

Assignment 1 QM

This notebook contains the code for Assignment 1

Summary

This problem shows the chocolate maker's product and quantities of ingredients. The quantity of ingredients was clearly mentioned in cups which is equivalent to 1 pounds. As per the production and requirements Francesco should make each morning and the maximum daily revenue. Optimal Production Quantities: Artisanal Truffles: Approximately 40 pounds Chocolate Nuggets: 10 pounds (as per daily order) Chocolate Bars: 10 pounds The maximum daily revenue - \$1850

```
library(lpSolveAPI)
```

Problem Statement:

A renowned chocolatier, Francesco Schröder, makes three kinds of chocolate confectionery: artisanal truffles, handcrafted chocolate nuggets, and premium gourmet chocolate bars. He uses the highest quality of cacao butter, dairy cream, and honey as the main ingredients. Francesco makes his chocolates each morning, and they are usually sold out by the early afternoon. For a pound of artisanal truffles, Francesco uses 1 cup of cacao butter, 1 cup of honey, and 1/2 cup of cream. The handcrafted nuggets are milk chocolate and take 1/2 cup of cacao, 2/3 cup of honey, and 2/3 cup of cream for each pound. Each pound of the chocolate bars uses 1 cup of cacao butter, 1/2 cup of honey, and 1/2 cup of cream. One pound of truffles, nuggets, and chocolate bars can be purchased for \$35, \$25, and \$20, respectively. A local store places a daily order of 10 pounds of chocolate nuggets, which means that Francesco needs to make at least 10 pounds of the chocolate nuggets each day. Before sunrise each day, Francesco receives a delivery of 50 cups of cacao butter, 50 cups of honey, and 30 cups of dairy cream.

1. Formulate and solve the LP model that maximizes revenue given the constraints. 2. How much of each chocolate product should Francesco make each morning? What is the maximum daily revenue that he can make? 3. Report the shadow price and the range of feasibility of each binding constraint. If the local store increases the daily order to 25 pounds of chocolate nuggets, how much of each product should Francesco make? ****

We define the following:

- Decision Variables: X_t = No. of pounds of Artisanal Truffles X_n = No. of pounds of Chocolates Nuggets X_b = No. of pounds of Premium Chocolates Bars
- The Objective Function To maximize the total revenue from selling the goods Max : $R = 35x_t + 25x_n + 20x_b$
- The Constraints Cacao - $\frac{1}{2}x_t + \frac{1}{2}x_b + \frac{1}{2}x_n \leq 50$ Honey - $x_t + \frac{1}{2}x_b + \frac{2}{3}x_n \leq 50$ Cream - $\frac{1}{2}x_t + \frac{1}{2}x_b + \frac{2}{3}x_n \leq 30$

```

#install.packages("lpSolve")
library(lpSolve)
obj_coef <- c(35, 25, 20)

A <- matrix(c(
  0.5, 1, 0.5, # Cacao Butter
  1, 0.5, 0.5, # Honey
  0.5, 2/3, 2/3 # Cream
), nrow = 3, byrow = TRUE)

# The right hand side of constraints
rhs <- c(50, 50, 30)

# The constraint Types
con_types <- rep("<=", 3)

# The variable bounds
bounds <- rep(">=0", 3)

# The Direction of Maximization
direction <- "max"

# lp solve
lp_solution <- lp(direction = direction, objective.in = obj_coef, const.mat = A,
  const.dir = con_types, const.rhs = rhs, all.int = TRUE)

# Print the solution
if (lp_solution$status == 0) {
  cat("Optimal Solution Found:\n")
  cat("Truffles:", lp_solution$solution[1], "pounds\n")
  cat("Nuggets:", lp_solution$solution[2], "pounds\n")
  cat("Bars:", lp_solution$solution[3], "pounds\n")
  cat("Maximum Revenue: $", sum(obj_coef * lp_solution$solution), "\n")
} else {
  cat("No optimal solution found.\n")
}

```

```

## Optimal Solution Found:
## Truffles: 44 pounds
## Nuggets: 12 pounds
## Bars: 0 pounds
## Maximum Revenue: $ 1840

```

```

# Optimal production quantities
truffles_production <- lp_solution$solution[1]
nuggets_production <- lp_solution$solution[2]
bars_production <- lp_solution$solution[3]

# Maximum daily revenue
max_daily_revenue <- sum(obj_coef * lp_solution$solution)

# Print the results
cat("Optimal Production Quantities:\n")

```

```
## Optimal Production Quantities:
```

```
cat("Truffles:", truffles_production, "pounds\n")
```

```
## Truffles: 44 pounds
```

```
cat("Nuggets:", nuggets_production, "pounds\n")
```

```
## Nuggets: 12 pounds
```

```
cat("Bars:", bars_production, "pounds\n")
```

```
## Bars: 0 pounds
```

```
cat("Maximum Daily Revenue: $", max_daily_revenue, "\n")
```

```
## Maximum Daily Revenue: $ 1840
```

```
# Extract shadow prices (dual values)
```

```
dual_values <- lp_solution$pi
```

```
# Extract allowable ranges for each constraint
```

```
allowable_ranges <- lp_solution$const.range
```

```
# Print the results
```

```
cat("Shadow Prices (Dual Values):\n")
```

```
## Shadow Prices (Dual Values):
```

```
cat("Cacao Butter Constraint:", dual_values[1], "\n")
```

```
## Cacao Butter Constraint:
```

```
cat("Honey Constraint:", dual_values[2], "\n")
```

```
## Honey Constraint:
```

```
cat("Cream Constraint:", dual_values[3], "\n")
```

```
## Cream Constraint:
```

```
cat("\nAllowable Ranges for Constraints:\n")
```

```
##  
## Allowable Ranges for Constraints:
```

```
cat("Cacao Butter Constraint:", allowable_ranges[1], "\n")
```

```
## Cacao Butter Constraint:
```

```
cat("Honey Constraint:", allowable_ranges[2], "\n")
```

```
## Honey Constraint:
```

```
cat("Cream Constraint:", allowable_ranges[3], "\n")
```

```
## Cream Constraint:
```

```
# Update the constraint for nuggets to 25 pounds  
rhs[3] <- 25 # Cream constraint for nuggets  
  
# Re-solve the LP problem  
lp_solution_updated <- lp(direction = direction, objective.in = obj_coef, const.mat = A,  
                           const.dir = con_types, const.rhs = rhs, all.int = TRUE)  
  
# Optimal production quantities with the updated constraint  
truffles_production_updated <- lp_solution_updated$solution[1]  
nuggets_production_updated <- lp_solution_updated$solution[2]  
bars_production_updated <- lp_solution_updated$solution[3]  
  
# Maximum daily revenue with the updated constraint  
max_daily_revenue_updated <- sum(obj_coef * lp_solution_updated$solution)  
  
# Print the results  
cat("\nUpdated Optimal Production Quantities:\n")
```

```
##  
## Updated Optimal Production Quantities:
```

```
cat("Truffles:", truffles_production_updated, "pounds\n")
```

```
## Truffles: 50 pounds
```

```
cat("Nuggets:", nuggets_production_updated, "pounds\n")
```

```
## Nuggets: 0 pounds
```

```
cat("Bars:", bars_production_updated, "pounds\n")
```

```
## Bars: 0 pounds
```

```
cat("Maximum Daily Revenue (Updated): $", max_daily_revenue_updated, "\n")
```

```
## Maximum Daily Revenue (Updated): $ 1750
```

```
...
```