



PRODUCTION PLANNING OPTIMIZATION AND SALES BUDGETING USING LAGRANGE MULTIPLIER IN WOVEN STRAPPING CRAFTS

St Nova Meirizha¹, Denny Astrie Anggraini², Agus Mulyadi³, Rio Saputra⁴

Universitas Muhammadiyah Riau^{1,2,3,4},

Jl. Tuanku Tambusai, Kota Pekanbaru, 28294^{1,2,3,4}

E-mail: novameirizha@umri.ac.id¹, dennyastrie@umri.ac.id², agusmulyadi@umri.ac.id³

ABSTRACT

UKM Tunas Harapan produces woven strapping products such as shopping baskets, along-along, mats, and pots with distribution areas such as Riau, North Sumatra, West Sumatra, Jambi, and Aceh. UKM find it difficult to plan the amount of production and control sales so that they often overproduce, which causes profits to be not maximized. The research objectives are calculating the optimal production amount and allocation to each distribution area, making an optimal sales budget plan, and calculating the profit obtained using the Lagrange multiplier method. The optimal number of production results for each product per period: 1878 shopping baskets, 1983 along-along, 283 mats, and 1425 pots. The allocation for each distribution area of each product in 1 year is Riau: 4662 shopping baskets, along- 4807 along, 837 mats, and 3658 pots. West Sumatra: 4445 shopping baskets, 5097 along-along, 841 mats, 3262 pots. North Sumatra: 5023 shopping baskets, 5608 along-along, 714 mats, 4017 pots. Jambi: 4198 shopping baskets, 4197 along-along, 615 mats, 3743 pots. Aceh: 4211 shopping baskets, 4092 along-along, 417 mats, pots, as many as 2421. While the optimal sales budget is Rp. 3,496.856,390 with the total profit obtained Rp. 1,748,394,343 the percentage of profit is 49.99%.

Keywords: Sales Budget, Lagrange Multiplier, Production Planning, Optimization, Small and Medium Enterprises (UKM)

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Address :

Jl. Urip Sumoharjo Km. 5 (Kampus II UMI)
Makassar Sulawesi Selatan.

Email :

Jiem@umi.ac.id

Phone :

+6281341717729

+6281247526640

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1. INTRODUCTION

The problem of optimization is one of the problems often experienced by the industrial sector, both on a large and small scale, such as home industries. In meeting consumer needs, the industrial sector requires optimization in its work. However, the industrial sector often needs help achieving this optimization in practice. Strapping woven crafts Tunas Harapan UKM is one of the industries in the Small and Medium Enterprises (SMEs) sector located in Perawang, Siak Regency, Riau Province. Generally, strapping

ropes are used as a means of binding or packing an object. However, UKM Tunas Harapan uses strapping ropes as a work of art that has a sale value in the form of woven products, such as shopping baskets. The woven products have been distributed to regions such as Riau, North Sumatra, West Sumatra, Jambi, and Aceh. However, UKM Tunas Harapan's owner needs help planning the amount of production and controlling sales, so they often experience excess production, which results in not maximizing profits.

Table 1. Sales Data for January 2020-March 2021

Period	Woven Products (Pcs)											
	Shopping Basket			Along-along			Mats			Pot		
	Production	Sold	Difference	Production	Sold	Difference	Production	Sold	Difference	Production	Sold	Difference
January	2000	1525	475	2000	1898	102	300	211	29	1500	1318	182
February	2000	1421	513	2000	1322	618	300	212	88	1500	1186	314
March	2000	1536	464	2000	1205	195	300	205	95	1500	1213	281
April	2000	2000	0	2000	1788	212	300	298	2	1500	1150	350
May	2000	1619	381	2000	2000	0	300	251	49	1500	913	581
June	2000	1303	691	2000	1183	217	300	300	0	1500	911	523
July	2000	1501	499	2000	1958	42	300	221	19	1500	1331	169
August	2000	2000	0	2000	1251	749	300	209	91	1500	1500	0
September	2000	1475	525	2000	1187	213	300	199	101	1500	1394	106
October	2000	1599	401	2000	2000	0	300	201	99	1500	1180	320
November	2000	2000	0	2000	1676	324	300	239	61	1500	991	503
December	2000	1617	383	2000	1997	3	300	300	0	1500	1431	69
January	2000	1712	288	2000	1809	191	300	295	5	1500	1389	111
February	2000	1130	210	2000	1189	211	300	289	11	1500	1317	123
March	2000	1690	310	2000	1886	114	300	261	33	1500	1411	89

Table 1 shows that the demand for each woven product from UKM Tunas Harapan often experiences excess production, as evidenced by the difference between the quantity produced and the number of products sold. To avoid accumulation in the warehouse due to limited capacity, the policy adopted by UKM Tunas Harapan is to sell excess products below the cost price (sale price). This policy resulted in the acquisition of profits to be not optimal. Through observations and interviews in the production and sales departments, there are several

indicators of the causes of problems faced by SMEs, including not having a production planning system and a standard sales budget. Even with this system, UKM Tunas Harapan can optimize the use of raw materials and production costs and target maximum profits in the future. Budgeting is a plan that is arranged systematically, which covers all company activities, which are expressed in monetary units, and are valid for a certain period to come (Munandar, 2013), (Nafarin, 2012), (Ruadianto, 2009). Meanwhile, the sales budget can be defined as the company's

future sales plan, where in preparing the budget, it is necessary to consider the factors that affect sales (Munandar, 2013), (Harahap, 1996).

Previous research on sales budgeting used the top-down method but needed to consider optimal sales while each industry's primary goal was to obtain optimal profits (Putrayasa, 2018). In addition, the least square method (LSM) is widely used in calculating sales budgets, such as building materials (Wijaya and Novelia, 2017), fertilizers (Eva, 2021), convection (Darwis and Yusiana, 2016), HDPE plastic (Retnosari, 2018), beverages (Retnosari, 2015), and furniture (Husnayetti, 2018). The Moment method can be used in sales budgeting when the historical data is odd/even and can be combined with the sales seasonality index (Fuad and Novita, 2016). Research (Rahayu, 2011) compared the moment method, LSM, semi-average, and quadratic method in determining sales budgets for concentrated latex and rubber smoke sheet (RSS), where the quadratic form was chosen because it has a minor error value. This is also supported by (Kurniawati, Jamiyla and Pratiwi, 2017). The Autoregressive Integrated Moving Average (ARIMA) method with the box-Jenkins approach in forecasting sales at distributors for industrial needs has a minor error value (Tan and Astuti, 2020). Analyzing the variance of the sales budget with actual production to measure company performance according to predetermined targets (Martin, Rahayuningsih and Safi'i, 2020; Utami and Setyariningsih, 2020). In addition, analysis of variance with descriptive qualitative research is used to determine the variance of sales budget and actual sales and the causes of these variances (Saputra and Putrayasa, 2018).

This study uses the Lagrange multiplier method in production planning and sales budget preparation. Previous studies have been researched by (Widya Nurcahayanty Tanjung, 2017), but the object of research is different, namely in food industry companies such as syrups, sauces, soy sauce, snacks, toddler nutrition, and drinks. At the same time, the object of this research is SMEs with non-food products, namely woven products. The Lagrange multiplier method is used to solve the rational function of a problem directly related to the constraint function. The Lagrange multiplier method with

Kuhn-Tucker conditions is used to minimize a function $f(x_1, x_2, \dots, x_n)$ with the inequality constraint $g(x_1, x_2, \dots, x_n) \leq a$ and both functions are continuous and differentiable to a simple minimum function without constraint.

$$h(x_1, \dots, x_n, \lambda) = f(x_1, \dots, x_n) + \lambda(g(x_1, \dots, x_n) - a) \quad (1)$$

Where λ does not depend on x is a Lagrange multiplier, and a is a non-negative constant. To minimize the unconstrained function $h = f + (g - a)$, the Kuhn-Tucker condition for a function with an inequality constraint must satisfy:

$$\frac{\partial h}{\partial x_i} = \frac{\partial f}{\partial x_i} + \frac{\partial g}{\partial x_i} = 0 \quad (2)$$

$$\frac{\partial h}{\partial \lambda} = g - a = 0$$

With $j = 1, 2, \dots, n$, the minimum value of $f(x_1, x_2, \dots, x_n)$ can be obtained by solving the equations for x_j and λ then each solution of this system of equations is a critical value of the function $f(x_1, x_2, \dots, x_n)$ (Safitri, Basriati and Zahara, 2019).

2. METHODS

The stages in implementing the method, the optimal number of products to be produced in the coming period, the total allocation of woven products for each distribution area, planning a sales budget, and calculating the maximum profit, with the following stages:

1. Calculation of Optimal Production Amount and Allocation to Each Distribution Area.
 - a. Plots of demand historical data,
 - b. Calculation of demand forecasting (time series method),
 - c. Comparison of MSE (Mean Square Error) forecasting results,
 - d. Determination of aggregate planning results,
 - e. Disaggregation of aggregate planning results.
2. Creating an Optimal Sales Budget Plan Using the Lagrange Multiplier Method

- a. Classification of production costs,
 - b. Kolmogorov-smirnov test,
 - c. Calculating the sales budget with the Lagrange multiplier method
 - d. Comparing the results of calculating the sales budget using the Lagrange multiplier method with the initial funding for UKM Tunas Harapan
3. Calculation of the Profits Obtained by Crafts of Woven Rope Strapping UKM Tunas Harapan
 - a. Profit Estimation,
 - b. Calculation of Return On Invest (ROI),
 - c. Calculation of Revenue Cost Ratio (R/C ratio),
 - d. Calculation of Break Even Point (BEP)

3. FINDINGS AND DISCUSSION

3.1. Calculation of Optimal Production Amount and Allocation to Each Distribution Area

3.1.1 Demand Historical Data Plots

The historical data used is sales data for UKM Tunas Harapan woven products for January 2020 to March 2021, as shown in Table 2.

Table 2. Product Demand

Period (2020-2021)	Woven Product Demand			
	Shopping Basket	Along-Along	Mats	Pots
January	1525	1698	271	1318
February	1427	1422	212	1186
March	1516	1405	205	1213
April	2000	1188	298	1150
May	1619	2000	251	913
June	1303	1183	300	977
July	1501	1958	221	1331
August	2000	1251	209	1500
September	1475	1187	199	1394
October	1599	2000	201	1180
November	2000	1676	239	991
December	1617	1997	300	1431
January	1712	1680	295	1389
February	1130	1889	289	1317
March	1690	1786	261	1411

3.1.2 Calculation of Demand Forecasting for 12 Periods & Mean Standard Error (MSE) for 10 Methods

The results of product forecasting for the following 12 periods with the best method, namely linear regression, are shown in table 3.

Table 3. Recapitulation of Forecasting With Linear Regression

Period (2020-2021)	Forecasting of Product Demand			
	Shopping Basket	Along-Along	Mats	Pots
1	1764	1882	269	1380
2	1778	1899	271	1396
3	1793	1917	273	1413
4	1807	1935	275	1429
5	1822	1952	278	1445
6	1836	1970	280	1461
7	1850	1987	282	1477
8	1865	2005	285	1493
9	1879	2022	287	1510
10	1894	2040	289	1526
11	1908	2058	291	1542
12	1922	2075	294	1558

3.1.3 Agregate Planning

Aggregate planning is used to calculate the total demand for needs during one planning period obtained from forecasting based on the results of the best method, as shown in Table 4.

Table 4. Demand Agregation

Period (2020-2021)	Forecasting of Product Demand				Agregat
	Shopping Basket	Along-Along	Mats	Pots	
1	1764	1882	269	1380	5295
2	1778	1899	271	1396	5345
3	1793	1917	273	1413	5396
4	1807	1935	275	1429	5446
5	1822	1952	278	1445	5496
6	1836	1970	280	1461	5547
7	1850	1987	282	1477	5597
8	1865	2005	285	1493	5648
9	1879	2022	287	1510	5698

10	1894	2040	289	1526	5748
11	1908	2058	291	1542	5799
12	1922	2075	294	1558	5849
Total					66865
Rata-Rata					5572

3.1.4 Disaggregation of Aggregate Planning Results

The disaggregation process aims to create a Master Production Schedule (MPS) for each item with details and the number of requests allocated to each region. MPS recapitulation shown in table 5.

Table 5. Master Production Schedule (MPS)

Periode	Products			
	Shopping basket	Along-Along	Mat	Pots
1	1785	1885	271	1354
2	1802	1903	274	1367
3	1819	1911	276	1380
4	1836	1939	279	1393
5	1853	1957	281	1406
6	1870	1974	284	1419
7	1887	1991	287	1432
8	1904	2010	289	1444
9	1921	2028	291	1457
10	1938	2046	294	1410
11	1955	2064	297	1483
12	1972	2082	299	1496

3.1.5 Calculation of Total Allocation of Products for Each Distribution Area

This stage determines the number of requests allocated to each distribution area by further disaggregating MPS and the sales contribution of each product in each region. Past data on demand for woven shopping basket products, along-along, mats, and pots in the previous 15 periods are shown in table 6.

Table 6. Historical Demand Data for Each Region

	Products			
	Shopping basket	Along-Along	Mat	Pots
FK	1	1	1	1

Area	Riau	5116	5276	916	4012
	West Sumatera	4878	5589	924	3882
	North Sumatera	5512	6164	785	4408
	Jambi	4607	4897	675	4107
	Aceh	4621	4494	457	2688
Total		24134	26120	3757	18767

Then calculate the percentage of sales contribution items for each region using the following formula.

$$\begin{aligned}
 &= \sum x \text{ Area} / \sum \text{Shopping basket} \quad (3) \\
 &= 5116 / 24734 * 100\% \\
 &= 20,7\%
 \end{aligned}$$

Table 7. Item Percentage for Each Region

Products	Fk	Riau	West Sumatera	North Sumatera	Jambi	Aceh
Shopping basket	1	20,70%	19,70%	22,30%	18,60%	18,70%
Along-Along	1	20,20%	21,40%	23,60%	17,60%	17,20%
Mat	1	24,40%	24,60%	20,90%	18,00%	12,20%
Pots	1	21,40%	19,10%	23,50%	21,90%	14,20%

$$\begin{aligned}
 &= (\text{MPS} \times \% \text{ item Percentage}) / (\text{FK}) \quad (4) \\
 &= (1785 \times 0,207) / 1 \\
 &= 369,2 \approx 369 \text{ products}
 \end{aligned}$$

3.2. Calculations to Make an Optimal Sales Budget Plan With the Lagrange Multiplier

3.2.1 Production Cost

Before making a sales budget, you must first know how many units of production and the costs for achieving these production results are shown in Table 8.

Table 8. Production Cost for Shopping Cart

No	Material	Quantity	Unit	Price per unit (Rp)	Total (Rp)	Variabel Cost (Rp)
1	Green Stripping	1575	Kg	5.000	7.875.000	1.000
2	Dark Green	1050	Kg	5.000	5.250.000	1.000

	Stripping						From table 9, it is known that the UKM Tunas Harapan budget in 2020 is IDR 3,620,000,000.
3	Scissor	14	Pcs	15.000	210.000	500	Using the Lagrange multiplier method, this budget is used as a comparison in determining the budget for the following year.
4	Knife	14	Pcs	15.000	210.000	500	
5	Knitting Gloves	5	lusin	16.000	80.000	1.000	The following year's Tunas Harapan UKM budget uses a Lagrange multiplier, namely the total cost of producing woven products from the demand for each region obtained from the results of disaggregation planning by considering the opportunity for maximum demand/sales and then multiplying it by the cost of production.
6	Stationary	14	package	48.000	672.000	800	After receiving the results of calculating the sales budget using the Lagrange multiplier method, it compares the initial sales budget calculation with the calculation of the sales budget using the Lagrange multiplier method.
7	Meter	14	Pcs	43.000	602.000	2.000	
8	Broom	14	Pcs	21.000	294.000	2.000	
9	Duster	14	Pcs	7.000	98.000	2.000	
10	first aid	1	kota	93.000	93.000		
11	Electricity cost	1	bulan	250.000	250.000		
12	Wages	27	orang	2.000.000	54.000.000		
Total				69.634.000	10.800.000		

3.2.2 The Normality Test

The normality test can use the maximum sales volume opportunity formula in the Lagrange multiplier method to determine the optimal sales budget. From the results of the normality test, it is known that the demand for each product is normally distributed because the calculated value of k_s (Kolmogorov Smirnov) is smaller than the table k_s value at $\alpha = 5\%$ with $n = 15$ (0.338) (Conover, 1999).

3.2.3 Calculation of the Optimal Sales Budget Using the Lagrange Multiplier

A Lagrange multiplier calculation with multi items is used to calculate the optimal sales budget for the following year. The following is the initial budget for UKM Tunas Harapan for the previous 12 periods, as shown in Table 9.

Table 9. Initial Budget

Products	Quantity (Unit)	Budget
Shopping Basket	24000	Rp 924.000.000
Along-Along	24000	Rp 1.620.000.000
Mat	3600	Rp 464.400.000
Pots	18000	Rp 612.000.000
Total		Rp 3.620.400.000

3.3. Calculation of the Profits Obtained by Crafts of Woven Strapping Straps

3.3.1 Profit Estimation

The estimated profit is the profit obtained by UKM Tunas Harapan, which is obtained from selling each product for each region by reducing the total revenue and expenditure. The recapitulation of the estimated profit shown in the appendix.

3.3.2 Return On Investment (ROI)

Return on investment is the ratio used to measure the ability of a company to generate profit from the capital invested in a business (investment) (Ichsan and Suhardi, 2015), (Jones, 1993).

Income	= IDR 5,245,244,326
Expenses	= IDR 3,496,849,983
Profit	= IDR 1,748,394,343
ROI	= (operating profit)/(expenses) x 100% (5)
	= 1,748,394,343/3,496,849,943 x 100%
	= 49.99 %

3.3.2 Revenue Cost Ratio (R/C Ratio)

The revenue-cost ratio is a tool to see the relative profit of a business in one year based on the costs used in the activity (Primyastanto, 2016b). Calculation of the R/C ratio by comparing total

income (revenue) with total expenses (costs) (Primyastanto, 2016a). If the R/C ratio is > 1.3, the business is feasible, while the R/C ratio < 1.3 is not feasible (Malika and Adiwijaya, 2018).

$$\begin{aligned}\text{Income} &= \text{IDR } 5,245,244,326 \\ \text{Expenses} &= \text{IDR } 3,496,849,983 \\ \text{R/C ratio} &= \text{income} / \text{expenses} \quad (6) \\ &= \text{IDR } 5,245,244,326 / \text{IDR } 3,496,849,983 \\ &= 1.49\end{aligned}$$

3.3.2 Break Even Point (BEP)

Estimating the break-even point is a way to determine or plan at what sales volume the company does not profit or suffer a loss (Sintha, 2019), (Batkovskiy, A. M., Semenova *et al.*, 2017).
a. BEP Units (Yusuf, 2014)

$$\begin{aligned}\text{FC} &= \text{IDR } 69,634,000 \\ \text{VC} &= \text{IDR } 10,800 \\ \text{P (Selling Price)} &= \text{IDR } .55,618 \\ \text{BEP} &= \text{FC}/(\text{P}-\text{VC}) \quad (7) \\ &= (\text{IDR } 69,634,000)/(\text{IDR } 55,618-\text{IDR } 10,800) \\ &= 1553.7 = 1554 \text{ units/month} \\ \text{BEP} &= 1554 \times 12 \text{ months} \\ &= 18,648 \text{ units/year}\end{aligned}$$

So, Tunas Harapan UKM has to sell 1554 shopping basket units/month or 18,648/year for a Break Even Point to occur.

b. Rupiah BEP

$$\begin{aligned}\text{BEP} &= \frac{\text{FC}}{1 - \frac{\text{VC}}{\text{P}}} \quad (8) \\ &= \frac{\text{IDR } 69,634,000}{1 - \frac{\text{IDR } 10,800}{\text{IDR } 55,618}} \\ &= \text{IDR } 86,394,540/\text{month} \\ \text{BEP} &= \text{IDR } 86,394,540 \times 12 \text{ months} \\ &= \text{IDR } 1,036,734,480\end{aligned}$$

So, this UKM Tunas Harapan business must get a turnover of Rp. 86,394,540/month or Rp. 1,036,734,480 so that a Break-Even Point occurs.

4. CONCLUSION AND SUGGESTION

Based on the results of aggregate planning disaggregation, the optimal production amount for each period is a shopping basket of 1,878 products (388 in Riau, 370 in West Sumatra, 419 in North Sumatra, 350 in Jambi, and 351 in

Aceh), 1983 products along-along (401 in Riau). , West Sumatra 425, North Sumatra 467, Jambi 350, and Aceh 341), mats 283 products (Riau 70, West Sumatra 70, North Sumatra 60, Jambi 51, and Aceh 35) and pots interest 1425 products (Riau 305, West Sumatra 272, North Sumatra 335, Jambi 312, and Aceh 202). In addition, with budget planning using the Lagrange multiplier method, the total sales budget for 12 periods for product allocation to 5 regions with a Lagrange multiplier value of 0 (M=0) is IDR 3,602,720,551 when compared to the initial SME Tunas Harapan sales budget Is Rp. 3,620,000,000, the M value must be reduced. Therefore a calculation is carried out with a smaller M value. However, because the M value ranges from 0-1, there is no value below 0, the calculation can be stopped, and it can be interpreted that the sales budget of IDR 3,602,720,551 is optimal. Based on estimated profits for 12 periods, it is found that Tunas Harapan UKM's profit is IDR 1,801,328,898 with a profit percentage of 49.99%, which is obtained from the calculation of return on investment (ROI). The profit ratio is that every IDR 1 capital issued can generate revenue of IDR 1.49. From the analysis of the R/C Ratio and the calculation of the break-even point (BEP), UKM Tunas Harapan experienced a break-even point in the sales of each product, 18648 shopping baskets, 17796 along-along, 2024 Tikar, 14544 pots with total turnover of IDR 4,064. 911668.

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APPENDIX 1 PROFIT ESTIMATION

Daerah Alokasi	Produk Anayaman	Harga Jual (Pi) (Rp)	Harga Pokok (Vi) (Rp)	Qi (Rp)	Qi.Vi (Rp)	Qi.Pi (Rp)	Profit (Qi.Pi - Qi.Vi) (Rp)
Riau	Keranjang Belanja	55.619	37.079	4.828	179.017.412	268.528.532	89.511.120
	Along-Along	99.652	66.435	5.043	335.031.705	502.545.036	167.513.331
	Tikar	193.874	129.249	885	114.385.365	171.578.490	57.193.125
	Pot Bunga	50.023	33.349	3.852	128.460.348	192.688.596	64.228.248
	Total				756.894.830	1.135.340.654	378.445.824
Sumatera Barat	Keranjang Belanja	55.618	37.079	4.611	170.971.269	256.454.598	85.483.329
	Along-Along	99.652	66.435	5.333	354.297.855	531.444.116	177.146.261
	Tikar	193.874	129.249	889	114.902.361	172.353.986	57.451.625
	Pot Bunga	50.023	33.349	3.457	115.287.493	172.929.511	57.642.018
	Total				755.458.978	1.133.182.211	377.723.233
Sumatera Utara	Keranjang Belanja	55.618	37.079	5.189	192.402.931	288.601.802	96.198.871
	Along-Along	99.652	66.435	5.843	388.179.705	582.266.636	194.086.931
	Tikar	193.874	129.249	763	98.616.987	147.925.862	49.308.875
	Pot Bunga	50.023	33.349	4.211	140.432.639	210.646.853	70.214.214
	Total				819.632.262	1.229.441.153	409.808.891
Jambi	Keranjang Belanja	55.618	37.079	4.364	161.812.756	242.716.952	80.904.196
	Along-Along	99.652	66.435	4.433	294.506.355	441.757.316	147.250.961
	Tikar	193.874	129.249	664	85.821.336	128.732.336	42.911.000
	Pot Bunga	50.023	33.349	3.937	131.295.013	196.940.551	65.645.538
	Total				673.435.460	1.010.147.155	336.711.695
Aceh	Keranjang Belanja	55.618	37.079	4.377	162.294.783	243.439.986	81.145.203
	Along-Along	99.652	66.435	4.328	287.530.680	431.293.856	143.763.176
	Tikar	193.874	129.249	466	60.230.034	90.345.284	30.115.250
	Pot Bunga	50.023	33.349	2.615	87.207.635	130.810.145	43.602.510
	Total				597.263.132	895.889.271	298.626.139
Grand Total Profit					3.005.421.530	4.508.111.173	1.801.315.782