

Supply Chain Analysis

Case Study 2: Rougir Cosmetics

1. What are the costs for producing the three products in-house?

The costs of producing a carton of each of the three products in house are as follows (see *Total Cost per Product Carton* on the first sheet of the attached excel file for the calculations):

- Face Cream:
 - Shift 1: \$32.15
 - Shift 2: \$34.17
- Body Cream:
 - Shift 1: \$37.35
 - Shift 2: \$39.81
- Hand Cream:
 - Shift 1: \$25.53
 - Shift 2: \$26.84

Clearly, when compared to the costs our outsourcing production of the Face and Body creams (costs are \$40 and \$55 per carton, respectively) it appears to be more attractive to produce in house, except for the caveat that RCI lacks the capability to produce everything in house.

2. Develop a linear programming model for this problem.

**Given the wording, I'm not sure if I'm only being asked to solve this in excel, or if I'm also expected to write out a formulation of the problem as was expected in the midterm, so to be safe I'll do both.*

The objective of this problem is to minimize the cost (Z) of production across two shifts in house at RCI and outsourcing to a subcontractor:

$$\begin{aligned}
 Z = & 32.15x_{11} & + 37.35x_{12} & + 25.53x_{13} & \leftarrow \text{Shift 1 production} \\
 & + 34.17x_{21} & + 39.81x_{22} & + 26.84x_{23} & \leftarrow \text{Shift 2 production} \\
 & + 40x_{31} & + 55x_{32} & & \leftarrow \text{Outsourced production}
 \end{aligned}$$

With decision variables x_{11-32} representing the quantity of product to be made either during that shift or via the subcontractor:

$x_{11,21}$ = Internal production of face cream cartons;

$x_{12,22}$ = Internal production of body cream cartons;

$x_{13,23}$ = Internal production of hand cream cartons;

x_{31} = Outsourced production of face cream cartons;

x_{32} = Outsourced production of body cream cartons;

Subject to:

Supply/Demand Constraints:

Face cream production:	x_{11}	$+ x_{21}$	$+ x_{31}$	$= 12000$
Body cream production:	x_{12}	$+ x_{22}$	$+ x_{32}$	$= 8000$
Hand cream production:	x_{13}	$+ x_{23}$		$= 18000$

Material constraints (lb/carton):

Purified water:	$8(x_{11}+x_{21})$	$+ 6(x_{12}+x_{22})$	$+ 7(x_{13}+x_{23})$	≤ 200000
Oil:	$(x_{11}+x_{21})$	$+ 3(x_{12}+x_{22})$	$+ 2(x_{13}+x_{23})$	≤ 50000
Scents and colors:	$0.5(x_{11}+x_{21})$	$+ 0.3(x_{12}+x_{22})$	$+ 0.4(x_{13}+x_{23})$	≤ 7500
Emulsifiers:	$0.5(x_{11}+x_{21})$	$+ 0.7(x_{12}+x_{22})$	$+ 0.6(x_{13}+x_{23})$	≤ 15000

Labor constraints (hrs/carton):

Shift 1, Stage 1:	$1.5(x_{11}+x_{21})$	$+ 1.8(x_{12}+x_{22})$	$+ (x_{13}+x_{23})$	≤ 15000
Shift 1, Stage 2:	$0.8(x_{11}+x_{21})$	$+ (x_{12}+x_{22})$	$+ 0.5(x_{13}+x_{23})$	≤ 10000
Shift 2, Stage 1:	$1.5(x_{11}+x_{21})$	$+ 1.8(x_{12}+x_{22})$	$+ (x_{13}+x_{23})$	≤ 13500
Shift 2, Stage 2:	$0.8(x_{11}+x_{21})$	$+ (x_{12}+x_{22})$	$+ 0.5(x_{13}+x_{23})$	≤ 9000

And $x_{11-32} \geq 0$

3. What production schedule minimizes total cost including outsourcing, and what is the corresponding value of the objective function?

The production schedule which minimizes total costs while satisfying demand given the constraints from the case study are as follows:

- Production during shift 1:
 - Body cream: 1,000 cartons
 - Hand cream: 13,200 cartons
- Production during shift 2:
 - Hand cream: 4,800 cartons
- Outsourced production:
 - Face cream: 12,000 cartons
 - Body cream: 7,000 cartons

The corresponding value of the objective function is **\$1,368,100.00**.

It's worth noting that in the given scenario Rougir has a lot of unused capacity, with the main binding constraint being the lack of the *scents and colors* raw materials for in-house production. I won't take this discussion much farther, but the Sensitivity Analysis suggests that for each pound of this raw material, \$50.96 could be saved for up to 1100 pounds of the material. A run of Solver using this additional capacity saves an additional \$56k, suggesting there is much that Rougir can still do to optimize their production.

It's also worth noting that although in-house production of face cream is cheaper than body cream, since face cream uses more of the limited raw material, Solver points us to instead produce body cream to stretch inhouse production further and help reduce the cost of outsourcing.