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1. Back Savers is a company that produces backpacks primarily for students. They are considering offering some combination of two different models—the Collegiate and the Mini. Both are made from the same rip-resistant nylon fabric. Back Savers has a long-term contract with a supplier of the nylon and receives a 5000 square-foot shipment of the material each week. Each Collegiate requires 3 square feet while each Mini requires 2 square feet. The sales forecasts indicate that at most 1000 Collegiates and 1200 Minis can be sold per week. Each Collegiate requires 45 minutes of labor to produce and generates a unit profit of $32. Each Mini requires 40 minutes of labor and generates a unit profit of $24. Back Savers has 35 laborers that each provides 40 hours of labor per week. Management wishes to know what quantity of each type of backpack to produce per week.

a. Clearly define the decision variables

X and Y are the decision variables - A represents collegiate and B is Mini

b. What is the objective function?

The main objective function is to maximize the profit of the company,

Profit P = 32A + 24B

c. What are the constraints?

Back Saver sells Collegiate and Mini. Let's say Collegiate is A and Mini is B.

Each Collegiate requires 3 square feet and Mini required 2 square feet and Back Savers receives 5000 square feet material each week.

3A+2B <= 5000

Collegiate produces 32$ profit and required 45 minutes labor.

Mini produces 24$ profit and required 40 minutes labor

Profit P = 32X + 24Y

Total labor required is (45A + 40B) minutes

Available labor is 35*40 = 1400hours

= 84000 minutes

45A + 40B <= 84000 minutes per week.

Sales forecasts indicate that at most 1000 Collegiates and 1200 Minis can be sold per week

A<= 1000

B<= 1200

And Variables must be greater than 0,

A,B >= 0

d. Write down the full mathematical formulation for this LP problem.

P = 32A + 24B

3A+2B <= 5000

45A + 40B <= 84000 minutes per week

A<= 1000

B<= 1200

2. The Weigelt Corporation has three branch plants with excess production capacity. Fortunately, the corporation has a new product ready to begin production, and all three plants have this capability, so some of the excess capacity can be used in this way. This product can be made in three sizes--large, medium, and small--that yield a net unit profit of $420, $360, and $300, respectively. Plants 1, 2, and 3 have the excess capacity to produce 750, 900, and 450 units per day of this product, respectively, regardless of the size or combination of sizes involved. The amount of available in-process storage space also imposes a limitation on the production rates of the new product. Plants 1, 2, and 3 have 13,000, 12,000, and 5,000 square feet, respectively, of in-process storage space available for a day's production of this product. Each unit of the large, medium, and small sizes produced per day requires 20, 15, and 12 square feet, respectively. Sales forecasts indicate that if available, 900, 1,200, and 750 units of the large, medium, and small sizes, respectively, would be sold per day. At each plant, some employees will need to be laid off unless most of the plant's excess production capacity can be used to produce the new product. To avoid layoffs if possible, management has decided that the plants should use the same percentage of their excess capacity to produce the new product. Management wishes to know how much of each of the sizes should be produced by each of the plants to maximize profit.

a. Clearly define the decision variables

Decision variables:

Let's say Yij , where i represents plants 1,2,3 and j represents size l, m, s.

Y1l, Y1m, Y1s variables for plant 1

Y2l, Y2m, Y2s variables for plant 2

Y3l, Y3m, Y3s variables for plant 3

b. Formulate the linear programming model for this problem.

Zmax is the maximum profit

Net unit profit of $420, $360, and $300

Zmax =420*(Y1l + Y2l + Y3l) + 360*(Y1m + Y2m + Y3m) + 300*(Y1s + Y2s + Y3s)

Since, plants 1, 2, and 3 have the excess capacity to produce 750, 900, and 450

Constraints for Max capacity:

Y1l + Y1m + Y1s ≤ 750

Y2l + Y2m + Y2s ≤ 900

Y3l + Y3m + Y3s ≤ 450

Plants 1, 2, and 3 have 13,000, 12,000, and 5,000 square feet, respectively, of in-process storage space available for days production:

Storage space:

20*Y1l + 15*Y1m + 12*Y1s ≤ 13000

20*Y2l + 15*Y2m + 12*Y2s ≤ 12000

20*Y3l + 15*Y3m + 12*Y3s ≤ 5000

900, 1,200, and 750 units of the large, medium, and small sizes, respectively, would be sold per day

900*(Y1l + Y1m + Y1s) – 750*(Y2l + Y2m + Y2s) = 0

450*(Y2l + Y2m + Y2s) – 900*(Y3l + Y3m + Y3s) = 0

450*(Y1l + Y1m + Y1s) – 750*(Y3l + Y3m + Y3s) = 0

Y1l+Y2l+Y3l <=900

Y1m+y2m+y3m <=1200

Y1s+Y2s+Y3s <=750

Yij ≥ 0 where i = 1, 2, 3 and j = l, m, s

R Code for LP Model

Sbaig1_Assignment2

Sharik Baig

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```
library(lpSolveAPI)

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

setwd("C:/Users/shari/OneDrive/Desktop/Business Analytics/QMM/Assignment2")

##a linear program with 9 decision variables and 0 constraints

lp <- make.lp(0,9, verbose = "neutral")
lp

## Model name:
##   a linear program with 9 decision variables and 0 constraints

## Model name:
##   a linear program with 9 decision variables and 0 constraints
## Add the constraints
add.constraint(lp, c(1,1,1,0,0,0,0,0,0), "<=", 750 )
add.constraint(lp, c(0,0,0,1,1,1,0,0,0), "<=", 900)
add.constraint(lp, c(0,0,0,0,0,0,1,1,1), "<=", 450)
add.constraint(lp, c(20,15,12,0,0,0,0,0,0), "<=", 13000)
add.constraint(lp, c(0,0,0,20,15,12,0,0,0), "<=", 12000)
add.constraint(lp, c(0,0,0,0,0,0,20,15,12), "<=", 5000)
add.constraint(lp, c(1,1,1,0,0,0,0,0,0), "<=", 900)
add.constraint(lp, c(0,0,0,1,1,1,0,0,0), "<=", 1200)
add.constraint(lp, c(0,0,0,0,0,0,1,1,1), "<=", 750)
add.constraint(lp, c(6, 6, 6, -5, -5, -5, 0, 0, 0), "=", 0)
add.constraint(lp, c( 3, 3, 3, 0, 0, 0, -5, -5, -5), "=", 0)

## Create objective function. We need maximum profit so change sense to max
set.objfn(lp, c(420,360,300,420,360,300,420,360,300))
lp.control(lp, sense='max')

## $anti.degen
## [1] "none"
##
## $basis.crash
## [1] "none"
##
```

```
## $bb.depthlimit
## [1] -50
##
## $bb.floorfirst
## [1] "automatic"
##
## $bb.rule
## [1] "pseudononint" "greedy"       "dynamic"      "rcostfixing"
##
## $break.at.first
## [1] FALSE
##
## $break.at.value
## [1] 1e+30
##
## $epsilon
##       epsb       epsd      epsel     epsint epsperturb   epspivot
##      1e-10      1e-09      1e-12      1e-07      1e-05      2e-07
##
## $improve
## [1] "dualfeas" "thetagap"
##
## $infinite
## [1] 1e+30
##
## $maxpivot
## [1] 250
##
## $mip.gap
## absolute relative
##    1e-11    1e-11
##
## $negrange
## [1] -1e+06
##
## $obj.in.basis
## [1] TRUE
##
## $pivoting
## [1] "devex"    "adaptive"
##
## $presolve
## [1] "none"
##
## $scalelimit
## [1] 5
##
## $scaling
## [1] "geometric"   "equilibrate" "integers"
##
```

```
## $sense
## [1] "maximize"
##
## $simplextype
## [1] "dual"   "primal"
##
## $timeout
## [1] 0
##
## $verbose
## [1] "neutral"
```

To identify the variables and constraints, Set the variable names and the constraints
set.bounds(lp, lower = c(0, 0, 0, 0, 0, 0, 0, 0, 0), columns = c(1,2,3,4,5,6,7,8,9))

```
RowNames <- c("Con1", "Con2", "Con3", "storage1", "Storage2", "Storage33", "S
ale1", "Sale2", "Sale3", "%C1", "%C2")
ColNames <- c("Large1", "Medium1", "Small1", "Large2", "Medium2", "Small2", "
Large3", "Medium3", "Small3")
dimnames(lp) <- list(RowNames, ColNames)
lp

## Model name:
##   a linear program with 9 decision variables and 11 constraints

## Model name:
##   a linear program with 9 decision variables and 11 constraints
write.lp(lp, filename = "QMMAssignment2.lp", type = "lp")
solve(lp)

## [1] 0

## [1] 0
get.objective(lp)

## [1] 696000

## [1] 696000
get.variables(lp)

## [1] 516.6667 177.7778   0.0000   0.0000 666.6667 166.6667   0.0000   0.000
0
## [9] 416.6667

## [1] 516.6667 177.7778   0.0000   0.0000 666.6667 166.6667   0.0000   0.000
0
## [9] 416.6667
```