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Optimization of Production and Distribution System with Branch and Bound Method Approach

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ABSTRACT : *The culinary business, one of which is the bakpia selling business, currently requires adequate strategies to compete in the broad market, considering that more and more similar businesses have sprung up. Not just a marketing strategy that can maximize company profits, but production strategies also play an essential role in maximizing profits. It doesn't stop there, and competition is getting tougher with the existence of production areas in one production area. This situation forces bakpia producers to rack their brains so they can still get maximum profit even though they are in an area that is the center of bakpia production, both in terms of production and distribution. This study aims to optimize the production system and find the best bakpia distribution route using the branch and bound method. Researchers, 1 collect two data) Production system data in the form of bakpia products sold and the materials used in the bakpia production process, and 2) Distribution data in the form of names and addresses for the distribution of bakpia from various locations and the distance from each outlet. Analysis of the data used in this study for calculating profit optimization in the production and distribution system is branch and bound. The results obtained from the optimization of the bakpia production system received the optimum value from the production of Bakpia Dry flavours of Cheese, Nastar, Gula Tarik, and Mini Sambal should be produced in as many as 780, 526, 462 and 877 boxes per day while for Bakpia Basah Kumbuh must produce 1364 boxes per day. For the production of Bakpia Kering types such as original, chocolate, blacksisem, vegetable, asin and Bakpia Basah, including green beans and regular, no show is carried out to achieve the maximum profit of Rp. 159.550.000,- per day. In the bakpia distribution system, obtained from 14 nodes as the point of destination and origin, the shortest bakpia distribution path is Sarifa By-Oleh Bandung, namely 1 – 14 – 8 – 9 – 4 – 5 – 6 – 2 – 3 – 7 – 10 – 11 – 12 – 13 – 1 with a total distance of 1872.12 Km.*

KEYWORDS: Branch And Bound, Production, Distribution

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I. INTRODUCTION

The company is where basic resources are managed so that a result is obtained in the form of goods or services that can be sold to consumers. This process is called production. To carry out these production activities, facilities must support production, including raw materials, labor, machinery and others. Therefore, a company manager must use production facilities appropriately so that the company's operational costs are always lower than the company's income so that the company's main goal can be achieved, namely getting the maximum profit, one of which is the bakpia manufacturing industry.

Bakpia is a typical food that tourists usually hunt as souvenirs. Bakpia's business is an opportunity for entrepreneurs to develop their business in making souvenirs. In the Bakpia Culinary business competition, market competition is rampant, not just one, two, three stores, but dozens of Bakpia shops trying to show off their taste and quality skills. In the competitive bakpia culinary business in today's modern era, adequate strategies needed to compete in the broad market. Not just a marketing strategy that can maximize company profits, but production strategies also play an important role in maximizing profits. It doesn't stop there, competition is getting tougher with the existence of production areas in one production area. This situation forces bakpia producers to rack their brains to keep getting maximum profit even though they are in an area that is the center of bakpia production, both in terms of production and distribution.

There is an increase in production every year, especially for companies in the same sector that are strict with companies in Indonesia. Thus, an effective and efficient production management is needed to maintain its business in maximizing its turnover (profit). Therefore, production management is often concerned with optimizing the amount of production based on the problems at hand.

One of the important parts in the industrial process is the availability of resources, which often results in direct and indirect inefficiency, especially in industrial companies that are still operating in a small to medium scope [1] . Therefore, business owners must apply economic principles where fewer costs or expenditures result in higher profit values, so optimization needs to be involved [2]. Based on the previous explanation, it can be concluded that optimization or optimization aims to minimize the amount of costs needed during the production process which produces the best profit based on the availability of resources to provide the maximum profit value (optimal) [2]. Therefore, every company needs a method that is the solution to the problem to optimize the amount of production.

The Branch and Bound method is common for finding optimal solutions for various Non-Integer optimization problems. The branch and bound method has a lower error rate than the cutting plane method because branching and restrictions on the branch and bound method are more efficient in obtaining all feasible answers [3] . In addition to determining the optimization of the amount of production, the researcher also applies the best product distribution route so that the distribution of products that causes an increase in distance and travel time will not have an impact on high transportation costs and delays in product delivery to consumers. For this reason, it is necessary to determine the optimal route so that the company can carry out distribution activities effectively and efficiently, the problem of determining this route is better known as the Traveling Salesman Problem (TSP). TSP is one of the common combinatorial optimization problems, in which one must visit all cities exactly once and return to the original city [4]. Based on the description of the problems above, the research aimed at implementing profit optimization in the production system and finding the best route in the distribution of bakpia using the branch and bound method.

II. RESEARCH METHODS

1. Data Collection and Processing

   Data was collected through direct interviews with tofu factory owners. The data collected consists of primary and secondary data. Primary data in the form of information on the use of tofu raw materials obtained from interviews. While secondary data comes from previous research literature studies containing information about objects and methods used. The sampling technique used was purposive sampling because the research object was selected based on the researcher's considerations. The data collected by researchers from one of bakpia shops in Yogyakarta are as follows.

   a. Raw material composition data and bakpia inventory data. Producing 12 types of bakpia namely, original Bakpia Kering, pandan Bakpia Kering, chocolate Bakpia Kering, cheese Bakpia Kering, nastar Bakpia Kering, Gula Tarik Bakpia Kering, blacksisem Bakpia Kering, vegetable Bakpia Kering, asin Bakpia Kering, mini chili Bakpia Kering, Bakpia Basah green beans, and kumbu Bakpia Basah.

   b. Data on selling prices, production costs and sales profits of 13 types of bakpia per box.

Table 1 . Sales Price, Production Cost, and Sales Profit Data (box)

Bakpia Type	Selling price
Original Bakpia Kering	IDR 30,000
Pandan Bakpia Kering	IDR 35,000
Chocolate Bakpia Kering	IDR 50,000
Cheese Bakpia Kering	IDR 50,000
Bakpia Kering Nastar	IDR 35,000
Bakpia Kering Gula Tarik	IDR 40,000
Blacksisem Bakpia Kering	IDR 35,000
Vegetable Bakpia Kering	IDR 35,000
Bakpia Kering Asin	IDR 35,000
Bakpia Kering Mini Sambal	IDR 40,000
Green Beans Bakpia Basah	IDR 30,000

Bakpia Basah Kumbu	IDR 30,000

c. In distribution data, data collection in this study uses Google Maps with the following conditions : land areas calculated using the car's distance. The following is the distance data in Kilometers (km).

Table 2. Distance Data

Distance	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
P1	0.00	33.90	35.74	36.34	9.45	45.55	333.92	344.12	77.97	96.97	156.31	220,21	568,19	572.89
P2	33.90	0.00	69.64	70.24	43.35	79.45	367.82	378.02	111.87	130.87	190.21	254.11	602.09	606.79
P3	35.74	69.64	0.00	0.60	28.34	64.44	322.25	332.45	111.31	130.31	138,90	202.80	548.56	553.26
P4	36.34	70.24	0.60	0.00	28.94	65.04	322.85	333.05	111.91	130.91	139.50	203.40	549.16	553.86
P5	9.45	43.35	28.34	28.94	0.00	36,10	326.32	336.52	87.41	106.41	156.12	220.02	559.49	564.19
P6	45.55	79.45	64.44	65.04	36,10	0.00	362.42	372.62	123.51	142.51	192.22	256.12	595.59	600.29
P7	333.92	367.82	322.25	322.85	326.32	362.42	0.00	10,20	394.85	413.85	438.92	502.82	253.17	257.87
P8	344.12	378.02	332.45	333.05	336.52	372.62	10,20	0.00	405.05	424.05	449.12	513.02	263.37	268.07
P9	77.97	111.87	111.31	111.91	87.41	123.51	394.85	405.05	0.00	19,00	185.94	249.84	637.09	641.79
P10	96.97	130.87	130.31	130.91	106.41	142.51	413.85	424.05	19,00	0.00	204.94	268.84	656.09	660.79
P11	156.31	190.21	138,90	139.50	156.12	192.22	438.92	449.12	185.94	204.94	0.00	63.90	639.31	644.01
P12	220,21	254.11	202.80	203.40	220.02	256.12	502.82	513.02	249.84	268.84	63.90	0.00	703.21	707.91
P13	568,19	602.09	548.56	549.16	559.49	595.59	253.17	263.37	637.09	656.09	639.31	703.21	0.00	4.70
P14	572.89	606.79	553.26	553.86	564.19	600.29	257.87	268.07	641.79	660.79	644.01	707.91	4.70	0.00

Description of Destination
P1 = Lalawuh Sunda
P2 = Indomaret Malioboro Points
P3 = Indomaret Tugu Station Points
P4 = Indomaret South Monjali Points
P5 = Indomaret Colombo Points
P6 = By - By Indonesia Archipelago
P7 = Venus Souvenir Center (Jatinegara)
P8 = Romlah Souvenirs from Jakarta
P9 = Typical of Old Jakarta
P10 = Romlah Souvenirs Jakarta Hayamwuruk Branch
P11 = Center By By Bandung
P12 = Kartika Sari
P13 = Sarifa Souvenirs from Bandung
P14 = Surabaya Square, Surabaya Souvenir Center

4. Application of Production and Distribution System Optimization

The data that researchers have collected is then processed using branch and bound techniques for both the production and bakpia distribution systems.

a. Production System

The branch and bound technique in optimizing production data described as follows [5}.

1) Determine the objective function and constraints.
2) Arrange all values into Simplex Table
3) Determine the key column (decision variable) entered as the entering variable . The key column is the column that has a value in row Z (the objective function) which is negative (-) with the largest number.
4) Specify the key line, to determine the variable that will leave the key line (leaving variable).
5) Change the values in the key row, by dividing by the key number. The key number is the value whose position is at the intersection of the key column and the key row.
6) Create a new row by changing the row values (other than the row key) so that the column key values = 0,
7) Repeat the above steps (steps 3 – 6 or called iterations), until there are no negative values in row Z (the line of the objective function)
8) Choose the variable with the largest fraction difference with the integers of each variable to be branched into sub-problems.

9) Create a new constraint $X_i^* \le X_i \le X_i^* + 1$, but because the range does not provide integer programming, consequently the integer value X_i fulfills one of the following conditions: $X_i^* \le X_i$ or $X_i \le X_i^* + 1$
10) Solve a linear programming model with new constraints added to each sub-problem. If the expected solution is an integer, then return to Step 9. But if it is not an integer then return to Step 3.
11) If the solution of one of the sub-problems has an integer value and the other solutions have no solution (not feasible), then the branching is not continued or stopped. Choose the optimal solution. Suppose several sub-problems have an integer value solution. In that case, the solution that has the largest Z value is chosen if the objective function is maximum and the solution that has the smallest if the objective function is the minimum to be the optimal solution.

b. Distribution System

The branch and bound technique in optimizing distribution data described as follows [6].

1) Form a matrix (A_{ij}) which is the distance matrix from each city that forms a matrix of size nxn, where n is the number of the initial city and all cities to be visited. Each element of the matrix C_{ij} is the distance from the *outlet point* i to *outlet* j, while i and j are vertices.
2) Reducing the A_{ij} matrix by subtracting each element with the smallest value in the row.
3) Reducing the Aij matrix by subtracting each element in the column with the smallest value and smallest value.
4) Furthermore, the reduction process will produce a root node boundary value of c(R) obtained from the sum of all the subtraction elements.
5) A matrix formed, the reduced matrix for the root node R.
6) Then if we assume that S is a child of R, so that the side (R,S) in the status tree, then we take several steps in the matrix A below:
   - Converts all value elements in row i and column j to the value
   - Converts element A(j,1) to value
   - Reduce matrix A as in steps 2-4 to produce another matrix such as matrix B.
   - Calculate the minimum weight value for each node according to the equation: c(S) = c(R) + A(i,j) + r, where c(S) is the minimum weight value for the S node, c(R) is the minimum weight value for the root node, A(i,j) is the edge elements (i,j) at vertices (R,S), and r is the sum of all subtractions to obtain a reduction matrix like step 4 but for vertex S.
7) The matrix reduction repeated continuously until a status tree formed with a small limit value.
8) Develop a route based on the nodes that have obtained.

5. Numerical Simulation

The numerical simulation in this study uses the help of QM for Windows software to solve the optimization case for the branch and bound method for production and WinQSB for distribution calculations.

6. Interpretation and Discussion

The results obtained from the production and distribution optimization completion model using the branch and bound method interpreted by researchers

III. RESULTS AND DISCUSSION

1. Production System

The objective function and the constraint function are as follows.

$\square = 30.000_{1}\_ + 35.000_{2}\_ + 50.000_{3}\_ + 50.000_{4}\_ + 35.000_{5}\_ + 40.000_{6} + \_35.000_{7}\_ + 35.000_{8}\_ + 35.000_{9}\_ + 40.000_{10}\_ + 30.000_{11} + 30.\_000_{12}\_$

Information :

x_1 :Bakpia Kering Original

x_2 :Bakpia Kering Pandan

x_3 :Bakpia Kering Coklat

x_4 :Bakpia Kering Keju

x_5 :Bakpia Kering Nastar

x_6 :Bakpia Kering Gula Tarik

x_7 :Bakpia Kering Blacksisem

x_8 :Bakpia Kering Sayur

x_9 :Bakpia Kering Asin

x_{10} :Bakpia Kering Mini Sambal

x_{11} :Bakpia Basah Kacang Hijau

x_{12} :Bakpia Basah Kumbu

The results of the optimum production solution value of the variables are as follows.

Table 2 Solution Results from Iteration

Variable	Status	Solution Value
X1	Non Base	0
X2	Non Base	0
X3	Base	780.57
X4	Base	526.6
X5	Base	462.07
X6	Base	52.1
X7	Non Base	0
X8	Non Base	0
X9	Non Base	0
X10	Base	877.11
X11	Base	1364.48
X12	Non Base	0
Z		159633600

So that the Bakpia Kering flavored with Cheese, Nastar, Gula Tarik and Mini Sambal must produced as many as 780.57, 526.6, 462.07 and 877.11 boxes per day while for Bakpia Basah Kumbuh it must produce 1364.48 boxes per day. For the production of Bakpia Kering types such as original, chocolate, *blacksisem* , vegetable, asin and Bakpia Basah including green beans and regular, no production is carried out to achieve the maximum profit of Rp. 159,633,600,- per day. However, this problem is still declared invalid because the solution needed by the researcher is the solution value in the form of an integer. Furthermore, the researchers carried out data processing using the *Branch and Bound method* so that the resulting solution was an integer number using QM For Windows software, the production system obtained using the branch and bound method as follows.

Table 3. *Branch and Bound* Calculation Results with *QM for Windows*

Iteration	Level	Added constraint	Solution type	Solution Value	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
			Optimal	159.550,000	0	0	780	526	462	52	0	0	0	877	1364	0
1	0		NON-integer	159,633,600	0	0	780.57	526.6	462.07	52.1	0	0	0	877.11	1364.48	0
2	1	X3<= 780	NON-integer	159,605,000	0	0	780	526.6	462.07	52.1	0	0	0	877.11	1364.48	0
3	2	X4<= 526	NON-integer	159.575000	0	0	780	526	462.07	52.1	0	0	0	877.11	1364.48	0
4	3	X5<= 462	NON-integer	159.572,700	0	0	780	526	462	52.1	0	0	0	877.11	1364.48	0
5	4	X6<= 52	NON-integer	159.568,700	0	0	780	526	462	52	0	0	0	877.11	1364.48	0
6	5	X10<= 877	NON-integer	159.564,900	0	0.11	780	526	462	52	0	0	0	877	1364.37	0
7	6	X2<= 0	NON-integer	159.564,900	0	0	780	526	462	52	0.11	0	0	877	1364.37	0
8	7	X7<= 0	NON-integer	159.564,900	0	0	780	526	462	52	0	0.11	0	877	1364.37	0
9	8	X8<= 0	NON-integer	159.564,900	0	0	780	526	462	52	0	0	0.11	877	1364.37	0
10	9	X9<= 0	NON-integer	159.564,400	0.11	0	780	526	462	52	0	0	0	877	1364.37	0
11	10	X1<= 0	NON-integer	159.564,400	0	0	780	526	462	52	0	0	0	877	1364.48	0

12	11	X11<= 1364	NON-integer	159,557,200	0	0	780	526	462	52	0	0	0	877	1364	0.24
13	12	X12<= 0	INTEGER	159.550,000	0	0	780	526	462	52	0	0	0	877	1364	0
14	12	X12>= 1	Suboptimal	159.534,400	0	0	780	526	462	52	0	0	0	877	1362.48	1
15	11	X11>= 1365	Infeasible													
16	10	X1>= 1	Suboptimal	159.528,700	1	0	780	526	462	52	0	0	0	876.11	1363.48	0
17	9	X9>= 1	Suboptimal	159.533,700	0	0	780	526	462	52	0	0	1	876.11	1363.48	0
18	8	X8>= 1	Suboptimal	159.533,700	0	0	780	526	462	52	0	1	0	876.11	1363.48	0
19	7	X7>= 1	Suboptimal	159.533,700	0	0	780	526	462	52	1	0	0	876.11	1363.48	0
20	6	X2>= 1	Suboptimal	159.533,700	0	1	780	526	462	52	0	0	0	876.11	1363.48	0
21	5	X10>= 878	Infeasible													
22	4	X6>= 53	Infeasible													
23	3	X5>= 463	Infeasible													
24	2	X4>= 527	Infeasible													
25	1	X3>= 781	Infeasible													

Based on table 5.5, the value of $X_3 = 780$ is obtained; $X_4 = 526$; $X_5 = 462$; $X_6 = 52$; $X_{10} = 877$; $X_{11} = 1364$ _ z = 159.550,000 is an integer variable that reaches the optimum point. Since the solution values of all sub-problems cannot be further branched, the iteration stops. Then the best optimal solution is selected. Therefore, it can be stated that the Bakpia Kering flavors of Cheese, Nastar, Gula Tarik and Mini Sambal must produced as many as 780, 526, 462 and 877 boxes per day, while for Bakpia Basah Kumbuh should produced 1364 boxes per day. For the production of Bakpia Kering types such as original, chocolate, *blacksisem* , vegetable, asin and Bakpia Basah including green beans and regular, no production is carried out to achieve the maximum profit of Rp. 159.550.000 ,- per day.

2. Distribution System

Transportation route analysis are to optimize the previous route by submitting a proposal for the transportation route using the Traveling Salesman Problem (TSP) method. The Traveling Salesman Problem (TSP) method used in this study uses the branch and bound method. From the calculations performed on the branch and bound method, there are alternative transportation routes that the company can use to distribute cakes. The routes and distances for bakpia distribution use the following methods:

TOUR	ROUTE	TOTAL DISTANCE (km)
P1	1 – 10 – 9 – 12 – 11 – 4 – 3 – 13 – 14 – 7 – 8 – 6 – 5 – 2 –1	1877,11
P2	1 – 14 – 9 – 8 – 11 – 10 – 3 – 2 – 12 – 13 – 6 – 7 – 5 – 4 – 1	1877,11
P3	1 – 11 – 12 – 5 – 6 – 4 – 3 – 14 – 13 – 8 – 7 – 10 – 9 – 2 – 1	1877,11
P4	1 – 9 – 8 – 6 – 7 – 13 – 12 – 3 – 2 – 5 – 4 – 11 – 10 – 14 – 1	1877,11
P5	1 – 12 – 11 – 6 – 5 – 8 – 7 – 14 – 13 – 9 – 10 – 3 – 4 – 2 – 1	1877,11
P6	1 – 14 – 11 – 10 – 5 – 4 – 7 – 6 – 13 – 12 – 8 – 9 – 2 – 3 – 1	1877,11
P7	1 – 2 – 14 – 13 – 10 – 9 – 4 – 3 – 6 – 5 – 12 – 11 – 7 – 8 – 1	1877,11
P8	1 – 13 – 12 – 9 – 8 – 3 – 2 – 5 – 4 – 11 – 10 – 6 – 7 – 14 – 1	1877,11

P9	1 – 4 – 3 – 10 – 9 – 5 – 6 – 13 – 14 – 12 – 11 – 8 – 7 – 2 – 1	1877,11
P10	1 – 14 – 3 – 2 – 9 – 8 – 4 – 5 – 12 – 13 – 11 – 10 – 7 – 6 –1	1877,11
P11	1 – 8 – 7 – 3 – 4 – 11 – 12 – 10 – 9 – 6 – 5 – 14 – 13 – 2 – 1	1877,11
P12	1 – 14 – 7 – 6 – 2 – 3 – 10 – 11 – 9 – 8 – 5 – 4 – 13 – 12 – 1	1877,11
P13	1 – 2 – 9 – 10 – 8 – 7 – 4 – 3 – 12 – 11 – 14 – 13 – 6 – 5 – 1	1877,11
P14	1 – 14 – 8 – 9 – 4 – 5 – 6 – 2 – 3 – 7 – 10 – 11 – 12 – 13 – 1	1872,12

The selected routes that have been calculated using the WINQSB software are: with knot beginning is P14 or Typical Surabaya Souvenir Center, namely 1 – 14 – 8 – 9 – 4 – 5 – 6 – 2 – 3 – 7 – 10 – 11 – 12 – 13 – 1 with total mileage 1872,12 km.

IV. CONCLUSION

It can be concluded that in the bakpia production system, the results of calculations using the simplex method are Bakpia Kering with Cheese, Nastar, Gula Tarik and Mini Sambal must be produced as many as 780.57, 526.6, 462.07 and 877.11 boxes per day while for Bakpia Basah Kumbuh it must produce 1364.48 boxes per day with a maximum profit of Rp. 159,633,600 per day. However, the optimum results obtained in research using the simplex method resulted in non-integer values. Therefore, the researcher continued with the next calculation to obtain the optimum value from the production of Bakpia Kering with Cheese, Nastar, Gula Tarik and Mini Sambal must be produced as many as 780, 526, 462 and 877 boxes per day while for Bakpia Basah Kumbuh, 1364 boxes per day . For the production of Bakpia Kering types such as original, chocolate, blacksisem, vegetable, asin and Bakpia Basah including green beans and regular, no production is carried out to achieve the maximum profit of Rp. 159.550.000,- per day.

Bakpia distribution system, obtained from 14 points of destination and origin, the shortest bakpia distribution route is the Typical Souvenir Center Surabaya, namely the Lalawuh Sunda route - Surabaya Square, Surabaya Typical Souvenir Center - Romlah Souvenirs Jakarta - Typical Jakarta Kota Tua - Indomaret South Monjali Point - Indomaret Colombo Point - Indomaret Colombo Point - By - By Indonesia Nusantara - Indomaret Malioboro Point - Indomaret Tugu Station Point - Venus Sentra Souvenir (Jatinegara) - Romlah Souvenir Jakarta Hayamwuruk Branch - Center By By Bandung - Kartika Sari - Sarifa Souvenirs Bandung - Lalawuh Sunda with a total distance of 1872.12 Km

Suggestions on the calculation of the optimization of the production system, it is expected to consider additional information for the company in determining the bakpia production plan so that the profits obtained increase such as considering the number of employees, employee salaries, or production time. In addition, researchers also use other methods in determining integer solutions such as Gomory Cut to compare the results of the best solution In analyzing the bakpia product distribution system, researchers should consider additional information such as distribution time, scheduling, or costs incurred during each outlet's delivery process.

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