Optimizing Production And Distribution With Distribution Route Management On Perishable Products

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Abstract. The research aims to minimize production costs with the management of distribution routes. Direction of the selected distribution route using the Production Routing Problem (PRP) model on the product is easily damaged. The PRP linear Model is resolved using LINGO software. The optimal production cost is Rp 84,701. The optimal route of distribution is stockroom- Sembada Market-Traditional Market-Minggu Market - stockroom. The optimal production amount is 27 pieces.

1. Introduction
The most common industrial form in Indonesia is the food industry. There are many traditional foods in Indonesia that are traded, including perishable products or without preservatives. Based on the issue, this research will focus on industry to engineer the best route simulation model in the production and distribution of the perishable products. A Perishable product is a product that has decreased quality throughout the lifetime of the product. In the delivery of perishable products from the point of origin to the destination point, time is a vital role because the delay in the arrival of products causing the economic value of the product decreases even lost. Therefore, it takes a transport strategy that can maintain shelf life, and product quality. The quantity of production of tempeh Ponimin’s industry every day is not the same, and therefore, the amount of tempeh production must be optimal to avoid excessive production. Determining the optimal amount of production, distribution, and inventory can use the PRP on the perishable inventory model\cite{1}. The PRP model is a development model of the Production Routing Problem model discussed by Adulyasak\cite{3}. Besides Adulyasak, the production routing problem has also been addressed in the research of Brahimi and Aouamb\cite{4}, discussed the issue of combining production routing problem formulation with backorder for multi items and study of Qiu\cite{2} concerning the use of the Branch and Price method in PRP on carbon emissions issues. In this research, PRP policy management that is Optimized Delivery-Optimized Selling (OD-OS) will be used to optimize production costs, production quantities, distribution, and routing of tempeh leaf products \cite{5}. Then, the PRP model has the advantages that are very suitable in managing distribution routes in the perishable product because of its benefits, as shown in the following figure 1. The linear solution from PRP will be resolved using a mathematical software that is LINGO software. LINGO is used to find the optimal solution for the PRP model.
Figure 1. Advantages and Disadvantages of distribution route management models.

2. PRP Model
PRP can formulate as follows

$$\text{min} \sum_{t \in T} \left( uq_t + fy_t + \sum_{i \in \mathcal{N}_0} \sum_{r=0}^t h_{irt} I_{irt} + \sum_{(i,j) \in A} \sum_{k \in K} c_{i,j} x_{ijkt} \right)$$  (1)

Subject to:

$$q_t - \sum_{i \in \mathcal{N}} r_{it} = I_{it} \quad \forall t \in T,$$  (2)

$$(1-a_{r,t-1}) I_{0t,t-1} - \sum_{i \in \mathcal{N}} r_{irt} = I_{ort} \quad \forall t \in T, r \in T_0, r \leq t - 1$$  (3)

$$r_{it} - d_{it} = I_{lt} \quad \forall i \in \mathcal{N}, t \in T$$  (4)

$$(1-a_{r,t-1}) I_{irt,t-1} - I_{irt,t-1} - r_{irt} - d_{irt} = I_{irt}$$  (5)

$$\sum_{r=0}^t d_{irt} = d_{lt}$$  (6)

$$\sum_{r=0}^t r_{irt} = \sum_{k \in K} r_{itk}$$  (7)

$$q_t \leq cy_t$$  (8)

$$r_{itk} \leq Qz_{itk}$$  (9)

$$\sum_{i \in \mathcal{N}} r_{irt} \leq Qz_{0tk} \quad \forall k \in K, i \in T$$  (10)

$$\sum_{r=0}^t I_{irt} \leq L_i$$  (11)
\[ \sum_{j \in N_0} x_{ijtk} = z_{itk} \quad (12) \]
\[ \sum_{j \in N_0} x_{ijtk} = \sum_{j \in N_0} x_{jikt} \quad \forall i \in N_0, k \in K, t \in T \quad (13) \]
\[ v_{itk} - v_{jkt} + Q x_{jikt} \leq Q - r_{jtk} \quad \forall (i,j) \in A, i \in N, t \in T, k \in K \quad (14) \]
\[ q_t \geq 0, y_t \in \{0,1\} \quad (15) \]
\[ I_{irt} \geq 0 \quad (16) \]
\[ d_{irt}, r_{irt} \geq 0 \quad \forall i \in N_0, t \in T_0, t \in T \quad (17) \]
\[ r_{irt} \geq 0 \quad (18) \]
\[ z_{itk} \in \{0,1\} \quad (19) \]
\[ x_{ijkt} \in \{0,1\} \quad (20) \]
\[ r_{itk} \leq v_{itk} \leq Q \quad (21) \]

\[ T_o = \text{set of intervals, indexed by } r \in \{0,1,\ldots,|T|\}; \]
\[ K = \text{set of vehicles, indexed by } k \in \{1,\ldots,|K|\}; \]
\[ f = \text{additional production costs}; \]
\[ u = \text{cost per unit of production}; \]
\[ a_{ot} = \text{rate of decline of product from initial inventory in interval } t; \]
\[ a_{rt} = \text{the rate of decline of products produced in interval } r \text{ in the interval } t; \]

The objective function (2) measures the costs of production, inventory, and routing. Subjects (2) and (3) a model of the flow balance of production, inventory, and delivery at the stockroom. Subjects (4) and (5) the flow model of the balance of stock, shipping, and consumption on the vendor. Issues (6) and (7) consider the composition of demand and delivery for vendors in each interval. Issue (8) ensures that the binary variable is one if production occurs. The subject (9) allows sending positive to the node in the interval only if this node visited in the interval. Issue (10) and (11) provide that vehicle and supply capacity limits met. Subject (12) function as a level Subject when the node is visited. Subject to (13) provide the balance of the flow vehicle. Subject (14) is a capacity constraint for PRPPI. Subjects (15) - (21) non-negativity, binaries, and range limitations.

Assumptions related to production, inventory, setbacks, and backorder is as follows.

(i) Production begins every interval.
(ii) Stocks at every vendor in interval \( t \) are defined as the total quantity of products until the end of the interval \( t \), not including the amount used for meet the demand at each vendor in the interval \( t \). Inventory deposited on interval \( t \) is defined as the total number of products until the end of interval \( t \), no including shipping to all vendors in the interval \( t \). Inventory in the interval previously assumed to deteriorate in the current interval at a rate of decline the known. Note that the longer the product is stored in stock, it will be the faster the work will be damaged and also significantly affect the cost of product storage.

(iii)\[ a_{r_1t} \geq a_{r_2t} \quad \forall t \in T, \ r_1 \in T_0, r_2 \in T_o, 0 \leq r_1 \leq r_2 \leq t \quad (22) \]
(iv)\[ h_{ir_1t} \geq h_{ir_2t} \quad \forall i \in N_o, \ t \in T, \ r_1 \in T_0, \ r_2 \in T_o, 0 \leq r_1 \leq r_2 \leq t \quad (23) \]
(v) re-ordering is not allowed.
To limit product choices to the interval of manufacture or sale different, we add the following additional variables and constraints to the PRPPI formulation (1) - (21).

\[ d_{irt} \leq d_{it} w_{irt} \quad \forall i \in N, \ r \in T_0, \ t \in T \]  \hspace{1cm} (24)

\[ r_{irt} \leq Q p_{irt} \quad \forall i \in N, \ r \in T_0, \ t \in T \] \hspace{1cm} (25)

\[ w_{irt} \in \{0, 1\} \] \hspace{1cm} (26)

\[ p_{irt} \in \{0, 1\} \] \hspace{1cm} (27)

Three priority shipping policies consist of implementing the First Produce First Deliver where suppliers always send the most manufactured goods early first. The second policy is the opposite. Under the Last Produced First Delivered is goods produced and then sent first. The third policy is the Optimized Delivery policy that is determined by the model. Three related sales priority policies are the First Produced First Sell policy, policy Last First Produce Sell, policies Optimized Selling. PRP with OD policies can be modeled by adding constraints (2) - (21), (25), (27) and PRP with OS policies can be modeled by adding constraints (2), (21), (24), (26).

3. Results and Discussion

Ponimin’s tempeh industry is an industry located in the tempeh industry Jl. Jawa Kecamatan Sari Rejo, Medan City, Sumatera Utara. Mr. Ponimin is producing tempeh every day and doing one stage of tempeh production. Process tempeh production starts at 13.00 WIB - 17.00 WIB. tempeh that is ready to sell distributed by Ponimin’s industry using a motorcycle that can accommodate tempeh up to 100 tempeh/type. The tempeh is sent to vendors in the Market Sembada, Market Traditional SariRejo, and Market Minggu every morning at 06.00 WIB. Route the journey to distribute leaf tempeh starts from Ponimin’s house to the Market Sembada then headed to the Market Traditional SariRejo after that to the Market Minggu SariRejo. On this research discussed the problems of production and distribution with the PRPPI model, the type of tempeh is leaf tempeh. This study uses data on the type of product and the selling price of each product, data availability of raw materials, data on the quantity of production and sales of production, data on production costs and additional costs of production, product distribution data to each vendors, production capacity data and vehicles as well as data fee distribution for each vendor for the interval of March, 2020.

Types of tempeh and tempeh sale price per piece presented in Table 1.

| Day       | Leafs | Chip | Stick |
|-----------|-------|------|-------|
| Monday    | 51    | 76   | 5 2   |
| Tuesday   | 38    | 83   | 5 2   |
| Wednesday | 52    | 67   | 5 2   |

In producing tempeh, Mr. Ponimin spent additional production costs such as labour costs work, water, firewood, and fuel. Data on additional production costs are presented in Table 2.
Table 2. Data On Additional Production Costs

| Additional Production | Additional cost |
|-----------------------|-----------------|
| Labour wages          | Rp10,000        |
| Water                 | Rp9,000         |
| Firewood              | Rp8,500         |
| Fuel                  | Rp5,500         |
| Total costs           | Rp33,000        |
| Data on additional production cost per Piece | Rp846 |

Table 3. Production Costs on Tuesday

| Material name (Rupiah) | Material prices | quantity of Material | Production Cost |
|------------------------|-----------------|----------------------|-----------------|
| Soy                    | 7,600/kg        | 10 kg                | Rp75,000        |
| tempeh yeast           | 50/gr           | 25 gr                | Rp1,350         |
| Leaf                   | 5000/Bal        | 3 Bal                | Rp15,000        |
| Total Cost             |                 |                      | Rp92,250        |
| Total Cost per Piece   |                 |                      | Rp2,365         |
| Additional Cost per Piece |              |                      | Rp846          |

Data on the number of leaf tempeh products sent to each vendor, leaf tempeh remaining in vendors, and maximal inventory of tempeh leaves at vendors on Tuesday is given in Table 4 follows.

Table 4. Data For Distribution

|                      | Sembada Market | Traditional SariRejo Market | Minggu Market |
|----------------------|----------------|----------------------------|---------------|
| Total Shipping       | 15             | 12                         | 12            |
| Remaining Sales      | 2              | 4                          | 2             |
| maximal Stock        | 35             | 30                         | 35            |

The route that Mr. Ponimin uses in distributing tempeh leaves to vendors at Sembada Market, Traditional SariRejo Market, and Minggu Market can see in Figure 2. Figure 2 explains the route to each vendor in the Market Sembada, Market Traditional Sarirejo The edge and the SariRejo Sunday Market that Ponimin does. Ponimin distribution routes can be depicted in graph form. Node 0 is a stockroom, and node 1 is the Sembada Market, node 2 is the Market Traditional SariRejo Market and node 3 is the Minggu Market. Tour (trip) in the distribution of Ponimin’s tempeh leaves is stockroom - Sembada Market – Traditional SariRejo Market - Minggu Market - stockroom. Sub tour used is \{(0,1),(1,2),(2,3),(3,0),(0,1),(1,3),(3,2),(2,0),(0,2),(2,1),(1,3),(3,0)\}. Data on transportation costs incurred by Ponimin’s industry in distributing tempeh leaves can see in Table 5.
3.1. PRP Model on Perishable Products

\[
\text{Min } A = 236q_1 + 846y_1 + (2000x_{0111} + 3000x_{1211} + 2000x_{2311} + 3000x_{3011} + 2000x_{0111} + 5000x_{1011} + 2000x_{2211} + 3000x_{2011} + 3000x_{2011} + 3000x_{2111} + 5000x_{1211} + 3000x_{2011} + 5000x_{3111} + 2000x_{1011} + 3000x_{3111} + 5000x_{3111} + 2000x_{1011} + 3000x_{2011} + 3000x_{3011} + 2000x_{3111} + 3000x_{2111} + 2000x_{1011} + 3000x_{3111} + 3000x_{2211} + 2000x_{2111} + 3000x_{2111} + 3000x_{1011} + 3000x_{2011} + 3000x_{3111} + 2000x_{3111} + 2000x_{1011} + 3000x_{3111} + 2000x_{3111} + 2000x_{1011}))
\]

Subject to:
\[
q_1 - (r_{111} + r_{211} + r_{311}) = 1011 (1 - 1) I_{1010} - (r_{101} + r_{201} + r_{301}) = I_{001}
\]
\[
r_{111} + d_{111} = I_{111} r_{211} - d_{211} = I_{211}
\]
\[
(1 - 1)I_{1010} + r_{101} - I_{101} = I_{101} (1 - 1)I_{200} + r_{201} - d_{201} = I_{201} (1 - 1)I_{300} + r_{301} - d_{301} = I_{301}
\]
\[
d_{101} + d_{111} = 13, d_{201} + d_{211} = 6, d_{301} + d_{211} = 8,
\]
\[
r_{101} + r_{111} = 1011, r_{101} = 0, r_{201} + r_{211} = 0, r_{301} + r_{311} = 0, r_{301} + r_{301} = 0,
\]
\[
qu_{1} = 45y_{1}, qu_{111} = 100z_{111}, qu_{211} = 100z_{211}, qu_{211} = 100z_{211}, qu_{111} + r_{211} + r_{211} = 100z_{011}
\]
\[
I_{101} + I_{111} = 35, I_{201} + I_{211} = 30, I_{301} + I_{311} = 35
\]
\[
x_{1011} + x_{1211} + x_{1311} = z_{111}, x_{2011} + x_{2111} + x_{2311} = z_{111}, x_{3011} + x_{3111} + x_{3211} = z_{111}
\]
Based on the results and discussion in the previous chapter, we conclude as a conclusion following.

(i) Using the PRP model in the production of tempeh, Mr. Ponimin could issue cheaper production costs. The difference in the cost of production of tempeh using a model PRP with the production costs incurred by Mr. Ponimin is Rp. 84,701.

(ii) The optimal route is the distributing route tempeh to the vendor from the stockroom proceed to the vendor with the number of tempeh requests the most.
(iii) Mr. Ponimin can produce tempeh for the next based production interval the quantity of production in the previous interval.

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