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The methodology of aggregate planning on lamp production based on transportation model

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Abstract. Production planning is an activity related to determining what to produce, how many to make, and what resources are needed to get a product determination. The problem faced by an industry makes lamp is the delay in orders leads time, lack of production capacity. This because the company only consider the regular capacity and overtime without other strategies consideration. This paper will look for a strategy combination to minimize production costs. The land transportation model is used to compile an aggregate plan that will considers regular ability, overtime, inventory, and subcontract. The total production cost for the next six months is IDR 218.046.000. By adding a source of demand order through a subcontract, the company does not experience loss sales twice and does not bear the cost of lost sales of IDR 15.540.000.

1. Introduction

Production planning is one of the most critical activities in organizational operations. Production planning is a company strategy in responding to market demand. Production is a process developed to convert human, material, capital, energy, and information inputs into specific outputs such as finished products and services in the right quantity and quality, to achieve the company goals [1]. Production planning is a structured step taken in a production arrangement to ensure that strategic inputs such as materials, labor, money, and machines are available at the right time and in the right quantity [2]. Production planning can be defined as a process to determine the amount of production, inventory, and workforce levels to meet fluctuating demand [3]. The purpose of production planning is basically to create the final product according to the scheduled demand by consumers.

Aggregate Production Planning is concerned with matching the consumer demand and the its ability to produce products over the medium term, which is about the next twelve months [4]. Production planning is the determination of the level or speed of factory production which is stated in the aggregate [5]. Aggregate is a plan made for all products that use the same source, without making a detail into different products (end item). Usually, the objective of aggregate planning is to minimize production costs during the planning period. The operations manager tries to determine the best way to meet the demand forecast by adjusting production rates, labor rates, inventory rates, overtime work, subcontract rates, and other controlled variables [6].

There are several strategies to plan aggregate production, namely by inventory manipulative, production rate, number of workers, capacity, or other controlled variables. If changes are made to a variable so that a change in production rate occurs, it is called a pure strategy. Meanwhile, a mixed strategy, is a combination of two or more pure strategy to obtain flexible production planning.

Several methods have been used to complete aggregate planning, such as trial and error [7] and graphics [8]. Aggregate planning using the graphical method was popular because it was easy to understand and use. However, graphic strategy does not guarantee optimal production plan [9]. Mathematical techniques are also used in aggregate planning such as fuzzy linear programming [10], genetic algorithms [11], and Multi-Attribute Decision Making (MADM) Approach [12]. Aggregate planning is also carried out with various strategies such as chase strategy, level scheduling strategy, and mixed strategy [9]. Chase Strategy is a planning strategy that determines the quantity of demand equal



to the predicted production demand. This strategy tries to achieve a level of output for each period that meets the demand forecast for that period. Production capacity is increased or decrease according to the demand. The level scheduling strategy is an aggregate plan in which the production rate remains the same output from period to period (constant output). The scheduling rate maintains a continuous level of production, production rate, or work level. Mixed Strategy involves change more than one controllable decision variable. Several combinations of variables are controlled to produce the best aggregate planning strategy. Some of these techniques are included in the large body of APP literature, give optimal solutions while others provide only near-optimal or acceptable solutions.

The transportation model is considered one of the most widely used linear mathematical models in practical life [13]. For example, goods transportation, traffic organization, mail schemes, etc. quickly and accurately. The concept of vehicle comes from the several of resources to provide several products, as well as several specific of demand for these products in certain quantities [14, 15]. The purpose of the transportation model is to build a plan for allocating supply capacity to provide what is needed based on consumer demand. Based on this concept, the transportation model can be used in aggregate planning.

The problem faced by an industry produces lamps often experience delays in order lead time. Regular capacity shortages are only met through overtime without other strategies consideration. Lack of regular capacity and overtime to produce on-demand lamp products lost sales. This paper will look for a combination of strategies that can minimize costs to prepare a production plan.

2. Methodology

The data is collected by using survey techniques (field research) aims to find problems that occur in the industry. Data collection is carried out with three methods, namely direct observation, interviews, and data documentation, such as reports and internal company records.

From the method used, this study is evaluation research. The production planning and control system consists of several sub-systems designed to achieve the two main targets of production planning and control fully, namely achieve customer satisfaction and a high level of utilization of production resources. For these targets reached maximally, all sub-systems must carry out, planning and control functions synergistically, for example planning and controlling materials, capacity, and production process. The research steps begin from forecasting demand data and continue with do the aggregate planning.

The steps in aggregate planning using a transportation model can be seen in Figure 1.

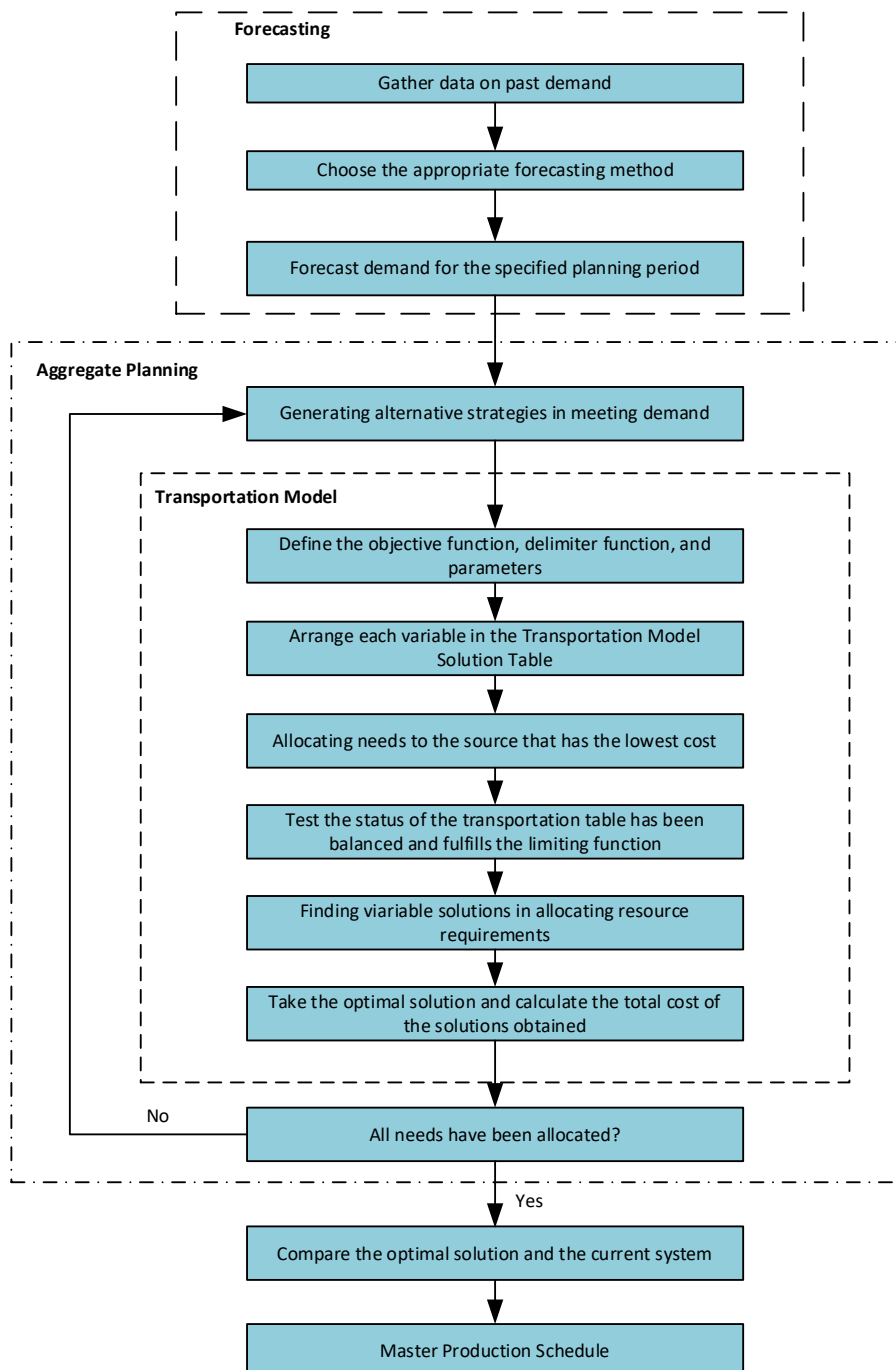


Figure 1. The Methodology of Aggregate Planning using Transportation Model

3. Result

3.1. Data Collection and Demand Forecasting

The data collection in aggregate planning is production capacity and production costs. The production capacity of the company consists of regular production capacity, overtime capacity, and the subcontracting policy by the company. Production costs include regular production costs, production costs of overtime and subcontract, inventory costs, and inventory shortage costs. This study aims to

optimize all company resources with minimal costs to meet customer demand with a transportation model.

In this model, the demand value is unknown, so it is estimated by using historical demand data. Time series models are used to estimate demand because the historical demand data results from observations from time to time. This paper focuses on estimate the steps of which demand data will continue into the planning period. Demand data patterns can be divided into four types, namely constant, seasonal, cyclical, and trend [16]. The results of demand forecasting using the double exponential smoothing method for the next 12 months can be seen in Table 1.

Table 1. Result of Demand Forecast

Period	Demand Forecast (Lamp Unit)
1	2469
2	2505
3	2587
4	2674
5	2734
6	2807
7	2840
8	2987
9	3053
10	2178
11	3404
12	3499

3.2. Aggregate Planning with Transportation Model

This study uses a transportation model to compile an aggregate production plan by minimizing production costs. The transportation model is used to obtain the minimum total production cost performance criteria. The function to reduce the total production cost by regular time capacity, overtime capacity, and subcontract capacity consideration.

To use a transportation model, the first thing to do is build a mathematical model and determine the purpose. The goal is to minimize the total cost of production. The basic form of the transportation model completion can be seen in Table 2.

The following is a mathematical model used in aggregate planning problems:

Objective function

$$\begin{aligned} \text{Min } Z = & \sum_{i=1}^n R_{11} CR_{11} + \dots + R_{1n} CR_{1n} + O_{11} CO_{11} + \dots + O_{1n} CO_{1n} + S_{11} CS_{11} + \dots + S_{1n} CS_{1n} \\ & + \dots + R_{m1} CR_{m1} + \dots + R_{mn} CR_{mn} + O_{m1} CO_{m1} + \dots + O_{mn} CO_{mn} + S_{m1} CS_{m1} + \dots \\ & + S_{mn} CS_{mn} \end{aligned} \quad (1)$$

Constraint function

$$\begin{aligned} R_{11} + O_{11} + S_{11} + \dots + R_{m1} + O_{m1} + S_{m1} &\geq D_1 \\ R_{12} + O_{12} + S_{12} + \dots + R_{m2} + O_{m2} + S_{m2} &\geq D_2 \\ R_{13} + O_{13} + S_{13} + \dots + R_{m3} + O_{m3} + S_{m3} &\geq D_n \\ R_{11} + R_{12} + R_{1n} &\leq S_{R1} \\ R_{m1} + R_{m2} + R_{mn} &\leq S_{Rm} \end{aligned}$$

$$\begin{aligned}
O_{11} + O_{12} + O_{1n} &\leq S_{o1} \\
O_{m1} + O_{m2} + O_{mn} &\leq S_{om} \\
S_{11} + S_{12} + S_{1n} &\leq S_{s1} \\
S_{m1} + S_{m2} + S_{mn} &\leq S_{sm}
\end{aligned}$$

Table 2. Transportation Model Solution

		d_1	d_2	.....	d_n	Supply
1	R	CR_{11} R_{11}	CR_{12} R_{12}	.....	CR_{1n} R_{1n}	S_{R1}
	O	CO_{11} O_{11}	CO_{12} O_{12}	.....	CO_{1n} O_{1n}	S_{O1}
	S	CS_{11} S_{11}	CS_{12} S_{12}	.....	CS_{1n} S_{1n}	S_{S1}
	R	CR_{21} R_{21}	CR_{22} R_{22}	.....	CR_{2n} R_{2n}	S_{R2}
	O	CO_{21} O_{21}	CO_{22} O_{22}	.....	CO_{2n} O_{2n}	S_{O2}
	S	CS_{21} S_{21}	CS_{22} S_{22}	.....	CS_{2n} S_{2n}	S_{S2}
M	R	CR_{m1} R_{m1}	CR_{m2} R_{m2}	.....	CR_{mn} R_{mn}	S_{Rm}
	O	CO_{m1} O_{m1}	CO_{m2} O_{m2}	.....	CO_{mn} O_{mn}	S_{Om}
	S	CS_{m1} S_{m1}	CS_{m2} S_{m2}	.....	CS_{mn} S_{mn}	S_{Sm}
	Demand	D_1	D_2		D_n	

Where CR is the regular time cost per unit, R is the production with regular time capacity, CO is the overtime cost per unit, O is the whole production with overtime capacity, CS is the subcontract cost per unit, and S is the number of subcontracts. D_n is the demand in period n is the result of forecasting. Whereas R is the number of products made at regular time capacity, O is the number of products made at overtime capacity, and S is the number of products used in subcontracting capacity. The company has final inventory of 150 lamps for the period. The results of aggregate planning with the transportation model for six periods can be seen in Table 3.

Table 3. Aggregate Planning with Transportation Model

Source		Period						Available Capacity	Used Capacity	Aggregate Plan
		1	2	3	4	5	6			
Inventory		150	0	2000	4000	6000	8000	10000		
1	Regular time	13000	15000	17000	19000	21000	23000	2140		
	Over-time	18000	20000	22000	24000	26000	28000	310	2140	
	Subcontract	22000	24000	26000	28000	30000	32000	500	179	2319
	Regular time		13000	15000	17000	19000	21000	2200		
2	Over-time		18000	20000	22000	24000	26000	400	2200	
	Subcontract		22000	24000	26000	28000	30000	500	386	2586
	Regular time			13000	15000	17000	19000	2170		
	Over-time			18000	20000	22000	24000	360	2170	2530
3	Subcontract			22000	24000	26000	28000	500	360	
	Regular time				13000	15000	17000	2250		
	Over-time				18000	20000	22000	400	2250	
	Subcontract				22000	24000	26000	500	400	2650
4	Regular time					13000	15000	2205		
	Over-time					18000	20000	370	2205	
	Subcontract					22000	24000	500	370	2734
	Regular time						13000	2125	159	
5	Over-time						18000	320	2125	
	Subcontract						22000	500	320	2804
	Regular time									
	Over-time									
6	Subcontract									
	Regular time									
	Over-time									
	Subcontract									
Demand		2469	2505	2587	2674	2734	2804			

The cost involved in aggregate planning is a regular production cost of IDR 13.000 per unit, overtime cost of IDR 18.000, - per unit, and the subcontract cost is IDR 22.000 per unit, and the inventory cost per period is IDR 2.000, - per unit. So that the total production cost based on the aggregate planning for six months is IDR 218.046.000, -. By using the subcontract strategy to meet consumer demand, the company does not experience two loss sales. If the old system is implemented by the company, the company will bear the cost of lost sales of IDR 15.540.000 (with a loss sales cost of IDR 30.000 per unit). In addition to the material effect, the loss of sales impacts on consumer confidence and company service levels. The strategy that companies can do to meet the demand is a combination of the company's internal capacity, inventory management, and subcontract.

4. Conclusion

In achieve consumer demand, a lamp production industry cannot rely on regular capacity and overtime. With these two capacities, the company experienced sales losses due to unsatisfied demand. The new strategy implemented by the company is to do subcontract to increase the company's ability to meet the demand.

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