

Fuzzy technique application in production planning at PT. XYZ

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FUZZY TECHNIQUE APPLICATION IN PRODUCTION PLANNING AT PT. XYZ

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ABSTRACT

Decision making is the important matter which often faced to a plant manager. With some alternatif available, the manager should be able to create priority scale to which alternatif should be taken according to company development concept. PT. XYZ is also experiencing this matter as a small to medium industry which produces soybean ketchup. To deal with the competition, company should have a production planning to survive in a competition. Production planning that will be done is according to two alternatives: Production Capacity Planning and Revise the Facility Layout. And to decide which plan would be taken, this paper uses Non-Numeric Expert Multi-Criteria Decision Making approach. Asking for two experts judgment from this company, and one expert is a senior lecturer at Industrial Engineering Department of Bina Nusantara University. To execute the alternatives, production capacity planning will use the fuzzy linear programming and to revise the facility layout is using fuzzy facility layout. Software LINDO is use to find the optimal solution from the usual linear programming and the fuzzy linear programming. While the fuzzy set is use to solve the fuzzy facility layout problem. Trapezoidal fuzzy number (TrFN) is used for expressing the membership function of fuzzyfication process, and geometric mean is used for defuzzyfication process. Fuzzy value (γ) gained from LINDO is 0,89. According to the result of Fuzzy facility layout, there are two alternatives of facility layout; first is to move the facility without adding with total cost Rp.919.590,- and second is to move and add the facilities with total cost Rp.1.033.631,-. For further research, it's possible to design a warehouse to separate the soyabean warehouse with supporting goods.

Key words: Fuzzy facility layout problem, Fuzzy linear programming.

1. INTRODUCTION

1.1. Background

Capacity production planning is one of the problems that need to be solving by PT.XYZ. From the PPIC (Production Planning and Inventory Control) annual report, it shows production capacity planned is greater than the actual production capacity. There are a lot of contributing factor; one of it is there is no demand prediction therefore the company didn't know how many basic material and product needed accurately. And if there is a rising in demand, often the company is not prepare with the right amount of employee, or if they have to work over time, how long is the over time, there fore the company often does the production capacity planning which is not irrelevant with market demands. There

fore the market demands couldn't be utilized as maximum as it could be.

The efficient factory placement planning is tightly connected with production planning. This company has a big area to produce its product (3052 square meter). This company is inefficient. They didn't use its area to its fullest capacity. For example the area that should have been use as a label stockroom, is misused as empty/dirty bottle storage. These empty bottles are stored here because the original empty/dirty bottle storage is full and couldn't hold any more empty bottles.

1.2 Purpose

1. Deciding important production planning alternatives to be suggest (prioritize) based on Non Numeric ME MCDM

2. To give production planning suggestions based on alternative chosen with fuzzy applications:
 - a. Suggesting Facility placement improvement.
 - b. Suggesting planning production capacity.

1.3 Problem Formula

The problem that has successfully formulated from production planning activity for PT.XYZ is:

1. The company is unable to meet consumer's demand, which means that the company tends to hardly achieve product capacity planning that has been planned.
2. Facility placement in this company is inefficient; this factor contributes a lot in product planning.

1.4 Outcome and Usefulness

1. The outcome expected from the research is: Production Capacity Planning, therefore the company will be wiser in production planning which is tightly connected with working hours and production target.
2. To give suggestions on Facility Placement Improvement, therefore the company will work well with material removal, which will be more efficient and the condition of the company will be cleaner and more work friendly. Therefore will increases working speed of the operator so the targeted production will be achieved.

2. RESEARCH METHOD

2.1 Thinking Framework

The first thinking flow is to decide the priority of action production planning which use Non Numeric ME.MCDM approach.

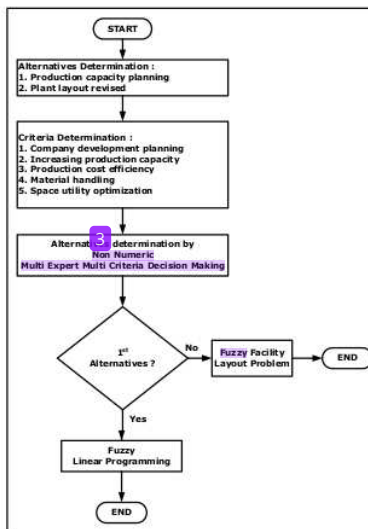


Figure 1. Thinking Framework

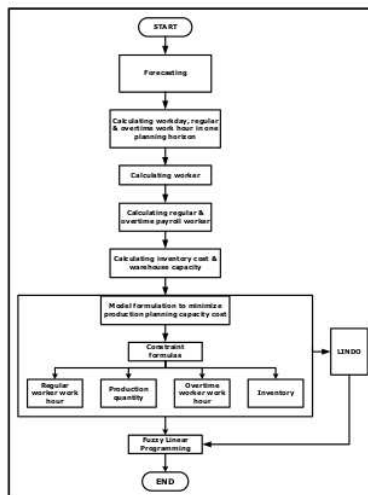


Figure 2. Fuzzy Linear Programming

2.2 Operational Planning Analysis

Demand data collected is for the period January 2002 until December 2003.

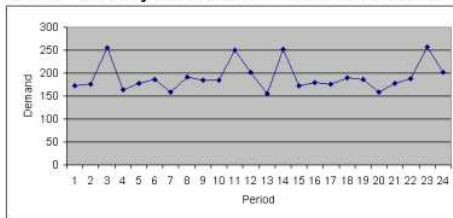


Figure 3 Data Period January 2002 – Desember 2003

2.3 Product Data

PT.XYZ owns 3 products which they produce everyday. The first product from this company is soy sauce. Additional product is chilly sauce and shrimp crackers. Soy sauce as the main product has 5 taste; sweet, regular sweet, sweet satay, barbecue, and original taste.

Soy sauce and the chilly sauce produce is packaged in five different packages that is suited with the demand. Which are;

1. 150 ml Plastic Bottle
2. 300 ml Plastic Bottle
3. 625 ml Plastic Bottle
4. 5 kg jar
5. 20 kg jar

The basic ingredient is black soy, from information collected the soy is collected from IPB, Solo and Jember University.

Additional ingredients are collected from local distributor. Additional ingredients include: palm sugar, salt, benzoate natrium, vinegar, MSG, lemon grass, laos, bay leaves, lemon leaves, garlic, adas and cinnamon stick.

According to the interview, It is known that selling price for soy sauce with the size of 625 ml is Rp.8.975,-. Therefore if its sell in one packaging box is Rp.107.700,-

Employment data collected for the PPIC sector and direct observation in the factory.

Table 1. Employment Data

Fasilitas	Jumlah
Soy warehouse	4
Fermentation	7
Fermentation area	4
Dirty bottle storage	2
Washing bottle area	14
Label storage	1
Extraction tank	7
Cooking tank	2
Filling area	20
Transite warehouse	2
Warehouse (product)	2

Take home pay=manday x longest day in
one planning horizone
= Rp.22.000,-/day x 27 day
= Rp.594.000/month

$$\begin{aligned} \text{Upah Tenaga Kerja Reguler} &= \frac{\text{Rp.594.000,-/bulan}}{196 \text{ jam/bulan}} \times 63 \text{ tenaga kerja} \\ &= \text{Rp.190.928,-/jam-tenaga kerja} \end{aligned}$$

Regular Cost = Rp.190.928/hour-worker
Overtime Cost = Rp.286.392/hour-worker

Supply cost that has been established is as big as 25% from product selling price, which is Rp.2.243,75,-/box/month or if rounded up Rp.2.244,-/box/month

Soy sauce product that is packaged in bottles is repackaged into a 32x24x30cm box. This is the same with the other *bongsang* packages with the same size. Each packaging cannot be stacked more than 8 stacks. Production Storage Capacity is 7192 boxes.

Due to the small storage room, it is only able to hold over production not more than 8%.

2.4 Data Procesing

After data is successfully collected, the overall data processing can be done based on the thinking scale that has been planned before.

There are two alternatives

- Alternative1= Production capacity planning
- Alternative2= Facility placement improvement

There are 5 criterias

- Criteria 1 = Factory development planning
- Criteria 2 = Increasing production capacity
- Criteria 3 = Production cost efficiency
- Criteria 4 = Material handling
- Criteria 5 = Area optimize used

There are 5 marking scale

- VI = Very Important
- I = Important
- A = Average
- NI = Not Important
- VNI = Very ot Important

Non Numerik ME-MCDM counting result is as follow:

$$P_{10} + I_{10-1} - I_{10} = 226.316$$

$$P_{11} + I_{11-1} - I_{11} = 228.300$$

$$P_{12} + I_{12-1} - I_{12} = 230.284$$

2. Regular work hour capacity constraint :

$$R_t + U_t = J_t \quad \dots 3)$$

Therefore :

$$R_1 + U_1 = 4375$$

$$R_2 + U_2 = 4128$$

$$R_3 + U_3 = 5292$$

$$R_4 + U_4 = 4500$$

$$R_5 + U_5 = 4400$$

$$R_6 + U_6 = 4500$$

$$R_7 + U_7 = 4941$$

$$R_8 + U_8 = 4500$$

$$R_9 + U_9 = 4888$$

$$R_{10} + U_{10} = 4758$$

$$R_{11} + U_{11} = 1428$$

$$R_{12} + U_{12} = 4775$$

3. Regular work hour utility constraint :

$$O_t - U_t = kP_t - R_t$$

$$O_t - U_t = k(F_t - I_{t-1} + I_t) - R_t$$

$$O_t - U_t = kF_t - kI_{t-1} + kI_t - R_t$$

Therefore :

$$O_t - U_t + R_t + kI_{t-1} - kI_t = kF_t \quad \dots 4)$$

Therefore :

$$O_1 - U_1 + R_1 + 0.3I_{1-1} - 0.3I_1 = 62537$$

$$O_2 - U_2 + R_2 + 0.3I_{2-1} - 0.3I_2 = 63133$$

$$O_3 - U_3 + R_3 + 0.3I_{3-1} - 0.3I_3 = 63728$$

$$O_4 - U_4 + R_4 + 0.3I_{4-1} - 0.3I_4 = 64323$$

$$O_5 - U_5 + R_5 + 0.3I_{5-1} - 0.3I_5 = 64918$$

$$O_6 - U_6 + R_6 + 0.3I_{6-1} - 0.3I_6 = 65514$$

$$O_7 - U_7 + R_7 + 0.3I_{7-1} - 0.3I_7 = 66109$$

$$O_8 - U_8 + R_8 + 0.3I_{8-1} - 0.3I_8 = 66704$$

$$O_9 - U_9 + R_9 + 0.3I_{9-1} - 0.3I_9 = 67299$$

$$O_{10} - U_{10} + R_{10} + 0.3I_{10-1} - 0.3I_{10} = 67895$$

$$O_{11} - U_{11} + R_{11} + 0.3I_{11-1} - 0.3I_{11} = 68490$$

$$O_{12} - U_{12} + R_{12} + 0.3I_{12-1} - 0.3I_{12} = 69085$$

4. Overtime work hour constraint :

$$kO_t - kU_t + kI_{t-1} - kI_t \leq kF_t \quad \dots 5)$$

Therefore :

$$0.0046O_1 - 0.0046U_1 + 0.0014I_{1-1} - 0.0014I_1 \leq 286$$

$$0.0043O_2 - 0.0043U_2 + 0.0013I_{2-1} - 0.0013I_2 \leq 270$$

$$0.0033O_3 - 0.0033U_3 + 0.0010I_{3-1} - 0.0010I_3 \leq 210$$

$$0.0039O_4 - 0.0039U_4 + 0.0012I_{4-1} - 0.0012I_4 \leq 251$$

$$0.0051O_5 - 0.0051U_5 + 0.0015I_{5-1} - 0.0015I_5 \leq 333$$

$$0.0039O_6 - 0.0039U_6 + 0.0012I_{6-1} - 0.0012I_6 \leq 256$$

$$0.0045O_7 - 0.0045U_7 + 0.0014I_{7-1} - 0.0014I_7 \leq 300$$

$$0.0039O_8 - 0.0039U_8 + 0.0012I_{8-1} - 0.0012I_8 \leq 260$$

$$0.0036O_9 - 0.0036U_9 + 0.0011I_{9-1} - 0.0011I_9 \leq 241$$

$$0.0047O_{10} - 0.0047U_{10} + 0.0014I_{10-1} - 0.0014I_{10} \leq 320$$

$$0.0061O_{11} - 0.0061U_{11} + 0.0018I_{11-1} - 0.0018I_{11} \leq 416$$

$$0.0027O_{12} - 0.0027U_{12} + 0.0008I_{12-1} - 0.0008I_{12} \leq 185$$

5. Product safety stock quantity constraint :

$$I_t \geq 0.08F_t \quad \dots 6)$$

Therefore :

$$I_1 \geq 16.677$$

$$I_2 \geq 16.835$$

$$I_3 \geq 16.994$$

$$I_4 \geq 17.153$$

$$I_5 \geq 17.312$$

$$I_6 \geq 17.470$$

$$I_7 \geq 17.629$$

$$I_8 \geq 17.788$$

$$I_9 \geq 17.947$$

$$I_{10} \geq 18.105$$

$$I_{11} \geq 18.264$$

$$I_{12} \geq 18.423$$

Fuzzy Linear Programming Formulation

According to data processing that has been done in LINDO, it is acknowledge some factors which will be explained below:

1. From the first LINDO output it was achieved Z minimum score of 318.469.900.000
2. To settle a new problem for the second LINDO input therefore it is needed to decide, the deciding production total which is a crucial thing in the fuzzy linear program discussion.

- *Right Hand Side* first problem is changed to become a difference between forecast result with forecast result with maximum capacity which is able to be achieved by PT.XYZ, which is 250.000 units.

- *Right Hand Side* first problem starting from January until December 2004 is process with the same procedures as above.
- Put this new problem with erasing the previous first problem.
- To do the execution in LINDO to achieve minimal score of Z.
- Minimal score of Z is 189.896.600.000

3. To achieve *fuzzy linear programming*, second processing is needed. It is achieved by:

- Decide output score I as big as 318.469.900.000 as maximum level
- Decide output score II as 189.896.600 as minimum level.
- To search maximum and minimum level, as bis as 128.600.300.000
- To make a new purpose function, which is:

$$\text{Maksimasi } Z = \chi \quad \dots 7)$$

- New problem as followed :

$$128600300000\chi + 83916P1 + 83916P2 + 83916P3 + 83916P4 + 83916P5 + 83914P6 + 83914P7 + 83941P8 + 83914P9 + 83914P10 + 83914P11 + 83914P12 + 190928R1 + 190928R2 + 190928R3 + 190928R4 + 190928R5 + 190928R6 + 190928R7 + 190928R8 + 190928R9 + 190928R10 + 190928R11 + 190928R12 + 95464O1 + 95464O2 + 95464O3 + 95464O4 + 95464O5 + 95464O6 + 95464O7 + 95464O8 + 95464O9 + 95464O10 + 95464O11 + 95464O12 + 2244I1 + 2244I2 + 2244I3 + 2244I4 + 2244I5 + 2244I6 + 2244I7 + 2244I8 + 2244I9 + 2244I10 + 2244I11 + 2244I12$$

$$\leq 318496900000 \quad \dots 8)$$
- With execution from LINDO software maximum Z obtained is 0.8947933

3. RESULT AND DISCUSSION

3.1 FACILITY PLACEMENT SUGGESTION

According to operational planning essay it is shown that the receiving area to the soy storage area is 11.7 meter, mean while according to professionals it is acknowledge that the correlation between both is very important, where the biggest

scale is wo meter, it means fixing both facility is needed. With maximum distance of 10 meter.

Based on the calculation, there is a correlation between facility with the criteria of NI, so it does not need to be fixed because the relation between them is not important.

Based from analysis above, the correlations that need to be checked are:

Table 3. Facilities that need to be fixed

Facility		Distance	Scale Distance
From	To		
Rec. area	Soy warehouse	11.7	(1, 1, 5.5, 10)
Rec. area	Label storage	21.7	(8, 11.67, 15.34, 19)
Soy warehouse	Fermentation area	13.1	(1, 1, 5.5, 10)
Soy fermentation area	Extraction area	46.5	(1, 1, 5.5, 10)
Washing bottle area	Filling area	17.7	(1, 1, 5.5, 10)
Label storage	Filling area	38.1	(1, 1, 5.5, 10)
Transite warehouse	Warehouse (product)	24.7	(1, 1, 5.5, 10)

To solve the problems from the table above, the arrangement of these facilities has to be fixed. The operation of this arrangement was done in the last chapter.

When doing the material handling cost, the cost from the NI dan VNI criteria is not to be timed with the range factor because there is no material flow happening between these facilities on the factory. So there is no relation between them.

Product Capacity Planning Suggestions

Based on the manufacturing data done on the last chapter, the purpose of the *fuzzy* solution is:

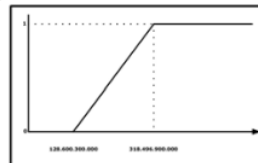


Figure 8. Purpose of Fuzzy Linear Programming

As the result, the *fuzzy* solution gives us the value of χ :

$$\text{Value } \chi = 0,8947933 \cong 0,89$$

With the value of 0,89 it means that the maximum revenue that can be reached is around Rp.318.469.900.000,-. So the production planning from January to December 2004 is :

Table 4. Total Production

Period	Production	Period	Production
Jan	59.219	July	64.736
Feb	73.070	Aug	63.070
March	71.402	Sept	61.403
April	69.736	Oct	59.736
May	68.070	Nov	58.069
June	66.403	Dec	56.403

4. CONCLUSION

- The priority factors based on expert opinion are determined by *Non Numeric ME-MCDM*.
- Two alternatives that are offered to solve the priority factors are the *fuzzy linear programming* to solve the production capacity planning, and the *fuzzy facility layout* to solve the arrangement of the factory places.
- The first priority with the value of I is to do the production planning while fixing the arrangement and the location of the facility. Then the second priority with the value of A is to do the production planning itself. The production planning from fixing the facility gives the factory owner two alternatives, which are:
 - Alternative I : Move the facility and not adding them more with the cost of Rp.919.509,-
 - Alternative II : Move the facility and add some more with the cost of Rp.1.033.631,-
- The value x that we get from the production capacity planning using the *fuzzy linear programming* is 0.89.

Suggestion

- This factory has to fixed their used bottle and soy soaking stove arrangement because it is disturbing the work of their operator.
- This factory soaking place.

- The next step is to add a warehouse that can keep the main material and separate them from the secondary material warehouse.
- The next step is to compare needs to add some toilet in the field next to the soy the *total cost* value that we got from the *fuzzy and Genetic Algorithm* solution.

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