

Goal Programming - Manasa Pullabhatla

The Emax Corporation's Research and Development Division has successfully developed three new products, prompting the need for a strategic decision on the optimal production mix. The primary focus of this decision revolves around three key factors:

1. **Maximizing Total Profit**
2. **Ensuring Workforce Stability and**
3. **Achieving a Yearly Earnings Increase Beyond the Current \$75 million Total Profit**

Objective Function

Maximize $Z = P - 6C - 3D$, where

P = Total discounted profit over the life of the new products,

C = Change in either direction towards the current level of employment,

D = decrease if any in next year's earnings from the current year's level.

Loading the required packages

```
library(lpSolve)
library(lpSolveAPI)
```

Loading the LP file from the current directory and printing the model

Defining $y1p$ and $y1m$ as the amount over (if any) and the amount under (if any) the employment level goal.

Defining $y2p$ and $y2m$ in the same way for the goal regarding earnings next year.

Defining $x1$, $x2$ and $x3$ as the production rates of Products 1, 2, and 3, respectively.

Also expressing P in terms of $x1$, $x2$ and $x3$ and the objective function in terms of $x1$, $x2$, $x3$, $y1p$, $y1m$, $y2p$ and $y2m$

```
emax_rd <- read.lp("emax.lp")
print(emax_rd)
```

```
## Model name:
##           x1      x2      x3      y1m      y1p      y2m      y2p
## Maximize   20      15      25      -6      -6      -3       0
## R1         6       4       5       1      -1       0       0 = 50
## R2         8       7       5       0       0       1      -1 = 75
## Kind       Std     Std     Std     Std     Std     Std     Std
## Type       Real    Real    Real    Real    Real    Real    Real
## Upper      Inf     Inf     Inf     Inf     Inf     Inf     Inf
## Lower      0       0       0       0       0       0       0
```

The impact of each of the new products (per unit rate of production) on each of these factors is shown in the following table:

```

emax_table <- matrix(c("Total Profit", "Employment Level", "Earnings Next Year",
                        20,6,8,
                        15,4,7,
                        25,5,5,
                        "Maximize", "=50", ">=75",
                        "Millions of Dollars", "Hundreds of Employees", "Millions of Dollars"), ncol=6,

colnames(emax_table) <- c("Factor", "Product 1", "Product 2", "Product 3", "Goal", "Units")

as.table(emax_table)

```

```

##      Factor      Product 1 Product 2 Product 3 Goal
## A Total Profit      20       15       25      Maximize
## B Employment Level  6        4        5      =50
## C Earnings Next Year 8        7        5      >=75
##      Units
## A Millions of Dollars
## B Hundreds of Employees
## C Millions of Dollars

```

Solving the goal programming model to obtain the objective and variable values

```

solve(emax_rd)

```

```

## [1] 0

```

```

get.objective(emax_rd)

```

```

## [1] 225

```

```

get.variables(emax_rd)

```

```

## [1] 0 0 15 0 25 0 0

```

Interpretation:

1. The firm aims to maximize the objective function by implementing units of combinations labeled as X1, X2, and X3. X1 represents Product 1, X2 represents Product 2, and X3 corresponds to Product 3. Due to certain constraints or limitations, it was found that the intended production of 20 units of Product 1 and 15 units of Product 2 resulted in a zero output. Consequently, the only feasible solution for production lies in Product 3, where the firm can produce 15 units of Product 3 to achieve maximum profit.
2. The goal was to stabilize the employment level with the maximum number of employees confined to 50 Hundred Employees but here in this case the firm exceeded the employment levels by 25 Hundred Employees (y1p) for which they would be needing to pay penalty for the excess/rise in the employees count.
3. The purpose of y2p and y2m was to represent the potential increase or decrease in next year's earnings compared to the current level. In this scenario, both y2p and y2m have been determined as "0," signifying that there is no projected change in next year's earnings relative to the current year. Consequently, the earnings for the upcoming year are expected to remain unchanged or constant.
4. The profit that the firm maximizing is called out by the objective function value which here in our case is 225 Million Dollars.