

Assignment 5 - Goal Programming

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The Research and Development Division of the Emax Corporation has developed three new products. A decision now needs to be made on which mix of these products should be produced. Management wants primary consideration given to three factors: total profit, stability in the workforce, and achieving an increase in the company's earnings next year from the \$75 million achieved this year.

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 required packages

```
library(lpSolve)
```

```
## Warning: package 'lpSolve' was built under R version 4.1.3
```

```
library(lpSolveAPI)
```

```
## Warning: package 'lpSolveAPI' was built under R version 4.1.3
```

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.

Define $x1$, $x2$ 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      Y1P      Y1M      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:

```
table_emax <- 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, byrow=TRUE)

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

as.table(table_emax)
```

##	Factor	Product 1	Product 2	Product 3	Goal	Units
## 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 25 0 0 0
```

Interpretation:

1. X1 - PRODUCT1, X2 - PRODUCT2 and X3 - Product 3 are the units of combination which the firm needs to implement in order to maximize the objective function. It claims that because the final answer is zero, it is impossible to produce 20 units of Product 1 and 15 units of Product 2 as anticipated. The only product that can be produced, however, is product 3 as a result of a change to X3. **15 Units of Product 3 to maximize the profit.**

2. The original objective was to stabilize the employment level with a maximum of 50 hundred employees, the firm exceeded the employment level by 25 hundred employees (Y1P). Because of the increase in staff, the firm has to pay penalty.

3. The main objective of Y2P and Y2M is determining whether the earnings for the following year will increase or decrease. It is obvious that there will be no increase or decrease in the next year as current level states "0".

4. The profit that the firm is maximizing is 225 million dollars which makes it evident from the objective function value.