Production planning optimization using *de novo programming* at Ceramics company in Indonesia

Haryadi Sarjono [a] , Mega Lidya Salim [b] Adi Teguh Suprapto [c]
[a, b, c] Management, School of Business Management, Bina Nusantara University
Jl. Kebon Jeruk Raya No. 27 Kebon Jeruk, Jakarta Barat 11530, Indonesia
Corresponding authour: aditeguhs992@binus.ac.id

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Abstract: In entering the era of free trade, manufacturing industries are often faced with complex problems in taking a decision to achieve company goals. One of those goals is to minimize production costs and maximize profits or profits obtained to ensure the survival of the company. PT.KOPIN is established since 1981 in the field of equipment dinnerware made of porcelain, such as plates, bowls, cups, tea pot, and saucer. This study focuses only on the production of plates. Some of the problems that occurred in each producing plates in the company is always a remaining balance of raw materials for the raw materials used are not depleted. This is a waste for the company because it is expected to cause the production planning problem, especially in terms of determining the amount of raw materials needed and how many of each product to be manufactured for the company to make a profit or maximum profit. The purpose of this study was to determine the amount of product to be produced by the plate companies using De Novo Programming so as to obtain the maximum profit.

Keywords*:* De Novo Programming, Product Planning Optimization, Profit.

Introduction

In recent years the ceramic industry in Indonesia is progressing. Data Various Ceramic Industry Association of Indonesia (ASAKI) Indonesia ceramics production volume grew 13 % in 2014 to 480 million square meters of 2013. With a turnover of 30 trillion IDR in 2014 predicted 2015 Indonesian ceramic turnover increased to 36 trillion IDR. Growth driven by the proliferation of property business in Indonesia and international market that accompanied by the shifting people's lifestyle needs of luxury goods. Increased property business led to the need for ceramics such as tiles, ceramic sanitary ware, ceramic ornaments and food tableware increases. While shifting in public life led to increased demand for ceramic items.

Other things that influence development of the ceramic industry in Indonesia is the availability of raw materials from natural Indonesia that meet the needs of ceramic production. One of ceramics that most in demand by consumers is tableware because it is the most commonly used products. Thus increasing population made the need for tableware is also increasing. The high demand for tableware encourage employers increase their production capacity.

Keeping consumers satisfied, the company used high quality raw materials, so company only produce high quality tableware. The company is engaged in equipment dinnerware made of porcelain, such as plates, bowls, cups of tea pot and saucer. This study focuses only on the production of the plate. Because of company’s difficulty in determining the optimal quantity of production in accordance with the availability of its resources, such as raw material, labor and machinery. Companies experiencing difficulty in determining how many units of each product to be manufactured optimally so that the company can gain maximum benefit.

In addition, within producing each plates are always made some remain raw materials because the raw materials used are not depleted. It is considered an extravagance for the company, because an estimated one of the reason is problem of production planning, especially in terms of determining the amount of raw materials needed for certain without excess or waste and how much of each product plate to be produced.

One method that appropriate for problems solving face by the company is using De Novo Programming. De novo Programming method approach in solving the optimization problem is done with a total system approach, meaning that in addition to determine the best combinations for output, it can also provide a proposed integrated use of resources through the budget available. In the method of De Novo Programming constraints of resources or raw materials are organized as efficiently as possible so it does not produce the rest.

Based on these issues, the company wants the efficiency of the consumption of raw materials, so it needs an optimal production plan to get the maximum benefit.

Problems and Scope

1. What forecasting method is most appropriate to apply to the company?
2. How many quantity of production proper and efficient for the company to obtain the maximum profit?

For research simplification, the scope or boundaries as follows:

1. The study focused only on the product plate, with the type of plate size 10 inch, 9 inch and size 8 inch.
2. The data used is the data request in January 2013 to November 2014.
3. It is assumed that there is no change in the selling price of each product and raw material prices during the study.
4. It is assumed that each product sold out.
5. It is assumed that the working environment both operators and other production facilities in good condition.

Research Objectives

1. To determine the forecasting methods are most appropriately applied to the company.
2. To determine the appropriate combination of quantity production to obtain the maximum benefit.

Theoretical Basis

According Iriani in (Mario T.Tabucanon 1988), Zeleny suggests a way to see a system where in addition to optimizing the existing system, he also suggested designing an optimal system. Which focused on creating an optimal design of system with high productivity which has several criteria [2].

There is a fundamental difference between the optimizing a system approach with optimum system design approach.

1. The first approach, Linear Programming approach, each resource limit is considered to have given by the previous and in the event of resource is not entirely used, deemed not affect the productivity of the system.
2. The second approach, resource constraints will contracted so it does not left a remainder, the second approach is known as the De Novo Programming.

De Novo Programming approach in solving optimization problems performed a total system approach, meaning that in addition to best determine the optimal combination of the output. This approach can provide a proposed integrated use of resources available through the budget because of the limited budget is an important requirement in the formulation De Novo Programming.

Research Method

This type of research used in this research is descriptive. Type of data that is quantitative, source of data used is secondary. Analytical method used is a De Novo Programming.

Forecasting

Demand forecasting uses historical data of January 2013 - November 2014. This forecasting is done to look at the magnitude of potential demand sales of each product in period of March 2015. Forecasting methods used to forecast demand for each product accurately is by using the Linear Regression method, because it has the smallest Mean Absolute Deviation (MAD). Forecasting calculations using QM for Windows 2. Here are the results of forecasting requests quantity of each product:

Table 1. Forecasting Results

PRODUCT	Mar-15
Plate Size 10 *inch*	68.589,55 → 68.590
Plate Size 9 inch	73.914,4663 → 73.914
Plate Size 8 inch	86.365,441→ 86.365

Source: Processed Data

Forecasting results total sales in March 2015 by the Linear Regression method in the table above will be used as constraints of the constraint functions that describe the fluctuations in demand in the formulation of De Novo Programming models for analyzing the optimal combination of products that must be produced by the company.

Production Planning with *De Novo Programming Method*

Production planning formulation by using *De Novo Programming* method:

Decision Variable Determination

The decision variable in production model is the unit quantity of produce product, they are:

X_1 = Plate Size 10 *inch*

X_2 = Plate Size 9 *inch*

X_3 = Plate Size 8 *inch*

Purpose Function Determination

The main objective of the company is to maximize profits, so it can be determined the objective function in maximizing profit by following equation:

Maksimization $Z = 25.000\ X_1 + 18.000\ X_2 + 12.000\ X_3$

Constrain Function Determination

Production Capacity Constrain

Machine production capacity of plate products is machines with the smallest capacity. Where the engine capacity for products of different dishes is to have the same value as it uses the same machine where the machine worked for 300 working days in a year. Then production capacity of machine for plate products type is as follows:

30.000 unit/day x 300 days = 9.000.000 unit/ year

The constrain function for production capacity:

$X_1 + X_2 + X_3 \leq 9.000.000$ unit/ year

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Raw material availability constrains

Table 2. Raw Material Composition

Raw Material	X1 = Plate Size 10 inch	X2 = Plate Size 9 inch	X3 = Plate Size 8 inch	Total
Ball Clay Gumpal Kalimantan	0,118636	0,101284	0,079571	33.122,13
HCS-01	0,020455	0,017463	0,013719	6598,047
Kaolin Gumpal AK	0,068091	0,058131	0,0045669	21885,462
Zirco Clay	0,051727	0,044161	0,034694	16626,102
Silica Sand 80#	0,09	0,076836	0,060364	28923,309
Potash Feldspar ex.India. Lokal	0,072455	0,061857	0,048596	23281,467
Potash Feldspar ex.India. Import	0,072455	0,061857	0,048596	23281,467
silicca Powder 200 # Lokal	0,013455	0,011487	0,009024	4346,559
silicca Powder 200 # Import	0,013455	0,011487	0,009024	4346,559
Dolomite	0,006909	0,005899	0,004634	2244,531
Calcined Aluminia Oxide	0,002249	0,00192	0,001508	756,384
Zirconium Super 01	0,002182	0,001863	0,001463	714,603
Prestia Case Import	0,000909	0,000776	0,00061	292,431
Prestia Case Lokal	0,000909	0,000776	0,00061	292,431
Prestia Cast Import	0,001364	0,001164	0,000915	440,3877
Prestia Cast Lokal	0,001364	0,001164	0,000915	440,3877
Prestia Cera Cast Import	0,004545	0,003881	0,003049	1461,4593
Prestia Cera Cast Lokal	0,004545	0,003881	0,003049	1461,4593
Prestia Millroll Import	0,018182	0,015522	0,012195	5842,8921
Prestia Millroll Lokal	0,018182	0,015522	0,012195	5842,8921

Source: Company (2015)

Constrains Raw Material Cost

The cost of the raw material is:

B = 33.122,125 (IDR 550) + 6.598,047 (IDR 590) + 21885,462 (IDR 680) + 16626,102 (IDR 1.100) + 28923,309 (IDR 580) + 23281,467 (IDR 1.850) + 23281,467 (IDR 1.850) + 4346,559 (IDR 1.106,55) + 4346,559 (IDR 1.106,55) + 2244,531 (IDR 810) + 756,384 (IDR 1.118,845) + 714,603 (IDR 1.700) + 292,431 (IDR 7.008,15) + 292,431 (IDR 7.008,15) + 440,3877 (IDR 2.581,95) + 440,3877 (IDR 2.581,95) + 1461,4593 (IDR 2.643,425) + 1461,4593 (IDR 2.643,425) + 5842,8921 (IDR 3.208,995) + 5842,8921 (IDR 3.208,995)

B = IDR 223.295.389

Raw material cost equation is as follows:

IDR 550 + IDR 590 + IDR 680 + IDR 1.100 + IDR 580 + IDR 1.850 + IDR 1.850 + IDR 1.106,55 + IDR 1.106,55 + IDR 810 + IDR 1.118,845 + IDR 1.700 + IDR 7.008,15 + IDR 7.008,15 + IDR 2.581,95 + IDR 2.581,95 + IDR 2.643,425 + IDR 2.643,425 + IDR 3.208,995 + IDR 3.208,995 $\leq$ IDR 223.295.389

With equation: $p_1 a_{1j} + p_2 a_{2j} + \ldots.. + p_m a_{mj} = v_j$ which is: j = 1, 2, 3.

Plate size 10 *inch* (V_1)

(V_1) = 0,118636 X_1 (IDR 550) + 0,020455 X_1 (IDR 590)+ 0,068091 X_1 (IDR 680) + 0,051727 X_1 (IDR 1.100) + 0,09 X_1 (IDR 580) + 0,072455 X_1 (IDR 1.850) + 0,072455 X_1 (IDR 1.850) + 0,013455 X_1 (IDR 1.106,55) + 0,013455 X_1 (IDR 1.106,55) + 0,006909 X_1 (IDR 810) +0,002249 X_1 (IDR 1.118,845) + 0,002182 X_1 (IDR 1.700) + 0,000909 X_1 (IDR 7.008,15) + 0,000909 X_1 (IDR 7.008,15) + 0,001364 X_1 (IDR 2.581,95) + 0,001364 X_1 (IDR 2.581,95) + 0,004545 X_1 (IDR 2.643,425) + 0,004545 X_1 (IDR 2.643,425) + 0,018182 X_1 (IDR 3.208,995) + 0,018182 X_1 (IDR 3.208,995)

(V_1) = IDR 702,9075666

Plate size 9 *inch* (V_2)

(V_2) = 0,101284 X_2 (IDR 550) + 0,017463 X_2 (IDR 590) + 0,058131 X_2 (IDR 680) + 0,044161 X_2 (IDR 1.100) + 0,076836 X_2 (IDR 580) + 0,061857 X_2 (IDR 1.850) + 0,061857 X_2 (IDR 1.850) + 0,011487 X_2 (IDR 1.106,55) + 0,011487 X_2 (IDR 1.106,55) + 0,005899 X_2 (IDR 810) + 0,00192 X_2 (IDR 1.118,845) + 0,001863 X_2 (IDR 1.700) + 0,000776 X_2 (IDR 7.008,15) + 0,000776 X_2 (IDR 7.008,15) + 0,001164 X_2

(IDR 2.581,95) + 0,001164 X_2 (IDR 2.581,95) + 0,003881 X_2 (IDR 2.643,425) + 0,003881 X_2 (IDR 2.643,425) + 0,015522 X_2 (IDR 3.208,995) + 0,015522 X_2 (IDR 3.208,995)
(V_2) = IDR 600,0924161

Plate size 8 *inch* (V_3)
(V_3) = 0,079571 X_3 (IDR 550) + 0,013719 X_3 (IDR 590) + 0,0045669 X_3 (IDR 680) + 0,034694 X_3 (IDR 1.100) + 0,060364 X_3 (IDR 580) + 0,048596 X_3 (IDR 1.850) + 0, 048596 X_3 (IDR 1.850) + 0,009024 X_3 (IDR 1.106,55) + 0,009024 X_3 (IDR 1.106,55) + 0,004634 X_3 (IDR 810) + 0,001508 X_3 (IDR 1.118,845) + 0,001463 X_3 (IDR 1.700) + 0,00061 X_3 (IDR 7.008,15) + 0,00061 X_3 (IDR 7.008,15) + 0,000915 X_3 (IDR 2.581,95) + 0,000915 X_3 (IDR 2.581,95) + 0,003049 X_3 (IDR 2.643,425) + 0,003049 X_3 (IDR 2.643,425) + 0,012195 X_3 (IDR 3.208,995) + 0,012195 X_3 (IDR 3.208,995)
(V_3) = IDR 443,5042499

The equation:
IDR 702,9075666 X_1 + IDR 600,0924161 X_2 + IDR 443,5042499 $X_3 \leq$ IDR 223.295.389

Demand Product Constrains
Demand product constrains are as follows:
$X_1 \leq 68.590$
$X_2 \leq 73.914$
$X_3 \leq 86.365$

After knowing the formulation of method of De Novo Programming, then made a settlement with using QM software for Windows 2. Based on the results of data processing using software QM 2 for windows, the optimal solution is obtained by producing a 10 inch platter size of 68.590 units, Plates measure 9 inch by 73.914 Plate unit and 8 inch size of 86.365 units. Here are the results of calculations using QM software for Windows 2.

Figure 1. Optimization Result

Objective
Maximize
Minimize

Instruction
There are more results available in additional windows. These may be opened by usir

PT. KEDAUNG ORIENTAL PORCELAIN

	Piring Uk 10 inc	Piring uk 9 inc	Piring uk 8 inc		RHS	Dual
Maximize	25.000,	18.000,	12.000,			
Kapasitas produksi	1,	1,	1,	<=	9.000.000,	0,
Ball Clay Gumpal Kalimantan	0,1186	0,1013	0,0796	<=	33.122,13	0,
HCS-01	0,0205	0,0175	0,0137	<=	6.598,047	0,
Kaolin Gumpal AK	0,0681	0,0581	0,0046	<=	21.855,46	0,
Zirco Clay	0,0517	0,0442	0,0347	<=	16.626,1	0,
Silica Sand 80#	0,09	0,0768	0,0604	<=	28.923,31	0,
Potash Feldspar ex.India. Lokal	0,0725	0,0619	0,0486	<=	23.281,47	0,
Potash Feldspar ex.India.	0,0725	0,0609	0,0486	<=	23.281,47	0,
silicca Powder 200 # Lokal	0,0135	0,0115	0,009	<=	4.346,559	0,
silicca Powder 200 # Import	0,0135	0,0115	0,009	<=	4.346,559	0,
Dolomite	0,0069	0,0059	0,0046	<=	2.244,531	0,
Calcined Aluminia Oxide	0,0022	0,0019	0,0015	<=	756,384	0,
Zirconium Super 01	0,0022	0,0019	0,0015	<=	714,603	0,
Prestia Case Import	0,0009	0,0008	0,0006	<=	292,431	0,
Prestia Case Lokal	0,0009	0,0008	0,0006	<=	292,431	0,
Prestia Cast Import	0,0014	0,0012	0,0009	<=	440,3877	0,
Prestia Cast Lokal	0,0014	0,0012	0,0009	<=	440,387	0,
Prestia Cera Cast Import	0,0045	0,0039	0,003	<=	1.461,459	0,
Prestia Cera Cast Lokal	0,0045	0,0039	0,003	<=	1.461,459	0,
Prestia Millroll Import	0,0182	0,0155	0,0122	<=	5.842,892	0,
Prestia Millroll Lokal	0,0182	0,0155	0,0122	<=	5.842,892	0,
Kendala Biaya (Budget)	702,9076	600,0924	443,5042	<=	223.295.400,	0,
Demand piring uk 10 inc	1,	0,	0,	<=	68.590,	25.000,
Demand piring uk 9 inc	0,	1,	0,	<=	73.914,	18.000,
Demand piring uk 8 inc	0,	0,	1,	<=	86.365,	12.000,
Solution->	68.590,	73.914,	86.365,		4.081.582.000,	

Source: Processed Data (2015)

Based on the results above, the profit calculation obtained results as the table below:

Table 3. Optimal Profit

Product	Quantity	Profit (*per unit*)	Profit (*per production*)
Plate Size 10 *inch*	68.590 unit	IDR 25.000	IDR 1.714.750.000,00
Plate Size 9 *inch*	73.914 unit	IDR 18.000	IDR 1.330.452.000,00
Plate Size 8 *inch*	86.365 unit	IDR 12.000	IDR 1.036.380.000,00
	Profit Total		IDR **4.081.582.000,00**

Source: Processed Data (2015)

So, in the period of March 2015 the company should manufacture Plate size 10 inch by 68.590 units, Plates measure 9 inches by 73.914 units and Plate size 8 inch by 86.365 units, to obtain the maximum profit of IDR 4.081.582.000.

Conclusions

Based on the results of research conducted and discussed in the previous chapter, it can be drawn some conclusions:

1. The most appropriate forecasting method used to predict the sales quantity of each product for the company is Linear Regression, because it has the smallest Mean Absolute Deviation (MAD) of all the methods used in this study. So that the results of forecasting with the Linear Regression method can be used by companies as a standard measure for the next period.
2. Optimal combination plates products to be produced by the company in the period March 2015 are 68.590 units for the plate size 10 inch, 73.914 units of plates 9 inches and 86.365 units of plate size 8 inch, so that it will obtain the maximum profit of IDR 4.081.582.000.

In this study, the advice can be given to the company:

1. Companies need to improve the efficiency of the supply of raw materials and labor so that the available resources can be used and utilized optimally, so that enterprises can derive the maximum benefit.
2. Companies can use the Linear Regression method in forecast the sales quantity in the future, so that the company can determine sales planned projections by more structured. In addition, companies can use the methods of De Novo Programming to assist decision makers, especially the production division in determining the right combination of products and can allocate overall resources are used effectively and efficiently, so that the company can minimize the production costs to be incurred.

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