764	262112	64	37733,9	148,1196	38	38	39178	1488764	1444	37733,9	148,1196
9	9	40257	362313	81	37733,9	148,1196	39	39	32015	1248585	1521	37733,9	148,1196
10	10	36605	366050	100	37733,9	148,1196	40	40	38347	1533880	1600	37733,9	148,1196
11	11	50456	555016	121	37733,9	148,1196	41	41	24100	988100	1681	37733,9	148,1196
12	12	59679	716148	144	37733,9	148,1196	42	42	27195	1142190	1764	37733,9	148,1196
13	13	46501	604513	169	37733,9	148,1196	43	43	26409	1135587	1849	37733,9	148,1196
14	14	36265	507710	196	37733,9	148,1196	44	44	37258	1639352	1936	37733,9	148,1196
15	15	41522	622830	225	37733,9	148,1196	45	45	45670	2055150	2025	37733,9	148,1196
16	16	40731	651696	256	37733,9	148,1196	46	46	48177	2216142	2116	37733,9	148,1196
17	17	21094	358598	289	37733,9	148,1196	47	47	42282	1987254	2209	37733,9	148,1196
18	18	43597	784746	324	37733,9	148,1196	48	48	69272	3325056	2304	37733,9	148,1196
19	19	41141	781679	361	37733,9	148,1196	49	49	53943	2643207	2401	37733,9	148,1196
20	20	37188	743760	400	37733,9	148,1196	50	50	43480	2174000	2500	37733,9	148,1196
21	21	39866	837186	441	37733,9	148,1196	51	51	52816	2693616	2601	37733,9	148,1196
22	22	57798	1271556	484	37733,9	148,1196	52	52	50521	2627092	2704	37733,9	148,1196
23	23	46030	1058690	529	37733,9	148,1196	53	53	35031	1856643	2809	37733,9	148,1196
24	24	46147	1107528	576	37733,9	148,1196	54	54	25184	1359936	2916	37733,9	148,1196
25	25	33002	825050	625	37733,9	148,1196	55	55	51473	2831015	3025	37733,9	148,1196
26	26	34831	905606	676	37733,9	148,1196	56	56	43948	2461088	3136	37733,9	148,1196
27	27	34506	931662	729	37733,9	148,1196	57	57	52688	3003216	3249	37733,9	148,1196
28	28	23190	649320	784	37733,9	148,1196	58	58	62069	3600002	3364	37733,9	148,1196
29	29	61146	1773234	841	37733,9	148,1196	59	59	57192	3374328	3481	37733,9	148,1196
30	30	23114	693420	900	37733,9	148,1196	60	60	63420	3805200	3600	37733,9	148,1196
			Total				1830	2535093	79985748	73810			

Information:
ty: Time multiplied by the need
t^2: Squared time
a: Intercept
b: Slope of the line

Table 8. Linear Calculation Part Two

No.	Linear	e	e^2		Linear	e	e^2
1	37882,02295	-5641,022951	31821139,93	31	42325,60978	6615,39022	43763387,76
2	38030,14251	4048,857488	16393246,96	32	42473,72934	-716,7293415	513700,9489
3	38178,26207	16802,73793	282332001,9	33	42621,8489	4398,151098	19343733,08
4	38326,38163	-6072,381634	36873818,71	34	42769,96846	2168,031537	4700360,743
5	38474,50119	-8411,501195	70753352,35	35	42918,08802	-9543,088024	91070529,04
6	38622,62076	-4946,620756	24469056,9	36	43066,20759	-4097,207585	16787110
7	38770,74032	19619,25968	384915350,5	37	43214,32715	4096,672854	16782728,47
8	38918,85988	-6154,859878	37882300,11	38	43362,44671	-4184,446707	17509594,25
9	39066,97944	1190,020561	1416148,936	39	43510,56627	-11495,56627	132148043,8
10	39215,099	-2610,099	6812616,788	40	43658,68583	-5311,685829	28214006,35
11	39363,21856	11092,78144	123049800,1	41	43806,80539	-19706,80539	388358178,7
12	39511,33812	20167,66188	406734585,6	42	43954,92495	-16759,92495	280895084,4
13	39659,45768	6841,542317	46806701,28	43	44103,04451	-17694,04451	313079211,2
14	39807,57724	-3542,577244	12549853,53	44	44251,16407	-6993,164073	48904343,76
15	39955,6968	1566,303195	2453305,7	45	44399,28363	1270,716366	1614720,082
16	40103,81637	627,1836343	393359,3112	46	44547,4032	3629,596805	13173972,96
17	40251,93593	-19157,93593	367026509	47	44695,52276	-2413,522756	5825092,095
18	40400,05549	3196,944512	10220454,22	48	44843,64232	24428,35768	596744659,1
19	40548,17505	592,8249514	351441,423	49	44991,76188	8951,238122	80124663,91
20	40696,29461	-3508,29461	12308131,07	50	45139,88144	-1659,881439	2755206,392
21	40844,41417	-978,4141706	957294,2892	51	45288,001	7527,999	56670768,94
22	40992,53373	16805,46627	282423696,5	52	45436,12056	5084,879439	25855998,91
23	41140,65329	4889,346707	23905711,23	53	45584,24012	-10553,24012	111370877,1
24	41288,77285	4858,227146	23602371,01	54	45732,35968	-20548,35968	422235085,7
25	41436,89241	-8434,892415	71147410,05	55	45880,47924	5592,520756	31276288,4
26	41585,01198	-6754,011976	45616677,77	56	46028,59881	-2080,598805	4328891,388
27	41733,13154	-7227,131537	52231430,25	57	46176,71837	6511,281634	42396788,51
28	41881,2511	-18691,2511	349362867,6	58	46324,83793	15744,16207	247878639,4
29	42029,37066	19116,62934	365445517,4	59	46472,95749	10719,04251	114897872,4
30	42177,49022	-19063,49022	363416659,3	60	46621,07705	16798,92295	282203812,3
		Total			2535093	1,38243E-10	6895096160

Information:
Linear: Linear forecasting calculation value
e: Error (Necessity-Linear)
e^2: Squared Error
The results for forecasting the demand for dry milled grain one year ahead (twelve periods) in the linear method obtained the following results:

Table 9. Linear forecasting results

Period	Requirements Forecasting
1	37882,02
2	38030,14
3	38178,26
4	38326,38
5	38474,5
6	38622,62
7	38770,74
8	38918,86
9	39066,98

10	39215,1
11	39363,22
12	39511,34

4.3. Forecasting Verification

The forecasting method used for next year is the linear forecasting method. This selected method is determined after calculating the MSE (Mean Square Error) value and obtaining constant MSE results of 121498262.3 and linear MSE of 114918269.3. These results show that the linear MSE value is smaller than the continuous MSE value, so the linear forecasting method is more suitable for forecasting the following year.

The linear forecasting results are then modeled to be close to the actual conditions. An index value is required to create a forecasting pattern, which comes from dividing the average of each period in five years by the total linear forecasting for one year, which is 464360. After obtaining the index value, then to find the forecasting value for each period or month, multiplication between the index value of each month and the total value of linear forecasting for a year is carried out, and the results are obtained as shown in the table below.

Table 10. Forecasting for one year ahead

Period	Average month/year	Index Value	Forecasting
1	42599,6	0,08402	39015,447
2	39166,6	0,07725	35871,285
3	43168	0,08514	39536,024
4	37008,6	0,07299	33894,851
5	34286,8	0,06762	31402,051
6	30553,2	0,06026	27982,581
7	45270,8	0,08929	41461,903
8	38583	0,0761	35336,787
9	45100,2	0,08895	41305,657
10	49917,4	0,09845	45717,558
11	45867	0,09046	42007,942
12	55497,4	0,10946	50828,08
Total	507018,6	1	464360,17
Average			38696,68054

The graph for forecasting results one year ahead is as follows:

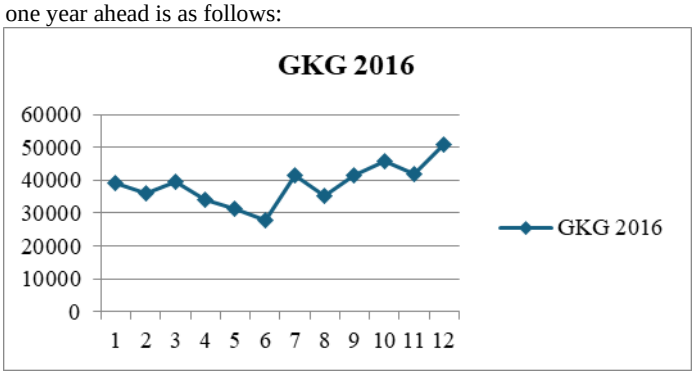

Fig 3. Forecasting result chart

4.4. Safety Stock Calculation

The results of the safety stock calculation using the forecasting data for the next year are as follows:

Table 11. Safety stock calculation

Period	Forecasting	Forecasting^2
1	39015,447	1522205109
2	35871,285	1286749115
3	39536,024	1563097213
4	33894,851	1148860891
5	31402,051	986088834,2
6	27982,581	783024838,8
7	41461,903	1719089435

8	35336,787	1248688519
9	41305,657	1706157299
10	45717,558	2090095095
11	42007,942	1764667160
12	50828,08	2583493704
Total	464360,17	18402217215
Average	38696,681	1533518101

Before looking for safety stock, we must find the standard deviation's value. The standard deviation value is 6274.2, and the value for the safety stock is 7309.43 kg.

4.5. Lot sizing calculation

The results of the lot sizing calculation using data from linear forecasting for the next year are as follows:

Table 12. Lot sizing calculation results (silver meal)

Period	Forecasting	M	K
*1	39015,44706	1	6000000
2	35871,28538	2	9887286,793
*2	35871,28538	1	6000000
3	39536,02425	2	10590916,66
*3	39536,02425	1	6000000
4	33894,85052	2	9507811,299
*4	33894,85052	1	6000000
5	31402,05143	2	9029193,875
*5	31402,05143	1	6000000
6	27982,58099	2	8372655,55
*6	27982,58099	1	6000000
7	41461,90341	2	10960685,46
*7	41461,90341	1	6000000
8	35336,78706	2	9784663,115
*8	35336,78706	1	6000000
9	41305,65699	2	10930686,14
*9	41305,65699	1	6000000
10	45717,55784	2	11777771,11
*10	45717,55784	1	6000000
11	42007,94163	2	11065524,79
*11	42007,94163	1	6000000
12	50828,07988	2	12758991,34
*12	50828,07988	1	6000000

Information:
M: Number of periods in a single message
K: Order cost for each period
*: Period with the most minor order cost

3. Conclusion

Based on the results of research and discussion, the authors can draw the following conclusions:

1. The forecasting results of the two methods show that forecasting using the linear method has a smaller error value. The forecasting error is obtained from the search results using the MSE (Mean Square Error) method. So, the method chosen to forecast the demand for dry unhusked rice (MDG) for twelve periods (one year) is the linear method, where demand in 2016 decreased by 12.06% from 2015. The data from the linear forecasting results are then formed into a forecasting pattern to get results that are close to the actual results so that the final results are as follows starting from periods one to twelve; (1) 39015.4 kg, (2) 35871.2 kg, (3) 39536 kg, (4) 33894.8 kg, (5)31402 kg, (6) 27982.5 kg, (7) 41461.9 kg, (8) 35336.7 kg, (9) 41305.6 kg, (10) 45717.5 kg, (11) 42007.9 kg, (12) 50828 kg.
2. The results of the lot sizing calculation (silver meal) show that for the next year, the minor cost of procuring the demand for milled dry grain (MDG) is obtained from the results of procuring demand every month. In other words, procurement is more appropriate

every month or period so that the costs incurred for grain inventory are smaller. The following data are the results of the silver meal lot sizing calculation: (1) 39015.4 kg, (2) 35871.2 kg, (3) 39536 kg, (4) 33894.8 kg, (5) 31402 kg, (6) 27982.5 kg, (7) 41461.9 kg, (8) 35336.7 kg, (9) 41305.6 kg, (10) 45717.5 kg, (11) 42007.9 kg, (12) 50828 kg. The cost incurred for each order is Rp. 6000,000.

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