Evaluating Company X's Product Mix and Product Size to Maximize Profit

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Abstract

Company X is a worldwide market dealing mainly in decorative paints and performance coating. More specifically the company is classified as a matrix organization that is divided into seven regions which are responsible for the sales of Marine (27%), Protective (24%), and Powder(10%) Coatings as well as Decorative Paints(39%). The company is represented in more than 100 countries in the world where it operates with 37 production facilities in over 21 countries and 63 companies in 45 countries. In this report, we will analyze how the company's investment in resources (raw materials) will allow them to reach their optimal combination of products to be produced to obtain a maximum return, and ultimately reach the goal of maximizing their profits.

Keywords
Operations Research, Optimization, Maximizing Profit, Paint Company, Decorative Paint.

Introduction:
Company X began the effort to reexamine their investment in resources with an emphasis on decorative paints as it formulates 39% of their business segment in order to maintain and accelerate the company's growth. This reexamination is done due to the fact that there is a strict shortage of production inputs that industries are facing nowadays which ultimately results in low output. With the present competitive pressure, managerial decisions are made accordingly, and hence the main objection of this study is to act alongside managerial decisions to know the amount and types of decorative paints to be manufactured and sold to earn maximum contribution.

1) Organic Growth:
The company's goal is to expand into new and existing markets by increasing capacity and utilizing all of its resources to expand operations and grow the company. Organic growth is often characterized by increased output, increased production efficiency and speed, increased revenue, and improved cash flow. It is important to a company's success.

Organic growth is achieved by:
- Continual optimization of commercial activities, which includes how goods and services are priced, advertised, and sold.
- Reallocation of funds into activities that generate earnings and growth.
- Creating and developing new commodities to sell and/or services to offer or building new operational models.

2) Four Segments:
Company X's goal of improving sales in:
Decorative Paints: Company X's Decorative paints is a prominent paint supplier to commercial, public, and residential structures, servicing both professionals and consumers directly as well as through a large network of Jotun Multicolor centers.

Protective Coatings: Company X's Protective Coatings provides high-quality protective coatings for on- and offshore oil and gas, energy, and infrastructure projects, such as passive fire protection, metallic finishes, high-temperature coatings, and cutting-edge anticorrosive protection.

Marine Coatings: Company X's Marine Coatings is a global leader in high-performance hull coatings for the maritime industry, providing high-quality coatings for sea stock, newbuilding, tanks, cargo holds, and drydocking projects, as well as megayachts and leisure yachts.

Powder Coatings: Company X's Powder Coatings is a leading provider to businesses in the building components, general industries, pipeline and appliance sectors, and furniture industries.

3) Differentiated Approach:
Company X's global view through a regional and local focus.

Methodology

Company X's maximization process of re-examining their investments in raw materials works alongside their main goals which include organic growth, improvement in their four segments, and a differentiated approach of a global view through a regional and local focus. However, in order for Company X to reexamine their investments in raw materials in the best way possible they must be aware of the products they hold that will allow them to profit the most and hence truly bring organic growth and improvement in the decorative paint segment of their business. This drives the company to look into maximizing their product size and product mix for decorative paints (specifically) in order to truly allocate costs spent on raw materials that will allow large production of the specific size and the specific product under decorative paints that will allow for great profit maximization.

Our goal was to first find out which size was the most profitable for Company X.
The company has 5 sizes 1.3 gallons paint size sold for $50, 2.6 gallons paint size sold for $95, 5.2 gallons paint size sold for $180, 6.6 gallons paint size sold for $220, and 13.2 gallons paint size sold for $450.

Why should Company X monitor their product size for decorative paints specifically?
Company X accounts for multiple sizes when it comes to producing decorative paints, these sizes vary from one gallon and go up to thirteen gallons. The large range of paint sizes prompts the company to invest in a large number of raw materials in order to fill and satisfy each of these paint sizes. Therefore, in order for the company to achieve its goal by allocating the right raw materials to invest in, selecting the correct paint size that holds the largest optimal solution and the correct composition of raw materials will aid the company in making targeted decisions for investment improvements. Ultimately, this would culminate in maximizing the revenue base of the company, satisfying customer demand, and eliminating wasteful raw material investment.

- Decision Variables
  - X1: 1.3 gallons paint size
  - X2: 2.6 gallons paint size
  - X3: 5.2 gallons paint size
  - X4: 6.6 gallons paint size
  - X5: 13.2 gallons paint size

- Selling Price
  SP of X1: $ 50
  SP of X2: $ 95
  SP of X3: $ 180
  SP of X4: $ 220
  SP of X5: $ 450

- Yielding the following Objective Function:
  Max Profit = 50X1 + 95X2 + 180X3 + 220X4 + 420X5

Each paint bottle at Company X is made up of the following components NP=6, Tylose, Ammonia, Sodium, Plyrone, Margal, GP, Foam, Tio, Solvent, Additives, Pigments, Extenders, and Binder.

1.3 gallons paint size is made out of 0.02 liters of NP=6, 0.05 liters of Tylose, 0.014 liters of Ammonia, 0.013 liters of Sodium, 0.034 liters of Plyrone, 0.012 liters of Margal, 0.14 liters of GP, 0.01 liters of Foam, 0.7 liters of Tio, 1 liter of solvent, 0.017 liters of additives, 0.5 liters of pigment, 1 liter of extenders, of 0.5 liters of the binder.

2.6 gallons paint size is made out of 0.04 liters of NP=6, 0.1 liters of Tylose, 0.028 liters of Ammonia, 0.026 liters of Sodium, 0.068 liters of Plyrone, 0.024 liters of Margal, 0.28 liters of GP, 0.02 liters of Foam, 1.4 liters of Tio, 2 liters of solvent, 0.034 liters of additives, 1 liter of pigment, 2 liters of extenders, 1 liter of a binder.

5.2 gallons paint size is made out of 0.08 liters of NP=6, 0.2 liters of Tylose, 0.056 liters of Ammonia, 0.052 liters of Sodium, 0.138 liters of Plyrone, 0.048 liters of Margal, 0.56 liters of GP, 0.04 liters of Foam, 2.8 liters of Tio, 4 liters of solvent, 0.068 liters of additives, 2 liters of pigment, 4 liters of extenders, 2 liters of a binder.

6.6 gallons paint size is made out of 0.01 liters of NP=6, 0.25 liters of Tylose, 0.07 liters of Ammonia, 0.065 liters of Sodium, 0.17 liters of Plyrone, 0.06 liters of Margal, 0.7 liters of GP, 0.05 liters of Foam, 3.5 liters of Tio, 5 liters of solvent, 0.085 liters of additives, 2.5 liters of pigment, 5 liters of extenders, 2.5 liters of a binder.

13.2 gallons paint size is made out of 0.2 liters of NP=6, 0.5 liters of Tylose, 0.14 liters of Ammonia, 0.13 liters of Sodium, 0.34 liters of Plyrone, 0.12 liters of Margal, 1.4 liters of GP, 0.1 liters of Foam, 7 liters of Tio, 10 liters of solvent, 0.17 liters of additives, 5 liters of pigment, 10 liters of extenders, of 5 liters of a binder.

Subject to these constraints
NP=6; CONSTRAINT
    0.02*x1+0.04*x2+0.08*x3+0.1*x4+0.2*x5<=27;
TYLOSE CONSTRAINT
    0.05*x1+0.1*x2+0.2*x3+0.25*x4+0.5*x5<=68;
AMMONIA CONSTRAINT
    0.014*x1+0.028*x2+0.056*x3+0.07*x4+0.14*x5<=19;
SODIUM CONSTRAINT
    0.013*x1+0.026*x2+0.052*x3+0.065*x4+0.13*x5<=18;
POLYRONE CONSTRAINT
    0.034*x1+0.068*x2+0.136*x3+0.17*x4+0.34*x5<=46;
MARGAL CONSTRAINT
    0.012*x1+0.024*x2+0.048*x3+0.06*x4+0.12*x5<=18;
GP CONSTRAINT
    0.14*x1+0.28*x2+0.56*x3+0.7*x4+1.4*x5<=189;
FOAM CONSTRAINT
    0.01*x1+0.02*x2+0.04*x3+0.05*x4+0.1*x5<=14;
TIO CONSTRAINT
    0.7*x1+1.4*x2+2.8*x3+3.5*x4+7*x5<=945;
SOLVENT CONSTRAINT

1*x1+2*x2+4*x3+5*x4+10*x5<=1500000;
ADDITIVES CONSTRAINT
0.017*x1+0.034*x2+0.068*x3+0.085*x4+0.17*x5<=20000;
PIGMENTS CONSTRAINT
0.5*x1+1*x2+2*x3+2.5*x4+5*x5<=7400;
EXTENDERS CONSTRAINT
1*x1+2*x2+4*x3+5*x4+10*x5<=2250000;
BINDER CONSTRAINT
0.5*x1+1*x2+2*x3+2.5*x4+5*x5<=19000;

Sensitivity Analysis
Using lingo solver, we concluded that to maximize profit for the month Company X should sell 1350 containers of the 1.3 gallons paint size.

Reduced cost:
For the 1.3 gallons paint size, the reduced cost is 0.
As for the 2.6 gallons paint size, the reduced cost is 5.
For the 5.2 gallons paint size, the reduced cost is 20.
For the6.6 gallons paint size, the reduced cost is 30.
And finally, for the 13.2 gallons paint size the reduced cost is 80.

Shadow price:
The shadow price for all the constraints is 0, except for the NP=6 constraint it is 2500.

Ranges:
Coefficients:
X1 =Current Coefficient is 50, Allowable Increase is INFINITY and Allowable decrease is 2.5.
X2=Current Coefficient is 95, Allowable Increase is 5 and Allowable decrease is INFINITY.
X3=Current Coefficient is 180, Allowable Increase is 20 and Allowable decrease is INFINITY.
X4=Current Coefficient is 220, Allowable Increase is 30 and Allowable decrease is INFINITY.
X5=Current Coefficient is 420, Allowable Increase is 80 and Allowable decrease is INFINITY.

Table 1: Coefficients Allowable Increase and Decrease

Coefficients	Allowable Increase	Allowable Decrease
X1	INFINITY	2.5
X2	5	INFINITY
X3	20	INFINITY
X4	30	INFINITY
X5	80	INFINITY

Constraints:
NP=6 =Current RHS is 27, Allowable Increase is INFINITY and Allowable decrease is 27.
TYLOSE =Current RHS is 68, Allowable Increase is INFINITY and Allowable decrease is 0.5.
AMMONIA =Current RHS is 19, Allowable Increase is INFINITY and Allowable decrease is 0.1.
SODIUM =Current RHS is 18, Allowable Increase is INFINITY and Allowable decrease is 0.45.
POLYRONE =Current RHS is 46, Allowable Increase is INFINITY and Allowable decrease is 0.1.
MARGAL =Current RHS is 18, Allowable Increase is INFINITY and Allowable decrease is 1.8.
GP =Current RHS is 189, Allowable Increase is INFINITY and Allowable decrease is 0.

FOAM =Current RHS is 14, Allowable Increase is INFINITY and Allowable decrease is 0.5.
TIO =Current RHS is 945, Allowable Increase is INFINITY and Allowable decrease is 0.
SOLVENT =Current RHS is 1500000, Allowable Increase is INFINITY and Allowable decrease is 1498650.
ADDITIVES=Current RHS is 20000, Allowable Increase is INFINITY and Allowable decrease is 19977.05.
PIGMENTS=Current RHS is 7400, Allowable Increase is INFINITY and Allowable decrease is 6725.
EXTENDERS=Current RHS is 2250000, Allowable Increase is INFINITY and Allowable decrease is 2248650.
BINDER=Current RHS is 19000, Allowable Increase is INFINITY and Allowable decrease is 18325.

Our second goal was to find out which paint type is the most profitable to maximize sales.

Why should Company X monitor their product mix for decorative paints?
When it comes to the production of decorative paints, the company fabricates various types of decorative paint product mixes; these types of decorative paints vary depending on their application and the client's requirements. The large range of types of paint grants the company the advantage of investing in a substantial amount of raw materials in order to fill and satisfy each of these types of paint. Therefore, in order for the company to make direct resolutions for investment improvements and to maximize their profit, they would have to develop production-demand based models designed to handle the available resources of concerns by:

1. Effective workforce management
2. Production
3. Demand schedule

In the fullness of time, this would lead up to maximizing the revenue base of the company and reducing expenditures in a bid to improve the profitability index of the establishment.

The range of Company X's household paint product mix includes Powder Finish, Antifungal, Silk Finish, Matte Finish, Texture Paint where each product holds its own selling price.

Their selling prices are as follows: Powder Finish is sold for \$ 86.45, Antifungal paint is sold for \$ 54.375, Silk Finish is sold for \$ 273.59, Matte Finish is sold for \$ 354.7 and Texture Paint is sold for \$ 50.
They are represented as:

- Decision Variables

X1: units of Powder Finish produced per month
X2: units of Antifungal paint produced per month
X3: units of Silk Finish produced per month
X4: units of Matte Finish produced per month
X5: units of texture paint produced per month

- Selling Price

SP of X1: \$ 86.45
SP of X2: \$ 54.375
SP of X3: \$ 273.59
SP of X4: \$ 354.7
SP of X5: \$ 50

- Yielding the following Objective Function:

Max Profit = 86.45X1 + 54.375X2 + 273.59X3 + 354.7X4 + 50X5

Maximizing Product Mix: (Constraints)
Regardless of their type, each household paint bottle at Company X is composed of water, titamin dioxide, calcium carbonate, a binder resin, additives, coloring paste, sand, kerosene, and pigment coloring material. Each type is also subjected to certain labor hours and demand constraints.

Powder finish is made up of water 135000, TITAMIN DIOXIDE 147150, CALCIUM CARBONATE 1283040, BINDER RESIN 51000, ADDITIVES 3570, COLOURING PASTE 3000, KEROSENE 779370, LABOUR HOURS 1985300, PIGMENT COLOURING MATERIALS 10800, DEMAND 2950622.

Antifungal paint is made up of WATER 67020,TITAMIN DIOXIDE122850,CALCIUM CARBONATE 599280, BINDER RESIN 42000, ADDITIVES 5355, COLOURING PASTE 1500,KEROSENE 346380,LABOUR HOURS 882400, PIGMENT COLOURING MATERIALS 5400,DEMAND 1062270.

Silk Finish is made up of TITAMIN DIOXIDE 47880,CALCIUM CARBONATE 63360,BINDER RESIN 38100,ADDITIVES,COLOURING PASTE 225,
360,KEROSENE 135000,LABOUR HOURS 343900,PIGMENT COLOURING MATERIALS 825,DEMAND 709611.

Matte finish is made up of TITAMIN DIOXIDE 24750,CALCIUM CARBONATE 26400,BINDER RESIN 21000,ADDITIVES 360,COLOURING PASTE 150, KEROSENE 90000,LABOUR HOURS 229300,PIGMENT COLOURING MATERIALS 540,DEMAND 2871119.

Texture paint is made up of WATER 105000, TITAMIN DIOXIDE 107100, CALCIUM CARBONATE 74976 0, BINDER, RESIN 147000, ADDITIVES 5356, COLOURING PASTE 1125, SAND 57750, KEROSENE 62490, LABOUR HOURS 159 00, PIGMENT COLOURING MATERIALS 9450, DEMAND 1178800.

Subject to these constraints:
WATER CONSTRAINT
135000*x1+67020*x2+105000*X5<=300000;
TITAMIN DIOXIDE CONSTRAINT
147150*x1+122850*x2+47880*x3+24750*x4+107100 *x5<=450000;
CALCIUM CARBONATE CONSTRAINT
1283040*x1+599280*x2+63360*x3+26400*x4+74976 0*x5<=2640000;
BINDER RESIN CONSTRAINT
51000*x1+42000*x2+38100*x3+21000*x4+147000*x 5<=300000;
ADDITIVES CONSTRAINT
3570*x1+5355*x2+360*x3+360*x4+5356*x5<=15000;
COLOURING PASTE CONSTRAINT
3000*x1+1500*x2+225*x3+150*x4+1125*x5<=7500;
SAND CONSTRAINT
57750*x5<=57750;
KEROSENE CONSTRAINT
779370*x1+346380*x2+135000*x3+90000*x4+62490 *x5<=1413240;
LABOUR HOURS PER PRODUCT CONSTRAINT
1985300*x1+882400*x2+343900*x3+229300*x4+159 00*x5<=3600100;
PIGMENT COLOURING MATERIALS CONSTRAINT
10800*x1+5400*x2+825*x3+540*x4+9450*x5<=27000;
DEMAND CONSTRAINT
2950622*x1+1062270*x2+2709611*x3+2871119*x4+ 1178800*x5<=49172638;

Sensitivity Analysis
Using lingo solver, we concluded that to maximize profit for the month Company X should sell 14.3 or 14 of the Matte Finish paint.

Reduced cost:
For the Powder Finish, the reduced cost is 774.964.
As for the Antifungal, the reduced cost is 655.025.
For the Silk Finish, the reduced cost is 369.9371.
For the Matte Finish, the reduced cost is 0.

And finally, for the Texture Paint, the reduced cost is 2432.9.

Shadow price:
The shadow price for all the constraints is 0

Ranges:
Coefficients:
X1 =Current Coefficient is 50, Allowable Increase is 774.9643 and Allowable decrease is INFINITY
X2=Current Coefficient is 54.37500, Allowable Increase is 655.0250 and Allowable decrease is INFINITY.
X3=Current Coefficient is 273.5900, Allowable Increase is 369.9371 and Allowable decrease is INFINITY.
X4=Current Coefficient is 354.7000, Allowable Increase is INFINITY and Allowable decrease is 203.9024.
X5=Current Coefficient is 50.00000, Allowable Increase is 2432.900 and Allowable decrease is INFINITY.

Table 2: Coefficients Allowable Increase and Decrease

Coefficients	Allowable Increase	Allowable Decrease
X1	774.9643	INFINITY
X2	655.0250	INFINITY
X3	369.9371	INFINITY
X4	INFINITY	203.9024
X5	2432.900	INFINITY

Constraints:
WATER=6 =Current RHS is 300000, Allowable Increase is INFINITY and Allowable decrease is 300000.
TITAMIN DIOXIDE =Current RHS is 450000, Allowable Increase is INFINITY and Allowable decrease is 96428.57.

CALCIUM CARBONATE =Current RHS is 2640000, Allowable Increase is INFINITY and Allowable decrease is 2262857.

BINDER RESIN =Current RHS is 300000, Allowable Increase is 29708.24 and Allowable decrease is 300000.

ADDITIVES =Current RHS is 15000, Allowable Increase is INFINITY and Allowable decrease is 9857.143.

COLOURING PASTE =Current RHS is 7500, Allowable Increase is INFINITY and Allowable decrease is 5357.

SAND =Current RHS is 57750, Allowable Increase is INFINITY and Allowable decrease is 57750.
KEROSENE =Current RHS is 1413240, Allowable Increase is INFINITY and Allowable decrease is 127525.7.

LABOUR HOURS PER PRODUCT =Current RHS is 3600100, Allowable Increase is INFINITY and Allowable decrease is 324385.7.

PIGMENT COLOURING MATERIALS =Current RHS is 27000, Allowable Increase is INFINITY and Allowable decrease is 19285.71.

DEMAND=Current RHS is 49172638, Allowable Increase is INFINITY and Allowable decrease is 8156652.

Conclusion

How Will the Two Maximization Processes Help Company X Reach Their Goal?
Since decorative paints shape up to 39% of the company's income, controlling the production of decorative paints will deem the most effective when it comes to the overall profit. Company X aims to maximize their profit in order to improve their four segments and the current market, therefore the reexamination of their investment in raw materials will be based on the best size and type that is concluded through maximizing the product size and product mix decorative paints.

To summarize, this maximization procedure will allow Company X to reevaluate their raw material investments by maximizing product mix and product size in order to have the best candidate to allow Company X to allocate their investments on the proper raw materials and amounts. The optimal product size was 1.3 Gallons, and the best product mix was Academy Paint, as determined through the process of maximizing product size and product mix. To optimize the profit from 1.3 gallons of Academy Paint, the company should allocate its investments to the appropriate raw ingredients and amounts.

A number of conclusions were drawn as a result of this investigation. Managers of the case study organization, for example, do not employ sophisticated scientific instruments such as LINGO to plan their operations and production.

This optimization model could be used in a factory setting to help managers to select the most profitable production plan. We can see the effects of changing resources on a profit from the results of using LINGO software to analyze the product mix of the company's five products (Powder Finish Paint, Antifungal Paint, Silk Finish Paint, Matte Finish Paint, and Textures Paint), and how it can help make informed decisions about resources used for production; water, titanium dioxide, calcium carbonate, a binder resin, color paste, additives, sand, kerosene, Pigment-coloring material, plant capacity It also enables managers to make decisions about employee overtime, the recruiting of temporary workers, and the use and ordering of raw supplies. This model may be utilized on a continuous basis, giving managers the flexibility to run what-if scenarios and gain meaningful insight into the impact of resource changes on profitability.

Tackling the uncertainty of today's international economy on the cusp of the twenty-first century, as well as technology innovation and other competitive forces that combine in a complex manner, complex decision-making problems arise. It is difficult to create a schedule that is both practical and cost-effective. As a result, organizations benefit from the acquisition of analytical methods like linear programming and associated software for analyzing and manipulating huge organization operations and production data.

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