Linear Programming

#1

Install Libraries

#2 ##“‘{r libraries_install}

##install.packages(“lpSolve”) ##install.packages(“lpSolveAPI”) ##install.packages(“zeallot”) ##install.packages(“Rglpk”) ##tinytex::install_tinytex()

```
## Load Libraries

#3

```r
library("lpSolve")
library("lpSolveAPI")
library("zeallot")
library("Rglpk")
```

Loading required package: slam

Using the GLPK callable library version 4.65
```

Simplex Tables Functions - Run but do not touch

#4

#5 ## Show Solution Function - Run but do not touch

———————————— Primal Problem ————————————-

#6 ## Build and show the primal problem

This is where you insert your primal problem: - Change the ‘min_max’, ‘Number_of_constraints’ and ‘Number_of_variables’ variables. - Change the coefficients of the objective function in the ‘objective_coefs’ variable. - Add all your constraints using ‘add.constraint()’. - Give names to your constraints and your decision variables in ‘RowNames’ and ‘ColNames’.

```
### ------ Create the model ------ ###

min_max <- 1  # -1 = minimum problem, 1 = maximum problem
Number_of_constraints <- 11  # Change to the number of constraints
Number_of_variables <- 9  # Change to the number of variables

lp_primal_model <- make.lp(0, Number_of_variables)

### ------ Set the objective function ------ ###

objective_coefs <- c(1, 1, 1, 1, 1, 1,-10000,-10000,-10000) # Fill the variables' coefficients in the o
set.objfn(lp_primal_model, objective_coefs)

### ------ Add all constraints ------ ###

add.constraint(lp_primal_model, c(-0.00001, -0.00002, 0, 0, 0, 0,1,0,0), "=", 0)
add.constraint(lp_primal_model, c(0, 0, -0.00001, -0.00002, 0, 0,0,1,0), "=", 0)
add.constraint(lp_primal_model, c(0, 0, 0, 0, -0.00001, -0.00002,0,0,1), "=", 0)
add.constraint(lp_primal_model, c(1, 0, 0, 0, 0, 0,0,0,0), "<=", 500000)
add.constraint(lp_primal_model, c(0, 0, 1, 0, 0, 0,0,0,0), "<=", 1000000)
add.constraint(lp_primal_model, c(0, 0, 0, 0, 1, 0,0,0,0), "<=", 2000000)
add.constraint(lp_primal_model, c(0, 0, 0, 0, 0, 0,1,0,0), "<=", 100)
add.constraint(lp_primal_model, c(0, 0, 0, 0, 0, 0,0,1,0), "<=", 100)
add.constraint(lp_primal_model, c(0, 0, 0, 0, 0, 0,0,0,1), "<=", 100)
add.constraint(lp_primal_model, c(0, 1, 0, 0, 0, 0,0,0,0), ">=", 1000000)
add.constraint(lp_primal_model, c(1, 1, 1, 1, 1, 1,0,0,0), "=", 10000000)




### ------ Set the names of the constraints and variables ------ ###

RowNames <- c("st1", "st2", "st3", "st4", "st5", "st6", "st7", "st8", "st9","st10","st11") # Give names
ColNames <- c("x11", "X21", "X12", "X22", "X13", "X23","y1","y2","y3") # Give names to the variables
dimnames(lp_primal_model) <- list(RowNames, ColNames) # Assign constraints and variables names

### ------ Show and solve the model ------ ###

if (min_max == 1){
  l <- lp.control(lp_primal_model, sense = "max")
}

lp_primal_model # Show the model
```

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

```
print("The solution's code is: ")
```

```
## [1] "The solution's code is: "
```

```
solve(lp_primal_model) # Solve the linear problem
```

```
## [1] 0
```

Status Codes: 0: “optimal solution found” 1: “the model is sub-optimal” 2: “the model is infeasible” 3: “the model is unbounded” 4: “the model is degenerate” 5: “numerical failure encountered” 6: “process aborted” 7: “timeout”

#7 ## Show the solution of the primal problem

```
### -------- Set the coefs matrix (A) and the constraints relations - don't change! -------- ###

c <-  objective_coefs  # Get objective function coefficients
b <-  get.rhs(lp_primal_model) # Get RHS
A <- matrix(nrow = Number_of_constraints, ncol = Number_of_variables, byrow = TRUE) # Initialize coefs
relations <- c() # Constraints directions

for (i in 1 :Number_of_constraints){
  for (j in 1 :Number_of_variables){
    A[i, j] <- get.mat(lp_primal_model,i,j)
  }
  relations <- append(relations, get.constr.type(lp_primal_model, i))
}

### -------- Find S_star -------- ###

tab <- simplexR(A, b, c, sense = min_max, relation = relations, Col_Names = ColNames, p_flag = 0)
s_star <- matrix(nrow = Number_of_constraints, ncol = Number_of_constraints, byrow = TRUE)
ind = 1
for (i in 1:dim(tab)[2]){
  if (grepl("A", colnames(tab)[i], fixed = TRUE) || (grepl("S", colnames(tab)[i], fixed = TRUE))){
    s_star[ , ind] <- tab[1:Number_of_constraints, i]
    ind <- ind + 1
  }
}


Show_Solution(lp_primal_model, Number_of_variables, Number_of_constraints, objective_coefs, ColNames, r
```

```
## [1] "The number of iterations was:  9"
## [1] "-------------------------------------------------------------------------"
## [1] "The optimal solution is:  8350000"
## [1] "-------------------------------------------------------------------------"
## [1] "                                                                         "
## [1] "The optimal values of the decision variables and their reduced costs are:"
## [1] "                                                                         "
##     Optimal Value Reduced Cost
## x11        500000            0
## X21       1000000            0
## X12       1000000            0
## X22       1500000            0
## X13       2000000            0
## X23       4000000            0
```

```
## y1             25            0
## y2             40            0
## y3            100            0
## [1] "                                                                                "
## [1] "The optimal values of the Slacks and their dual prices are:"
## [1] "                                                                                "
##     Optimal Value Dual Price
## A1              0     -1e+04
## A2              0     -1e+04
## A3              0     -1e+04
## S4              0      1e-01
## S5              0      1e-01
## S6              0      1e-01
## S7             75      0e+00
## S8             60      0e+00
## S9              0      0e+00
## L10             0      0e+00
## A11             0      8e-01
## [1] "--------------------------------------------------------------------------------"
## [1] "                                                                                "
## [1] "Ranges In Which The Basis Is Unchanged:"
## [1] "                                                                                "
## [1] "Ranges Of Objective Function Coefficients:"
## [1] "                                                                                "
##     Current Coef Coef From Coef Till
## x11            1     9e-01   1.0e+30
## X21            1    -1e+30   1.0e+00
## X12            1     9e-01   1.0e+30
## X22            1     1e+00   1.0e+00
## X13            1     9e-01   1.0e+30
## X23            1     1e+00   1.2e+00
## y1        -10000    -2e+04  -1.0e+04
## y2        -10000    -1e+04  -1.0e+04
## y3        -10000    -1e+04   1.0e+30
## [1] "                                                                                "
## [1] "Ranges Of RHS:"
## [1] "                                                                                "
##       Current RHS RHS From RHS Till
##  [1,]       0e+00      -35       55
##  [2,]       0e+00      -45       55
##  [3,]       0e+00      -20       80
##  [4,]       5e+05        0  4000000
##  [5,]       1e+06        0  2750000
##  [6,]       2e+06        0  3750000
##  [7,]       1e+02       45      135
##  [8,]       1e+02       45      100
##  [9,]       1e+02       20      100
## [10,]       1e+06  1000000  4750000
## [11,]       1e+07  8250000 12750000
```

#8 ## Show the simplex tables - Run but do not change.

**** If you have a minimum problem - multiply the optimal solution by (-1)! ****

```r
### -------- Show simplex tables -------- ###

t <- simplexR(A, b, c, sense = min_max, relation = relations, Col_Names = ColNames, p_flag = 1)
```

```
## [1] "Start constructing Simplex Tableau"
## [1] "Tableau constructed"
## [1] "Artificial variable 'A' added at column  10 and row  1  -> phase I algorithm required"
## [2] "Artificial variable 'A' added at column  11 and row  2  -> phase I algorithm required"
## [3] "Artificial variable 'A' added at column  12 and row  3  -> phase I algorithm required"
## [4] "Artificial variable 'A' added at column  20 and row  10  -> phase I algorithm required"
## [5] "Artificial variable 'A' added at column  21 and row  11  -> phase I algorithm required"
## [1] "BigM-method is used, with bigM = 1e+09"
## [1] "Initial Tableau (Tableau 0)"
##             x11          X21         X12         X22         X13         X23
## A1  -1.0000e-05 -2.00000e-05  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## A2   0.0000e+00  0.00000e+00 -1.0000e-05 -2.0000e-05  0.0000e+00  0.0000e+00
## A3   0.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00 -1.0000e-05 -2.0000e-05
## S4   1.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## S5   0.0000e+00  0.00000e+00  1.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## S6   0.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00  1.0000e+00  0.0000e+00
## S7   0.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## S8   0.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## S9   0.0000e+00  0.00000e+00  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## A10  0.0000e+00  1.00000e+00  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00
## A11  1.0000e+00  1.00000e+00  1.0000e+00  1.0000e+00  1.0000e+00  1.0000e+00
## Z   -9.9999e+08 -1.99998e+09 -9.9999e+08 -9.9998e+08 -9.9999e+08 -9.9998e+08
##             y1         y2         y3 A1 A2 A3 S4 S5 S6 S7 S8 S9    L10 A10 A11
## A1           1          0          0  1  0  0  0  0  0  0  0  0  0e+00   0   0
## A2           0          1          0  0  1  0  0  0  0  0  0  0  0e+00   0   0
## A3           0          0          1  0  0  1  0  0  0  0  0  0  0e+00   0   0
## S4           0          0          0  0  0  0  1  0  0  0  0  0  0e+00   0   0
## S5           0          0          0  0  0  0  0  1  0  0  0  0  0e+00   0   0
## S6           0          0          0  0  0  0  0  0  1  0  0  0  0e+00   0   0
## S7           1          0          0  0  0  0  0  0  0  1  0  0  0e+00   0   0
## S8           0          1          0  0  0  0  0  0  0  0  1  0  0e+00   0   0
## S9           0          0          1  0  0  0  0  0  0  0  0  1  0e+00   0   0
## A10          0          0          0  0  0  0  0  0  0  0  0  0 -1e+00   1   0
## A11          0          0          0  0  0  0  0  0  0  0  0  0  0e+00   0   1
## Z   -999990000 -999990000 -999990000  0  0  0  0  0  0  0  0  0  1e+09   0   0
##             b
## A1   0.0e+00
## A2   0.0e+00
## A3   0.0e+00
## S4   5.0e+05
## S5   1.0e+06
## S6   2.0e+06
## S7   1.0e+02
## S8   1.0e+02
## S9   1.0e+02
## A10  1.0e+06
## A11  1.0e+07
## Z   -1.1e+16
## [1] "--------------------------------------------------------------------------"
```

```
## [1] "Iteration 1"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 2"
## [1] "Pivot row: 10"
## [1] "New tableau at the end of iteration 1"
##             x11 X21         X12         X22         X13         X23         y1
## A1  -1.0000e-05   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          1
## A2   0.0000e+00   0 -1.0000e-05 -2.0000e-05  0.0000e+00  0.0000e+00          0
## A3   0.0000e+00   0  0.0000e+00  0.0000e+00 -1.0000e-05 -2.0000e-05          0
## S4   1.0000e+00   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S5   0.0000e+00   0  1.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S6   0.0000e+00   0  0.0000e+00  0.0000e+00  1.0000e+00  0.0000e+00          0
## S7   0.0000e+00   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          1
## S8   0.0000e+00   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S9   0.0000e+00   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## X21  0.0000e+00   1  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## A11  1.0000e+00   0  1.0000e+00  1.0000e+00  1.0000e+00  1.0000e+00          0
## Z   -9.9999e+08   0 -9.9999e+08 -9.9998e+08 -9.9999e+08 -9.9998e+08 -999990000
##             y2         y3 A1 A2 A3 S4 S5 S6 S7 S8 S9         L10          A10
## A1           0          0  1  0  0  0  0  0  0  0  0 -2.0000e-05  2.00000e-05
## A2           1          0  0  1  0  0  0  0  0  0  0  0.0000e+00  0.00000e+00
## A3           0          1  0  0  1  0  0  0  0  0  0  0.0000e+00  0.00000e+00
## S4           0          0  0  0  0  1  0  0  0  0  0  0.0000e+00  0.00000e+00
## S5           0          0  0  0  0  0  1  0  0  0  0  0.0000e+00  0.00000e+00
## S6           0          0  0  0  0  0  0  1  0  0  0  0.0000e+00  0.00000e+00
## S7           0          0  0  0  0  0  0  0  1  0  0  0.0000e+00  0.00000e+00
## S8           1          0  0  0  0  0  0  0  0  1  0  0.0000e+00  0.00000e+00
## S9           0          1  0  0  0  0  0  0  0  0  1  0.0000e+00  0.00000e+00
## X21          0          0  0  0  0  0  0  0  0  0  0 -1.0000e+00  1.00000e+00
## A11          0          0  0  0  0  0  0  0  0  0  0  1.0000e+00 -1.00000e+00
## Z   -999990000 -999990000  0  0  0  0  0  0  0  0  0 -9.9998e+08  1.99998e+09
##     A11            b
## A1    0  2.00000e+01
## A2    0  0.00000e+00
## A3    0  0.00000e+00
## S4    0  5.00000e+05
## S5    0  1.00000e+06
## S6    0  2.00000e+06
## S7    0  1.00000e+02
## S8    0  1.00000e+02
## S9    0  1.00000e+02
## X21   0  1.00000e+06
## A11   1  9.00000e+06
## Z     0 -9.00002e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 2"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 1"
## [1] "Pivot row: 4"
## [1] "New tableau at the end of iteration 2"
##     x11 X21         X12         X22         X13         X23         y1
## A1    0   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          1
## A2    0   0 -1.0000e-05 -2.0000e-05  0.0000e+00  0.0000e+00          0
## A3    0   0  0.0000e+00  0.0000e+00 -1.0000e-05 -2.0000e-05          0
```

```
## x11   1   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S5    0   0  1.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S6    0   0  0.0000e+00  0.0000e+00  1.0000e+00  0.0000e+00          0
## S7    0   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          1
## S8    0   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## S9    0   0  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## X21   0   1  0.0000e+00  0.0000e+00  0.0000e+00  0.0000e+00          0
## A11   0   0  1.0000e+00  1.0000e+00  1.0000e+00  1.0000e+00          0
## Z     0   0 -9.9999e+08 -9.9998e+08 -9.9999e+08 -9.9998e+08 -999990000
##             y2         y3 A1 A2 A3          S4 S5 S6 S7 S8 S9         L10
## A1           0          0  1  0  0  1.0000e-05  0  0  0  0  0 -2.0000e-05
## A2           1          0  0  1  0  0.0000e+00  0  0  0  0  0  0.0000e+00
## A3           0          1  0  0  1  0.0000e+00  0  0  0  0  0  0.0000e+00
## x11          0          0  0  0  0  1.0000e+00  0  0  0  0  0  0.0000e+00
## S5           0          0  0  0  0  0.0000e+00  1  0  0  0  0  0.0000e+00
## S6           0          0  0  0  0  0.0000e+00  0  1  0  0  0  0.0000e+00
## S7           0          0  0  0  0  0.0000e+00  0  0  1  0  0  0.0000e+00
## S8           1          0  0  0  0  0.0000e+00  0  0  0  1  0  0.0000e+00
## S9           0          1  0  0  0  0.0000e+00  0  0  0  0  1  0.0000e+00
## X21          0          0  0  0  0  0.0000e+00  0  0  0  0  0 -1.0000e+00
## A11          0          0  0  0  0 -1.0000e+00  0  0  0  0  0  1.0000e+00
## Z   -999990000 -999990000  0  0  0  9.9999e+08  0  0  0  0  0 -9.9998e+08
##              A10 A11             b
## A1   2.00000e-05   0  2.500000e+01
## A2   0.00000e+00   0  0.000000e+00
## A3   0.00000e+00   0  0.000000e+00
## x11  0.00000e+00   0  5.000000e+05
## S5   0.00000e+00   0  1.000000e+06
## S6   0.00000e+00   0  2.000000e+06
## S7   0.00000e+00   0  1.000000e+02
## S8   0.00000e+00   0  1.000000e+02
## S9   0.00000e+00   0  1.000000e+02
## X21  1.00000e+00   0  1.000000e+06
## A11 -1.00000e+00   1  8.500000e+06
## Z    1.99998e+09   0 -8.500025e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 3"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 3"
## [1] "Pivot row: 5"
## [1] "New tableau at the end of iteration 3"
##     x11 X21 X12         X22         X13         X23         y1         y2
## A1    0   0   0  0.0000e+00  0.0000e+00  0.0000e+00          1          0
## A2    0   0   0 -2.0000e-05  0.0000e+00  0.0000e+00          0          1
## A3    0   0   0  0.0000e+00 -1.0000e-05 -2.0000e-05          0          0
## x11   1   0   0  0.0000e+00  0.0000e+00  0.0000e+00          0          0
## X12   0   0   1  0.0000e+00  0.0000e+00  0.0000e+00          0          0
## S6    0   0   0  0.0000e+00  1.0000e+00  0.0000e+00          0          0
## S7    0   0   0  0.0000e+00  0.0000e+00  0.0000e+00          1          0
## S8    0   0   0  0.0000e+00  0.0000e+00  0.0000e+00          0          1
## S9    0   0   0  0.0000e+00  0.0000e+00  0.0000e+00          0          0
## X21   0   1   0  0.0000e+00  0.0000e+00  0.0000e+00          0          0
## A11   0   0   0  1.0000e+00  1.0000e+00  1.0000e+00          0          0
## Z     0   0   0 -9.9998e+08 -9.9999e+08 -9.9998e+08 -999990000 -999990000
```

```
##             y3 A1 A2 A3          S4          S5 S6 S7 S8 S9         L10
## A1           0  1  0  0  1.0000e-05  0.0000e+00  0  0  0  0 -2.0000e-05
## A2           0  0  1  0  0.0000e+00  1.0000e-05  0  0  0  0  0.0000e+00
## A3           1  0  0  1  0.0000e+00  0.0000e+00  0  0  0  0  0.0000e+00
## x11          0  0  0  0  1.0000e+00  0.0000e+00  0  0  0  0  0.0000e+00
## X12          0  0  0  0  0.0000e+00  1.0000e+00  0  0  0  0  0.0000e+00
## S6           0  0  0  0  0.0000e+00  0.0000e+00  1  0  0  0  0.0000e+00
## S7           0  0  0  0  0.0000e+00  0.0000e+00  0  1  0  0  0.0000e+00
## S8           0  0  0  0  0.0000e+00  0.0000e+00  0  0  1  0  0.0000e+00
## S9           1  0  0  0  0.0000e+00  0.0000e+00  0  0  0  1  0.0000e+00
## X21          0  0  0  0  0.0000e+00  0.0000e+00  0  0  0  0 -1.0000e+00
## A11          0  0  0  0 -1.0000e+00 -1.0000e+00  0  0  0  0  1.0000e+00
## Z   -999990000  0  0  0  9.9999e+08  9.9999e+08  0  0  0  0 -9.9998e+08
##              A10 A11             b
## A1   2.00000e-05   0  2.500000e+01
## A2   0.00000e+00   0  1.000000e+01
## A3   0.00000e+00   0  0.000000e+00
## x11  0.00000e+00   0  5.000000e+05
## X12  0.00000e+00   0  1.000000e+06
## S6   0.00000e+00   0  2.000000e+06
## S7   0.00000e+00   0  1.000000e+02
## S8   0.00000e+00   0  1.000000e+02
## S9   0.00000e+00   0  1.000000e+02
## X21  1.00000e+00   0  1.000000e+06
## A11 -1.00000e+00   1  7.500000e+06
## Z    1.99998e+09   0 -7.500035e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 4"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 5"
## [1] "Pivot row: 6"
## [1] "New tableau at the end of iteration 4"
##     x11 X21 X12         X22 X13         X23         y1         y2         y3 A1
## A1    0   0   0  0.0000e+00   0  0.0000e+00          1          0          0  1
## A2    0   0   0 -2.0000e-05   0  0.0000e+00          0          1          0  0
## A3    0   0   0  0.0000e+00   0 -2.0000e-05          0          0          1  0
## x11   1   0   0  0.0000e+00   0  0.0000e+00          0          0          0  0
## X12   0   0   1  0.0000e+00   0  0.0000e+00          0          0          0  0
## X13   0   0   0  0.0000e+00   1  0.0000e+00          0          0          0  0
## S7    0   0   0  0.0000e+00   0  0.0000e+00          1          0          0  0
## S8    0   0   0  0.0000e+00   0  0.0000e+00          0          1          0  0
## S9    0   0   0  0.0000e+00   0  0.0000e+00          0          0          1  0
## X21   0   1   0  0.0000e+00   0  0.0000e+00          0          0          0  0
## A11   0   0   0  1.0000e+00   0  1.0000e+00          0          0          0  0
## Z     0   0   0 -9.9998e+08   0 -9.9998e+08 -999990000 -999990000 -999990000  0
##     A2 A3          S4          S5          S6 S7 S8 S9         L10          A10
## A1   0  0  1.0000e-05  0.0000e+00  0.0000e+00  0  0  0 -2.0000e-05  2.00000e-05
## A2   1  0  0.0000e+00  1.0000e-05  0.0000e+00  0  0  0  0.0000e+00  0.00000e+00
## A3   0  1  0.0000e+00  0.0000e+00  1.0000e-05  0  0  0  0.0000e+00  0.00000e+00
## x11  0  0  1.0000e+00  0.0000e+00  0.0000e+00  0  0  0  0.0000e+00  0.00000e+00
## X12  0  0  0.0000e+00  1.0000e+00  0.0000e+00  0  0  0  0.0000e+00  0.00000e+00
## X13  0  0  0.0000e+00  0.0000e+00  1.0000e+00  0  0  0  0.0000e+00  0.00000e+00
## S7   0  0  0.0000e+00  0.0000e+00  0.0000e+00  1  0  0  0.0000e+00  0.00000e+00
## S8   0  0  0.0000e+00  0.0000e+00  0.0000e+00  0  1  0  0.0000e+00  0.00000e+00
```

```
## S9   0  0  0.0000e+00  0.0000e+00  0.0000e+00  0  0  1  0.0000e+00  0.00000e+00
## X21  0  0  0.0000e+00  0.0000e+00  0.0000e+00  0  0  0 -1.0000e+00  1.00000e+00
## A11  0  0 -1.0000e+00 -1.0000e+00 -1.0000e+00  0  0  0  1.0000e+00 -1.00000e+00
## Z    0  0  9.9999e+08  9.9999e+08  9.9999e+08  0  0  0 -9.9998e+08  1.99998e+09
##     A11             b
## A1    0  2.500000e+01
## A2    0  1.000000e+01
## A3    0  2.000000e+01
## x11   0  5.000000e+05
## X12   0  1.000000e+06
## X13   0  2.000000e+06
## S7    0  1.000000e+02
## S8    0  1.000000e+02
## S9    0  1.000000e+02
## X21   0  1.000000e+06
## A11   1  5.500000e+06
## Z     0 -5.500055e+15
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 5"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 7"
## [1] "Pivot row: 1"
## [1] "New tableau at the end of iteration 5"
##     x11 X21 X12         X22 X13         X23 y1         y2         y3        A1
## y1    0   0   0  0.0000e+00   0  0.0000e+00  1          0          0         1
## A2    0   0   0 -2.0000e-05   0  0.0000e+00  0          1          0         0
## A3    0   0   0  0.0000e+00   0 -2.0000e-05  0          0          1         0
## x11   1   0   0  0.0000e+00   0  0.0000e+00  0          0          0         0
## X12   0   0   1  0.0000e+00   0  0.0000e+00  0          0          0         0
## X13   0   0   0  0.0000e+00   1  0.0000e+00  0          0          0         0
## S7    0   0   0  0.0000e+00   0  0.0000e+00  0          0          0        -1
## S8    0   0   0  0.0000e+00   0  0.0000e+00  0          1          0         0
## S9    0   0   0  0.0000e+00   0  0.0000e+00  0          0          1         0
## X21   0   1   0  0.0000e+00   0  0.0000e+00  0          0          0         0
## A11   0   0   0  1.0000e+00   0  1.0000e+00  0          0          0         0
## Z     0   0   0 -9.9998e+08   0 -9.9998e+08  0 -999990000 -999990000 999990000
##     A2 A3     S4          S5          S6 S7 S8 S9    L10    A10 A11
## y1   0  0  1e-05  0.0000e+00  0.0000e+00  0  0  0 -2e-05  2e-05   0
## A2   1  0  0e+00  1.0000e-05  0.0000e+00  0  0  0  0e+00  0e+00   0
## A3   0  1  0e+00  0.0000e+00  1.0000e-05  0  0  0  0e+00  0e+00   0
## x11  0  0  1e+00  0.0000e+00  0.0000e+00  0  0  0  0e+00  0e+00   0
## X12  0  0  0e+00  1.0000e+00  0.0000e+00  0  0  0  0e+00  0e+00   0
## X13  0  0  0e+00  0.0000e+00  1.0000e+00  0  0  0  0e+00  0e+00   0
## S7   0  0 -1e-05  0.0000e+00  0.0000e+00  1  0  0  2e-05 -2e-05   0
## S8   0  0  0e+00  0.0000e+00  0.0000e+00  0  1  0  0e+00  0e+00   0
## S9   0  0  0e+00  0.0000e+00  0.0000e+00  0  0  1  0e+00  0e+00   0
## X21  0  0  0e+00  0.0000e+00  0.0000e+00  0  0  0 -1e+00  1e+00   0
## A11  0  0 -1e+00 -1.0000e+00 -1.0000e+00  0  0  0  1e+00 -1e+00   1
## Z    0  0  1e+09  9.9999e+08  9.9999e+08  0  0  0 -1e+09  2e+09   0
##               b
## y1   2.50000e+01
## A2   1.00000e+01
## A3   2.00000e+01
## x11  5.00000e+05
```

```
## X12  1.00000e+06
## X13  2.00000e+06
## S7   7.50000e+01
## S8   1.00000e+02
## S9   1.00000e+02
## X21  1.00000e+06
## A11  5.50000e+06
## Z   -5.50003e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 6"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 19"
## [1] "Pivot row: 7"
## [1] "New tableau at the end of iteration 6"
##     x11 X21 X12         X22 X13         X23 y1         y2         y3
## y1    0   0   0  0.0000e+00   0  0.0000e+00  1          0          0
## A2    0   0   0 -2.0000e-05   0  0.0000e+00  0          1          0
## A3    0   0   0  0.0000e+00   0 -2.0000e-05  0          0          1
## x11   1   0   0  0.0000e+00   0  0.0000e+00  0          0          0
## X12   0   0   1  0.0000e+00   0  0.0000e+00  0          0          0
## X13   0   0   0  0.0000e+00   1  0.0000e+00  0          0          0
## L10   0   0   0  0.0000e+00   0  0.0000e+00  0          0          0
## S8    0   0   0  0.0000e+00   0  0.0000e+00  0          1          0
## S9    0   0   0  0.0000e+00   0  0.0000e+00  0          0          1
## X21   0   1   0  0.0000e+00   0  0.0000e+00  0          0          0
## A11   0   0   0  1.0000e+00   0  1.0000e+00  0          0          0
## Z     0   0   0 -9.9998e+08   0 -9.9998e+08  0 -999990000 -999990000
##              A1 A2 A3     S4          S5          S6     S7 S8 S9 L10    A10
## y1   0.0000e+00  0  0  0e+00  0.0000e+00  0.0000e+00  1e+00  0  0   0  0e+00
## A2   0.0000e+00  1  0  0e+00  1.0000e-05  0.0000e+00  0e+00  0  0   0  0e+00
## A3   0.0000e+00  0  1  0e+00  0.0000e+00  1.0000e-05  0e+00  0  0   0  0e+00
## x11  0.0000e+00  0  0  1e+00  0.0000e+00  0.0000e+00  0e+00  0  0   0  0e+00
## X12  0.0000e+00  0  0  0e+00  1.0000e+00  0.0000e+00  0e+00  0  0   0  0e+00
## X13  0.0000e+00  0  0  0e+00  0.0000e+00  1.0000e+00  0e+00  0  0   0  0e+00
## L10 -5.0000e+04  0  0 -5e-01  0.0000e+00  0.0000e+00  5e+04  0  0   1 -1e+00
## S8   0.0000e+00  0  0  0e+00  0.0000e+00  0.0000e+00  0e+00  1  0   0  0e+00
## S9   0.0000e+00  0  0  0e+00  0.0000e+00  0.0000e+00  0e+00  0  1   0  0e+00
## X21 -5.0000e+04  0  0 -5e-01  0.0000e+00  0.0000e+00  5e+04  0  0   0  0e+00
## A11  5.0000e+04  0  0 -5e-01 -1.0000e+00 -1.0000e+00 -5e+04  0  0   0  0e+00
## Z   -4.9999e+13  0  0  5e+08  9.9999e+08  9.9999e+08  5e+13  0  0   0  1e+09
##     A11            b
## y1    0  1.00000e+02
## A2    0  1.00000e+01
## A3    0  2.00000e+01
## x11   0  5.00000e+05
## X12   0  1.00000e+06
## X13   0  2.00000e+06
## L10   0  3.75000e+06
## S8    0  1.00000e+02
## S9    0  1.00000e+02
## X21   0  4.75000e+06
## A11   1  1.75000e+06
## Z     0 -1.75003e+15
## [1] "------------------------------------------------------------------------"
```

```
## [1] "Iteration 7"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 10"
## [1] "Pivot row: 11"
## [1] "New tableau at the end of iteration 7"
##     x11 X21 X12    X22 X13    X23 y1         y2         y3 A1 A2 A3     S4
## y1    0   0   0  0e+00   0  0e+00  1          0          0  0  0  0  0e+00
## A2    0   0   0 -2e-05   0  0e+00  0          1          0  0  1  0  0e+00
## A3    0   0   0  0e+00   0 -2e-05  0          0          1  0  0  1  0e+00
## x11   1   0   0  0e+00   0  0e+00  0          0          0  0  0  0  1e+00
## X12   0   0   1  0e+00   0  0e+00  0          0          0  0  0  0  0e+00
## X13   0   0   0  0e+00   1  0e+00  0          0          0  0  0  0  0e+00
## L10   0   0   0  1e+00   0  1e+00  0          0          0  0  0  0 -1e+00
## S8    0   0   0  0e+00   0  0e+00  0          1          0  0  0  0  0e+00
## S9    0   0   0  0e+00   0  0e+00  0          0          1  0  0  0  0e+00
## X21   0   1   0  1e+00   0  1e+00  0          0          0  0  0  0 -1e+00
## A1    0   0   0  2e-05   0  2e-05  0          0          0  1  0  0 -1e-05
## Z     0   0   0  0e+00   0  0e+00  0 -999990000 -999990000  0  0  0  1e+04
##         S5     S6        S7 S8 S9 L10    A10        A11           b
## y1   0e+00  0e+00         1  0  0   0  0e+00 0.0000e+00  1.0000e+02
## A2   1e-05  0e+00         0  0  0   0  0e+00 0.0000e+00  1.0000e+01
## A3   0e+00  1e-05         0  0  0   0  0e+00 0.0000e+00  2.0000e+01
## x11  0e+00  0e+00         0  0  0   0  0e+00 0.0000e+00  5.0000e+05
## X12  1e+00  0e+00         0  0  0   0  0e+00 0.0000e+00  1.0000e+06
## X13  0e+00  1e+00         0  0  0   0  0e+00 0.0000e+00  2.0000e+06
## L10 -1e+00 -1e+00         0  0  0   1 -1e+00 1.0000e+00  5.5000e+06
## S8   0e+00  0e+00         0  1  0   0  0e+00 0.0000e+00  1.0000e+02
## S9   0e+00  0e+00         0  0  1   0  0e+00 0.0000e+00  1.0000e+02
## X21 -1e+00 -1e+00         0  0  0   0  0e+00 1.0000e+00  6.5000e+06
## A1  -2e-05 -2e-05        -1  0  0   0  0e+00 2.0000e-05  3.5000e+01
## Z    1e+04  1e+04 999990000  0  0   0  1e+09 9.9998e+08 -6.4991e+10
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 8"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 8"
## [1] "Pivot row: 2"
## [1] "New tableau at the end of iteration 8"
##     x11 X21 X12          X22 X13    X23 y1 y2         y3 A1         A2 A3     S4
## y1    0   0   0      0.00000   0  0e+00  1  0          0  0          0  0  0e+00
## y2    0   0   0     -0.00002   0  0e+00  0  1          0  0          1  0  0e+00
## A3    0   0   0      0.00000   0 -2e-05  0  0          1  0          0  1  0e+00
## x11   1   0   0      0.00000   0  0e+00  0  0          0  0          0  0  1e+00
## X12   0   0   1      0.00000   0  0e+00  0  0          0  0          0  0  0e+00
## X13   0   0   0      0.00000   1  0e+00  0  0          0  0          0  0  0e+00
## L10   0   0   0      1.00000   0  1e+00  0  0          0  0          0  0 -1e+00
## S8    0   0   0      0.00002   0  0e+00  0  0          0  0         -1  0  0e+00
## S9    0   0   0      0.00000   0  0e+00  0  0          1  0          0  0  0e+00
## X21   0   1   0      1.00000   0  1e+00  0  0          0  0          0  0 -1e+00
## A1    0   0   0      0.00002   0  2e-05  0  0          0  1          0  0 -1e-05
## Z     0   0   0 -19999.80000   0  0e+00  0  0 -999990000  0 999990000  0  1e+04
##              S5     S6        S7 S8 S9 L10    A10        A11            b
## y1      0.00000  0e+00         1  0  0   0  0e+00 0.0000e+00          100
## y2      0.00001  0e+00         0  0  0   0  0e+00 0.0000e+00           10
## A3      0.00000  1e-05         0  0  0   0  0e+00 0.0000e+00           20
```

```
## x11     0.00000  0e+00         0  0  0   0  0e+00 0.0000e+00       500000
## X12     1.00000  0e+00         0  0  0   0  0e+00 0.0000e+00      1000000
## X13     0.00000  1e+00         0  0  0   0  0e+00 0.0000e+00      2000000
## L10    -1.00000 -1e+00         0  0  0   1 -1e+00 1.0000e+00      5500000
## S8     -0.00001  0e+00         0  1  0   0  0e+00 0.0000e+00           90
## S9      0.00000  0e+00         0  0  1   0  0e+00 0.0000e+00          100
## X21    -1.00000 -1e+00         0  0  0   0  0e+00 1.0000e+00      6500000
## A1     -0.00002 -2e-05        -1  0  0   0  0e+00 2.0000e-05           35
## Z   19999.90000  1e+04 999990000  0  0   0  1e+09 9.9998e+08 -54991100000
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 9"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 9"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 9"
##     x11 X21 X12          X22 X13          X23 y1 y2 y3 A1        A2        A3
## y1    0   0   0      0.00000   0      0.00000  1  0  0  0         0         0
## y2    0   0   0     -0.00002   0      0.00000  0  1  0  0         1         0
## y3    0   0   0      0.00000   0     -0.00002  0  0  1  0         0         1
## x11   1   0   0      0.00000   0      0.00000  0  0  0  0         0         0
## X12   0   0   1      0.00000   0      0.00000  0  0  0  0         0         0
## X13   0   0   0      0.00000   1      0.00000  0  0  0  0         0         0
## L10   0   0   0      1.00000   0      1.00000  0  0  0  0         0         0
## S8    0   0   0      0.00002   0      0.00000  0  0  0  0        -1         0
## S9    0   0   0      0.00000   0      0.00002  0  0  0  0         0        -1
## X21   0   1   0      1.00000   0      1.00000  0  0  0  0         0         0
## A1    0   0   0      0.00002   0      0.00002  0  0  0  1         0         0
## Z     0   0   0 -19999.80000   0 -19999.80000  0  0  0  0 999990000 999990000
##         S4          S5          S6        S7 S8 S9 L10    A10         A11
## y1   0e+00     0.00000     0.00000         1  0  0   0  0e+00 0.0000e+00
## y2   0e+00     0.00001     0.00000         0  0  0   0  0e+00 0.0000e+00
## y3   0e+00     0.00000     0.00001         0  0  0   0  0e+00 0.0000e+00
## x11  1e+00     0.00000     0.00000         0  0  0   0  0e+00 0.0000e+00
## X12  0e+00     1.00000     0.00000         0  0  0   0  0e+00 0.0000e+00
## X13  0e+00     0.00000     1.00000         0  0  0   0  0e+00 0.0000e+00
## L10 -1e+00    -1.00000    -1.00000         0  0  0   1 -1e+00 1.0000e+00
## S8   0e+00    -0.00001     0.00000         0  1  0   0  0e+00 0.0000e+00
## S9   0e+00     0.00000    -0.00001         0  0  1   0  0e+00 0.0000e+00
## X21 -1e+00    -1.00000    -1.00000         0  0  0   0  0e+00 1.0000e+00
## A1  -1e-05    -0.00002    -0.00002        -1  0  0   0  0e+00 2.0000e-05
## Z    1e+04 19999.90000 19999.90000 999990000  0  0   0  1e+09 9.9998e+08
##                b
## y1           100
## y2            10
## y3            20
## x11       500000
## X12      1000000
## X13      2000000
## L10      5500000
## S8            90
## S9            80
## X21      6500000
## A1            35
## Z   -34991300000
```

```
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 10"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 4"
## [1] "Pivot row: 11"
## [1] "New tableau at the end of iteration 10"
##     x11 X21 X12 X22 X13    X23 y1 y2 y3        A1        A2        A3     S4
## y1    0   0   0   0   0  0e+00  1  0  0         0         0         0  0e+00
## y2    0   0   0   0   0  2e-05  0  1  0         1         1         0 -1e-05
## y3    0   0   0   0   0 -2e-05  0  0  1         0         0         1  0e+00
## x11   1   0   0   0   0  0e+00  0  0  0         0         0         0  1e+00
## X12   0   0   1   0   0  0e+00  0  0  0         0         0         0  0e+00
## X13   0   0   0   0   1  0e+00  0  0  0         0         0         0  0e+00
## L10   0   0   0   0   0  0e+00  0  0  0    -50000         0         0 -5e-01
## S8    0   0   0   0   0 -2e-05  0  0  0        -1        -1         0  1e-05
## S9    0   0   0   0   0  2e-05  0  0  0         0         0        -1  0e+00
## X21   0   1   0   0   0  0e+00  0  0  0    -50000         0         0 -5e-01
## X22   0   0   0   1   0  1e+00  0  0  0     50000         0         0 -5e-01
## Z     0   0   0   0   0  0e+00  0  0  0 999990000 999990000 999990000  1e-01
##         S5     S6        S7 S8 S9 L10    A10    A11       b
## y1   0e+00  0e+00  1.00e+00  0  0   0  0e+00  0e+00     100
## y2  -1e-05 -2e-05 -1.00e+00  0  0   0  0e+00  2e-05      45
## y3   0e+00  1e-05  0.00e+00  0  0   0  0e+00  0e+00      20
## x11  0e+00  0e+00  0.00e+00  0  0   0  0e+00  0e+00  500000
## X12  1e+00  0e+00  0.00e+00  0  0   0  0e+00  0e+00 1000000
## X13  0e+00  1e+00  0.00e+00  0  0   0  0e+00  0e+00 2000000
## L10  0e+00  0e+00  5.00e+04  0  0   1 -1e+00  0e+00 3750000
## S8   1e-05  2e-05  1.00e+00  1  0   0  0e+00 -2e-05      55
## S9   0e+00 -1e-05  0.00e+00  0  1   0  0e+00  0e+00      80
## X21  0e+00  0e+00  5.00e+04  0  0   0  0e+00  0e+00 4750000
## X22 -1e+00 -1e+00 -5.00e+04  0  0   0  0e+00  1e+00 1750000
## Z    1e-01  1e-01  5.96e-03  0  0   0  1e+09  1e+09 8350000
## [1] "------------------------------------------------------------------------"
## [1] "Status: End"
## [1] "------------------------------------------------------------------------"
```

- Dual Problem -

#9 ## Build and show the dual problem

This is where you insert your dual problem: - Change the 'min_max_dual', 'Number_of_constraints_dual' and 'Number_of_variables_dual' variables. - Change the coefficients of the objective function in the 'objective_coefs_dual' variable. - Add all your constraints using 'add.constraint()'. - Give names to your constraints and your decision variables in 'RowNames_dual' and 'ColNames_dual'.

```
### ------ Create the model ------ ###

min_max_dual <- 1  # -1 = minimum problem, 1 = maximum problem
Number_of_constraints_dual <- 9  # Change to the number of constraints
Number_of_variables_dual <- 15 # Change to the number of variables
```

```
lp_dual_model <- make.lp(0, Number_of_variables_dual)

### ------ Set the objective function ------ ###

objective_coefs_dual <- c(0,0,0,0,0,0,-500000,-1000000,-2000000,-100,-100,-100,1000000,-10000000,100000
set.objfn(lp_dual_model, objective_coefs_dual)

### ------ Add all constraints ------ ###

add.constraint(lp_dual_model, c(-0.00001,0.00001,0,0,0,0,1,0,0,0,0,0,0,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(-0.00002,0.00002,0,0,0,0,0,0,0,0,0,0,-1,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(0,0,-0.00001,0.00001,0,0,0,1,0,0,0,0,0,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(0,0,-0.00002,0.00002,0,0,0,0,0,0,0,0,0,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(0,0,0,0,-0.00001,0.00001,0,0,1,0,0,0,0,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(0,0,0,0,-0.00002,0.00002,0,0,0,0,0,0,0,1,-1), ">=", 1)
add.constraint(lp_dual_model, c(1,-1,0,0,0,0,0,0,0,1,0,0,0,0,0), ">=", -10000)
add.constraint(lp_dual_model, c(0,0,1,-1,0,0,0,0,0,0,1,0,0,0,0), ">=", -10000)
add.constraint(lp_dual_model, c(0,0,0,0,1,-1,0,0,0,0,0,1,0,0,0), ">=", -10000)
### ------ Set the names of the constraints and variables ------ ###

RowNames_dual <- c("st1", "st2", "st3","st4","st5","st6","st7","st8","st9") # Give names to the constra
ColNames_dual <- c("t1'", "t1''", "t2'", "t2''","t3'","t3''","t4","xt5","t6","t7","t8","t9","t10","t11'
dimnames(lp_dual_model) <- list(RowNames_dual, ColNames_dual) # Assign constraints and variables names

### ------ Show and solve the model ------ ###

if (min_max_dual == 1){
  l <- lp.control(lp_dual_model, sense = "max")
}

lp_dual_model # Show the model
```

```
## Model name:
##   a linear program with 15 decision variables and 9 constraints
```

```
print("The solution's code is: ")
```

```
## [1] "The solution's code is: "
```

```
solve(lp_dual_model) # Solve the linear problem
```

```
## [1] 0
```

Status Codes: 0: “optimal solution found” 1: “the model is sub-optimal” 2: “the model is infeasible” 3: “the model is unbounded” 4: “the model is degenerate” 5: “numerical failure encountered” 6: “process aborted” 7: “timeout”

#10 ## Show the solution of the dual problem

```
### -------- Set the coefs matrix (A) and the constraints relations - don't change! -------- ###
```

```r
c_dual <-  objective_coefs_dual  # Get objective function coefficients
b_dual <-  get.rhs(lp_dual_model) # Get RHS
A_dual <- matrix(nrow = Number_of_constraints_dual, ncol = Number_of_variables_dual, byrow = TRUE) # In
relations_dual <- c() # Constraints directions

for (i in 1 :Number_of_constraints_dual){
  for (j in 1 :Number_of_variables_dual){
    A_dual[i,j] <- get.mat(lp_dual_model,i,j)
  }
  relations_dual <- append(relations_dual, get.constr.type(lp_dual_model, i))
}

### -------- Find S_star -------- ###
tab_dual <- simplexR(A_dual, b_dual, c_dual, sense = min_max_dual, relation = relations_dual, Col_Names
s_star_dual <- matrix(nrow = Number_of_constraints_dual, ncol = Number_of_constraints_dual, byrow = TRU
ind = 1
for (i in 1:dim(tab_dual)[2]){
  if (grepl("A", colnames(tab_dual)[i], fixed = TRUE) || (grepl("S", colnames(tab_dual)[i], fixed = TRU
    s_star_dual[ , ind] <- tab_dual[1:Number_of_constraints_dual, i]
    ind <- ind + 1
  }
}


Show_Solution(lp_dual_model, Number_of_variables_dual, Number_of_constraints_dual, objective_coefs_dual
```

```
## [1] "The number of iterations was:  9"
## [1] "-------------------------------------------------------------------------------"
## [1] "The optimal solution is:  -8350000"
## [1] "-------------------------------------------------------------------------------"
## [1] "                                                                               "
## [1] "The optimal values of the decision variables and their reduced costs are:"
## [1] "                                                                               "
##       Optimal Value Reduced Cost
## t1'           0e+00            0
## t1''          1e+04            0
## t2'           0e+00            0
## t2''          1e+04            0
## t3'           0e+00            0
## t3''          1e+04            0
## t4            1e-01            0
## xt5           1e-01            0
## t6            1e-01            0
## t7            0e+00          -75
## t8            0e+00            0
## t9            0e+00          -60
## t10           0e+00            0
## t11'          8e-01            0
## t11''         0e+00            0
## [1] "                                                                               "
## [1] "The optimal values of the Slacks and their dual prices are:"
## [1] "                                                                               "
##    Optimal Value Dual Price
```

```
## L1             0    -500000
## L2             0   -1000000
## L3             0   -1000000
## L4             0   -4500000
## L5             0   -2000000
## L6             0   -1000000
## L7             0        -25
## L8             0       -100
## L9             0        -40
## [1] "--------------------------------------------------------------------------------"
## [1] "                                                                                "
## [1] "Ranges In Which The Basis Is Unchanged:"
## [1] "                                                                                "
## [1] "Ranges Of Objective Function Coefficients:"
## [1] "                                                                                "
##       Current Coef Coef From     Coef Till
## t1'          0e+00  -1.0e+30  0.000000e+00
## t1''         0e+00  -2.5e+01  0.000000e+00
## t2'          0e+00  -1.0e+30  3.959154e-15
## t2''         0e+00  -2.0e+01  3.959154e-15
## t3'          0e+00  -1.0e+30 -3.309014e-15
## t3''         0e+00  -4.0e+01  3.309014e-15
## t4          -5e+05  -1.5e+06  0.000000e+00
## xt5         -1e+06  -3.0e+06  0.000000e+00
## t6          -2e+06  -3.0e+06  0.000000e+00
## t7          -1e+02  -1.0e+30 -2.500000e+01
## t8          -1e+02  -1.0e+30 -4.000000e+01
## t9          -1e+02  -1.0e+30 -4.000000e+01
## t10          1e+06  -1.0e+30  2.000000e+06
## t11'        -1e+07  -1.3e+07 -1.000000e+07
## t11''        1e+07  -1.0e+30  1.000000e+07
## [1] "                                                                                "
## [1] "Ranges Of RHS:"
## [1] "                                                                                "
##       Current RHS RHS From RHS Till
##  [1,]           1      1.1      1.1
##  [2,]           1      1.0      1.0
##  [3,]           1      1.1      1.1
##  [4,]           1      1.0      1.0
##  [5,]           1      1.1      1.1
##  [6,]           1      1.2      1.2
##  [7,]      -10000 -10000.0 -10000.0
##  [8,]      -10000      0.0      0.0
##  [9,]      -10000 -10000.0 -10000.0
```

#11 ## Show the simplex tables of the dual problem - Run but do not change.

**** If you have a minimum problem - multiply the optimal solution by (-1)! ****

```
### -------- Show simplex tables -------- ###

simplexR(A_dual, b_dual, c_dual, sense = min_max_dual, relation = relations_dual, Col_Names = ColNames_
```

```
## [1] "Start constructing Simplex Tableau"
```

```
## [1] "Tableau constructed"
## [1] "Artificial variable 'A' added at column  17 and row  1  -> phase I algorithm required"
## [2] "Artificial variable 'A' added at column  19 and row  2  -> phase I algorithm required"
## [3] "Artificial variable 'A' added at column  21 and row  3  -> phase I algorithm required"
## [4] "Artificial variable 'A' added at column  23 and row  4  -> phase I algorithm required"
## [5] "Artificial variable 'A' added at column  25 and row  5  -> phase I algorithm required"
## [6] "Artificial variable 'A' added at column  27 and row  6  -> phase I algorithm required"
## [1] "BigM-method is used, with bigM = 1e+09"
## [1] "Initial Tableau (Tableau 0)"
##       t1'   t1''    t2'   t2''    t3'   t3''         t4       xt5        t6  t7
## A1 -1e-05  1e-05  0e+00  0e+00  0e+00  0e+00          1  0.00e+00  0.00e+00   0
## A2 -2e-05  2e-05  0e+00  0e+00  0e+00  0e+00          0  0.00e+00  0.00e+00   0
## A3  0e+00  0e+00 -1e-05  1e-05  0e+00  0e+00          0  1.00e+00  0.00e+00   0
## A4  0e+00  0e+00 -2e-05  2e-05  0e+00  0e+00          0  0.00e+00  0.00e+00   0
## A5  0e+00  0e+00  0e+00  0e+00 -1e-05  1e-05          0  0.00e+00  1.00e+00   0
## A6  0e+00  0e+00  0e+00  0e+00 -2e-05  2e-05          0  0.00e+00  0.00e+00   0
## S7 -1e+00  1e+00  0e+00  0e+00  0e+00  0e+00          0  0.00e+00  0.00e+00  -1
## S8  0e+00  0e+00 -1e+00  1e+00  0e+00  0e+00          0  0.00e+00  0.00e+00   0
## S9  0e+00  0e+00  0e+00  0e+00 -1e+00  1e+00          0  0.00e+00  0.00e+00   0
## Z   3e+04 -3e+04  3e+04 -3e+04  3e+04 -3e+04 -999500000 -9.99e+08 -9.98e+08 100
##     t8  t9       t10      t11'     t11''     L1 A1     L2 A2     L3 A3     L4
## A1   0   0         0  1.00e+00 -1.00e+00 -1e+00  1  0e+00  0  0e+00  0  0e+00
## A2   0   0        -1  1.00e+00 -1.00e+00  0e+00  0 -1e+00  1  0e+00  0  0e+00
## A3   0   0         0  1.00e+00 -1.00e+00  0e+00  0  0e+00  0 -1e+00  1  0e+00
## A4   0   0         0  1.00e+00 -1.00e+00  0e+00  0  0e+00  0  0e+00  0 -1e+00
## A5   0   0         0  1.00e+00 -1.00e+00  0e+00  0  0e+00  0  0e+00  0  0e+00
## A6   0   0         0  1.00e+00 -1.00e+00  0e+00  0  0e+00  0  0e+00  0  0e+00
## S7   0   0         0  0.00e+00  0.00e+00  0e+00  0  0e+00  0  0e+00  0  0e+00
## S8  -1   0         0  0.00e+00  0.00e+00  0e+00  0  0e+00  0  0e+00  0  0e+00
## S9   0  -1         0  0.00e+00  0.00e+00  0e+00  0  0e+00  0  0e+00  0  0e+00
## Z  100 100 999000000 -5.99e+09  5.99e+09  1e+09  0  1e+09  0  1e+09  0  1e+09
##    A4     L5 A5     L6 A6 S7 S8 S9      b
## A1  0  0e+00  0  0e+00  0  0  0  0  1e+00
## A2  0  0e+00  0  0e+00  0  0  0  0  1e+00
## A3  0  0e+00  0  0e+00  0  0  0  0  1e+00
## A4  1  0e+00  0  0e+00  0  0  0  0  1e+00
## A5  0 -1e+00  1  0e+00  0  0  0  0  1e+00
## A6  0  0e+00  0 -1e+00  1  0  0  0  1e+00
## S7  0  0e+00  0  0e+00  0  1  0  0  1e+04
## S8  0  0e+00  0  0e+00  0  0  1  0  1e+04
## S9  0  0e+00  0  0e+00  0  0  0  1  1e+04
## Z   0  1e+09  0  1e+09  0  0  0  0 -6e+09
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 1"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 14"
## [1] "Pivot row: 1"
## [1] "New tableau at the end of iteration 1"
##            t1'      t1''    t2'   t2''    t3'   t3''         t4       xt5
## t11' -1.00e-05  1.00e-05  0e+00  0e+00  0e+00  0e+00          1  0.00e+00
## A2   -1.00e-05  1.00e-05  0e+00  0e+00  0e+00  0e+00         -1  0.00e+00
## A3    1.00e-05 -1.00e-05 -1e-05  1e-05  0e+00  0e+00         -1  1.00e+00
## A4    1.00e-05 -1.00e-05 -2e-05  2e-05  0e+00  0e+00         -1  0.00e+00
## A5    1.00e-05 -1.00e-05  0e+00  0e+00 -1e-05  1e-05         -1  0.00e+00
```

```
## A6    1.00e-05 -1.00e-05  0e+00  0e+00 -2e-05  2e-05         -1  0.00e+00
## S7   -1.00e+00  1.00e+00  0e+00  0e+00  0e+00  0e+00          0  0.00e+00
## S8    0.00e+00  0.00e+00 -1e+00  1e+00  0e+00  0e+00          0  0.00e+00
## S9    0.00e+00  0.00e+00  0e+00  0e+00 -1e+00  1e+00          0  0.00e+00
## Z    -2.99e+04  2.99e+04  3e+04 -3e+04  3e+04 -3e+04 4990500000 -9.99e+08
##             t6  t7  t8  t9       t10 t11' t11''        L1        A1     L2 A2
## t11'  0.00e+00   0   0   0         0    1    -1 -1.00e+00  1.00e+00  0e+00  0
## A2    0.00e+00   0   0   0        -1    0     0  1.00e+00 -1.00e+00 -1e+00  1
## A3    0.00e+00   0   0   0         0    0     0  1.00e+00 -1.00e+00  0e+00  0
## A4    0.00e+00   0   0   0         0    0     0  1.00e+00 -1.00e+00  0e+00  0
## A5    1.00e+00   0   0   0         0    0     0  1.00e+00 -1.00e+00  0e+00  0
## A6    0.00e+00   0   0   0         0    0     0  1.00e+00 -1.00e+00  0e+00  0
## S7    0.00e+00  -1   0   0         0    0     0  0.00e+00  0.00e+00  0e+00  0
## S8    0.00e+00   0  -1   0         0    0     0  0.00e+00  0.00e+00  0e+00  0
## S9    0.00e+00   0   0  -1         0    0     0  0.00e+00  0.00e+00  0e+00  0
## Z    -9.98e+08 100 100 100 999000000    0     0 -4.99e+09  5.99e+09  1e+09  0
##          L3 A3     L4 A4     L5 A5     L6 A6 S7 S8 S9      b
## t11'  0e+00  0  0e+00  0  0e+00  0  0e+00  0  0  0  0  1e+00
## A2    0e+00  0  0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## A3   -1e+00  1  0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## A4    0e+00  0 -1e+00  1  0e+00  0  0e+00  0  0  0  0  0e+00
## A5    0e+00  0  0e+00  0 -1e+00  1  0e+00  0  0  0  0  0e+00
## A6    0e+00  0  0e+00  0  0e+00  0 -1e+00  1  0  0  0  0e+00
## S7    0e+00  0  0e+00  0  0e+00  0  0e+00  0  1  0  0  1e+04
## S8    0e+00  0  0e+00  0  0e+00  0  0e+00  0  0  1  0  1e+04
## S9    0e+00  0  0e+00  0  0e+00  0  0e+00  0  0  0  1  1e+04
## Z     1e+09  0  1e+09  0  1e+09  0  1e+09  0  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 2"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 16"
## [1] "Pivot row: 2"
## [1] "New tableau at the end of iteration 2"
##           t1'      t1''    t2'   t2''    t3'   t3''     t4       xt5        t6
## t11' -2.00e-05  2.00e-05  0e+00  0e+00  0e+00  0e+00      0  0.00e+00  0.00e+00
## L1   -1.00e-05  1.00e-05  0e+00  0e+00  0e+00  0e+00     -1  0.00e+00  0.00e+00
## A3    2.00e-05 -2.00e-05 -1e-05  1e-05  0e+00  0e+00      0  1.00e+00  0.00e+00
## A4    2.00e-05 -2.00e-05 -2e-05  2e-05  0e+00  0e+00      0  0.00e+00  0.00e+00
## A5    2.00e-05 -2.00e-05  0e+00  0e+00 -1e-05  1e-05      0  0.00e+00  1.00e+00
## A6    2.00e-05 -2.00e-05  0e+00  0e+00 -2e-05  2e-05      0  0.00e+00  0.00e+00
## S7   -1.00e+00  1.00e+00  0e+00  0e+00  0e+00  0e+00      0  0.00e+00  0.00e+00
## S8    0.00e+00  0.00e+00 -1e+00  1e+00  0e+00  0e+00      0  0.00e+00  0.00e+00
## S9    0.00e+00  0.00e+00  0e+00  0e+00 -1e+00  1e+00      0  0.00e+00  0.00e+00
## Z    -7.98e+04  7.98e+04  3e+04 -3e+04  3e+04 -3e+04 500000 -9.99e+08 -9.98e+08
##       t7  t8  t9        t10 t11' t11'' L1     A1        L2        A2     L3 A3
## t11'   0   0   0 -1.000e+00    1    -1  0  0e+00 -1.00e+00  1.00e+00  0e+00  0
## L1     0   0   0 -1.000e+00    0     0  1 -1e+00 -1.00e+00  1.00e+00  0e+00  0
## A3     0   0   0  1.000e+00    0     0  0  0e+00  1.00e+00 -1.00e+00 -1e+00  1
## A4     0   0   0  1.000e+00    0     0  0  0e+00  1.00e+00 -1.00e+00  0e+00  0
## A5     0   0   0  1.000e+00    0     0  0  0e+00  1.00e+00 -1.00e+00  0e+00  0
## A6     0   0   0  1.000e+00    0     0  0  0e+00  1.00e+00 -1.00e+00  0e+00  0
## S7    -1   0   0  0.000e+00    0     0  0  0e+00  0.00e+00  0.00e+00  0e+00  0
## S8     0  -1   0  0.000e+00    0     0  0  0e+00  0.00e+00  0.00e+00  0e+00  0
## S9     0   0  -1  0.000e+00    0     0  0  0e+00  0.00e+00  0.00e+00  0e+00  0
```

```
## Z    100 100 100 -3.991e+09    0     0  0  1e+09 -3.99e+09  4.99e+09  1e+09  0
##          L4 A4     L5 A5     L6 A6 S7 S8 S9      b
## t11'  0e+00  0  0e+00  0  0e+00  0  0  0  0  1e+00
## L1    0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## A3    0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## A4   -1e+00  1  0e+00  0  0e+00  0  0  0  0  0e+00
## A5    0e+00  0 -1e+00  1  0e+00  0  0  0  0  0e+00
## A6    0e+00  0  0e+00  0 -1e+00  1  0  0  0  0e+00
## S7    0e+00  0  0e+00  0  0e+00  0  1  0  0  1e+04
## S8    0e+00  0  0e+00  0  0e+00  0  0  1  0  1e+04
## S9    0e+00  0  0e+00  0  0e+00  0  0  0  1  1e+04
## Z     1e+09  0  1e+09  0  1e+09  0  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 3"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 13"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 3"
##         t1'   t1''       t2'      t2''    t3'   t3''     t4        xt5
## t11'  0e+00  0e+00 -1.00e-05  1.00e-05  0e+00  0e+00      0          1
## L1    1e-05 -1e-05 -1.00e-05  1.00e-05  0e+00  0e+00     -1          1
## t10   2e-05 -2e-05 -1.00e-05  1.00e-05  0e+00  0e+00      0          1
## A4    0e+00  0e+00 -1.00e-05  1.00e-05  0e+00  0e+00      0         -1
## A5    0e+00  0e+00  1.00e-05 -1.00e-05 -1e-05  1e-05      0         -1
## A6    0e+00  0e+00  1.00e-05 -1.00e-05 -2e-05  2e-05      0         -1
## S7   -1e+00  1e+00  0.00e+00  0.00e+00  0e+00  0e+00      0          0
## S8    0e+00  0e+00 -1.00e+00  1.00e+00  0e+00  0e+00      0          0
## S9    0e+00  0e+00  0.00e+00  0.00e+00 -1e+00  1e+00      0          0
## Z     2e+01 -2e+01 -9.91e+03  9.91e+03  3e+04 -3e+04 500000 2992000000
##              t6  t7  t8  t9 t10 t11' t11'' L1     A1    L2        A2         L3
## t11'  0.00e+00   0   0   0   0    1    -1  0  0e+00 0e+00         0 -1.000e+00
## L1    0.00e+00   0   0   0   0    0     0  1 -1e+00 0e+00         0 -1.000e+00
## t10   0.00e+00   0   0   0   1    0     0  0  0e+00 1e+00        -1 -1.000e+00
## A4    0.00e+00   0   0   0   0    0     0  0  0e+00 0e+00         0  1.000e+00
## A5    1.00e+00   0   0   0   0    0     0  0  0e+00 0e+00         0  1.000e+00
## A6    0.00e+00   0   0   0   0    0     0  0  0e+00 0e+00         0  1.000e+00
## S7    0.00e+00  -1   0   0   0    0     0  0  0e+00 0e+00         0  0.000e+00
## S8    0.00e+00   0  -1   0   0    0     0  0  0e+00 0e+00         0  0.000e+00
## S9    0.00e+00   0   0  -1   0    0     0  0  0e+00 0e+00         0  0.000e+00
## Z    -9.98e+08 100 100 100   0    0     0  0  1e+09 1e+06 999000000 -2.991e+09
##               A3     L4 A4     L5 A5     L6 A6 S7 S8 S9      b
## t11'           1  0e+00  0  0e+00  0  0e+00  0  0  0  0  1e+00
## L1             1  0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## t10            1  0e+00  0  0e+00  0  0e+00  0  0  0  0  0e+00
## A4            -1 -1e+00  1  0e+00  0  0e+00  0  0  0  0  0e+00
## A5            -1  0e+00  0 -1e+00  1  0e+00  0  0  0  0  0e+00
## A6            -1  0e+00  0  0e+00  0 -1e+00  1  0  0  0  0e+00
## S7             0  0e+00  0  0e+00  0  0e+00  0  1  0  0  1e+04
## S8             0  0e+00  0  0e+00  0  0e+00  0  0  1  0  1e+04
## S9             0  0e+00  0  0e+00  0  0e+00  0  0  0  1  1e+04
## Z    3991000000  1e+09  0  1e+09  0  1e+09  0  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 4"
## [1] "--------------------------------------------------------------------------"
```

```
## [1] "Pivot column: 20"
## [1] "Pivot row: 4"
## [1] "New tableau at the end of iteration 4"
##         t1'   t1''        t2'       t2''    t3'   t3''     t4    xt5        t6
## t11'  0e+00  0e+00 -2.000e-05  2.000e-05  0e+00  0e+00      0  0e+00  0.00e+00
## L1    1e-05 -1e-05 -2.000e-05  2.000e-05  0e+00  0e+00     -1  0e+00  0.00e+00
## t10   2e-05 -2e-05 -2.000e-05  2.000e-05  0e+00  0e+00      0  0e+00  0.00e+00
## L3    0e+00  0e+00 -1.000e-05  1.000e-05  0e+00  0e+00      0 -1e+00  0.00e+00
## A5    0e+00  0e+00  2.000e-05 -2.000e-05 -1e-05  1e-05      0  0e+00  1.00e+00
## A6    0e+00  0e+00  2.000e-05 -2.000e-05 -2e-05  2e-05      0  0e+00  0.00e+00
## S7   -1e+00  1e+00  0.000e+00  0.000e+00  0e+00  0e+00      0  0e+00  0.00e+00
## S8    0e+00  0e+00 -1.000e+00  1.000e+00  0e+00  0e+00      0  0e+00  0.00e+00
## S9    0e+00  0e+00  0.000e+00  0.000e+00 -1e+00  1e+00      0  0e+00  0.00e+00
## Z     2e+01 -2e+01 -3.982e+04  3.982e+04  3e+04 -3e+04 500000  1e+06 -9.98e+08
##       t7  t8  t9 t10 t11' t11'' L1     A1    L2        A2 L3     A3         L4
## t11'   0   0   0   0    1    -1  0  0e+00 0e+00         0  0  0e+00 -1.000e+00
## L1     0   0   0   0    0     0  1 -1e+00 0e+00         0  0  0e+00 -1.000e+00
## t10    0   0   0   1    0     0  0  0e+00 1e+00        -1  0  0e+00 -1.000e+00
## L3     0   0   0   0    0     0  0  0e+00 0e+00         0  1 -1e+00 -1.000e+00
## A5     0   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  1.000e+00
## A6     0   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  1.000e+00
## S7    -1   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0.000e+00
## S8     0  -1   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0.000e+00
## S9     0   0  -1   0    0     0  0  0e+00 0e+00         0  0  0e+00  0.000e+00
## Z    100 100 100   0    0     0  0  1e+09 1e+06 999000000  0  1e+09 -1.991e+09
##              A4     L5 A5     L6 A6 S7 S8 S9      b
## t11'          1  0e+00  0  0e+00  0  0  0  0  1e+00
## L1            1  0e+00  0  0e+00  0  0  0  0  0e+00
## t10           1  0e+00  0  0e+00  0  0  0  0  0e+00
## L3            1  0e+00  0  0e+00  0  0  0  0  0e+00
## A5           -1 -1e+00  1  0e+00  0  0  0  0  0e+00
## A6           -1  0e+00  0 -1e+00  1  0  0  0  0e+00
## S7            0  0e+00  0  0e+00  0  1  0  0  1e+04
## S8            0  0e+00  0  0e+00  0  0  1  0  1e+04
## S9            0  0e+00  0  0e+00  0  0  0  1  1e+04
## Z    2991000000  1e+09  0  1e+09  0  0  0  0 -1e+07
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 5"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 22"
## [1] "Pivot row: 5"
## [1] "New tableau at the end of iteration 5"
##         t1'   t1''    t2'   t2''        t3'       t3''     t4    xt5        t6
## t11'  0e+00  0e+00  0e+00  0e+00 -1.000e-05  1.000e-05      0  0e+00         1
## L1    1e-05 -1e-05  0e+00  0e+00 -1.000e-05  1.000e-05     -1  0e+00         1
## t10   2e-05 -2e-05  0e+00  0e+00 -1.000e-05  1.000e-05      0  0e+00         1
## L3    0e+00  0e+00  1e-05 -1e-05 -1.000e-05  1.000e-05      0 -1e+00         1
## L4    0e+00  0e+00  2e-05 -2e-05 -1.000e-05  1.000e-05      0  0e+00         1
## A6    0e+00  0e+00  0e+00  0e+00 -1.000e-05  1.000e-05      0  0e+00        -1
## S7   -1e+00  1e+00  0e+00  0e+00  0.000e+00  0.000e+00      0  0e+00         0
## S8    0e+00  0e+00 -1e+00  1e+00  0.000e+00  0.000e+00      0  0e+00         0
## S9    0e+00  0e+00  0e+00  0e+00 -1.000e+00  1.000e+00      0  0e+00         0
## Z     2e+01 -2e+01  0e+00  0e+00  1.009e+04 -1.009e+04 500000  1e+06 993000000
##       t7  t8  t9 t10 t11' t11'' L1     A1    L2        A2 L3     A3 L4     A4
```

```
## t11'   0   0   0   0    1    -1  0  0e+00 0e+00         0  0  0e+00  0  0e+00
## L1     0   0   0   0    0     0  1 -1e+00 0e+00         0  0  0e+00  0  0e+00
## t10    0   0   0   1    0     0  0  0e+00 1e+00        -1  0  0e+00  0  0e+00
## L3     0   0   0   0    0     0  0  0e+00 0e+00         0  1 -1e+00  0  0e+00
## L4     0   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  1 -1e+00
## A6     0   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00
## S7    -1   0   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00
## S8     0  -1   0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00
## S9     0   0  -1   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00
## Z    100 100 100   0    0     0  0  1e+09 1e+06 999000000  0  1e+09  0  1e+09
##             L5         A5     L6 A6 S7 S8 S9      b
## t11' -1.00e+00          1  0e+00  0  0  0  0  1e+00
## L1   -1.00e+00          1  0e+00  0  0  0  0  0e+00
## t10  -1.00e+00          1  0e+00  0  0  0  0  0e+00
## L3   -1.00e+00          1  0e+00  0  0  0  0  0e+00
## L4   -1.00e+00          1  0e+00  0  0  0  0  0e+00
## A6    1.00e+00         -1 -1e+00  1  0  0  0  0e+00
## S7    0.00e+00          0  0e+00  0  1  0  0  1e+04
## S8    0.00e+00          0  0e+00  0  0  1  0  1e+04
## S9    0.00e+00          0  0e+00  0  0  0  1  1e+04
## Z    -9.91e+08 1991000000  1e+09  0  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 6"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 24"
## [1] "Pivot row: 6"
## [1] "New tableau at the end of iteration 6"
##         t1'   t1''    t2'   t2''      t3'     t3''     t4    xt5     t6  t7  t8
## t11'  0e+00  0e+00  0e+00  0e+00 -2.0e-05  2.0e-05      0  0e+00  0e+00   0   0
## L1    1e-05 -1e-05  0e+00  0e+00 -2.0e-05  2.0e-05     -1  0e+00  0e+00   0   0
## t10   2e-05 -2e-05  0e+00  0e+00 -2.0e-05  2.0e-05      0  0e+00  0e+00   0   0
## L3    0e+00  0e+00  1e-05 -1e-05 -2.0e-05  2.0e-05      0 -1e+00  0e+00   0   0
## L4    0e+00  0e+00  2e-05 -2e-05 -2.0e-05  2.0e-05      0  0e+00  0e+00   0   0
## L5    0e+00  0e+00  0e+00  0e+00 -1.0e-05  1.0e-05      0  0e+00 -1e+00   0   0
## S7   -1e+00  1e+00  0e+00  0e+00  0.0e+00  0.0e+00      0  0e+00  0e+00  -1   0
## S8    0e+00  0e+00 -1e+00  1e+00  0.0e+00  0.0e+00      0  0e+00  0e+00   0  -1
## S9    0e+00  0e+00  0e+00  0e+00 -1.0e+00  1.0e+00      0  0e+00  0e+00   0   0
## Z     2e+01 -2e+01  0e+00  0e+00  1.8e+02 -1.8e+02 500000  1e+06  2e+06 100 100
##       t9 t10 t11' t11'' L1     A1    L2        A2 L3     A3 L4     A4 L5     A5
## t11'   0   0    1    -1  0  0e+00 0e+00         0  0  0e+00  0  0e+00  0  0e+00
## L1     0   0    0     0  1 -1e+00 0e+00         0  0  0e+00  0  0e+00  0  0e+00
## t10    0   1    0     0  0  0e+00 1e+00        -1  0  0e+00  0  0e+00  0  0e+00
## L3     0   0    0     0  0  0e+00 0e+00         0  1 -1e+00  0  0e+00  0  0e+00
## L4     0   0    0     0  0  0e+00 0e+00         0  0  0e+00  1 -1e+00  0  0e+00
## L5     0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00  1 -1e+00
## S7     0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00  0  0e+00
## S8     0   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00  0  0e+00
## S9    -1   0    0     0  0  0e+00 0e+00         0  0  0e+00  0  0e+00  0  0e+00
## Z    100   0    0     0  0  1e+09 1e+06 999000000  0  1e+09  0  1e+09  0  1e+09
##          L6       A6 S7 S8 S9      b
## t11' -1e+00 1.00e+00  0  0  0  1e+00
## L1   -1e+00 1.00e+00  0  0  0  0e+00
## t10  -1e+00 1.00e+00  0  0  0  0e+00
## L3   -1e+00 1.00e+00  0  0  0  0e+00
```

```
## L4   -1e+00 1.00e+00  0  0  0  0e+00
## L5   -1e+00 1.00e+00  0  0  0  0e+00
## S7    0e+00 0.00e+00  1  0  0  1e+04
## S8    0e+00 0.00e+00  0  1  0  1e+04
## S9    0e+00 0.00e+00  0  0  1  1e+04
## Z     9e+06 9.91e+08  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 7"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 6"
## [1] "Pivot row: 2"
## [1] "New tableau at the end of iteration 7"
##          t1'     t1''    t2'   t2'' t3' t3''       t4    xt5     t6  t7  t8
## t11' -1.0e-05  1.0e-05  0e+00  0e+00   0    0  1.0e+00  0e+00  0e+00   0   0
## t3''  5.0e-01 -5.0e-01  0e+00  0e+00  -1    1 -5.0e+04  0e+00  0e+00   0   0
## t10   1.0e-05 -1.0e-05  0e+00  0e+00   0    0  1.0e+00  0e+00  0e+00   0   0
## L3   -1.0e-05  1.0e-05  1e-05 -1e-05   0    0  1.0e+00 -1e+00  0e+00   0   0
## L4   -1.0e-05  1.0e-05  2e-05 -2e-05   0    0  1.0e+00  0e+00  0e+00   0   0
## L5    0.0e+00  0.0e+00  0e+00  0e+00   0    0  5.0e-01  0e+00 -1e+00   0   0
## S7   -1.0e+00  1.0e+00  0e+00  0e+00   0    0  0.0e+00  0e+00  0e+00  -1   0
## S8    0.0e+00  0.0e+00 -1e+00  1e+00   0    0  0.0e+00  0e+00  0e+00   0  -1
## S9   -5.0e-01  5.0e-01  0e+00  0e+00   0    0  5.0e+04  0e+00  0e+00   0   0
## Z     1.1e+02 -1.1e+02  0e+00  0e+00   0    0 -8.5e+06  1e+06  2e+06 100 100
##       t9 t10 t11' t11''     L1        A1    L2        A2 L3     A3 L4     A4 L5
## t11'   0   0    1    -1 -1e+00  1.00e+00 0e+00         0  0  0e+00  0  0e+00  0
## t3''   0   0    0     0  5e+04 -5.00e+04 0e+00         0  0  0e+00  0  0e+00  0
## t10    0   1    0     0 -1e+00  1.00e+00 1e+00        -1  0  0e+00  0  0e+00  0
## L3     0   0    0     0 -1e+00  1.00e+00 0e+00         0  1 -1e+00  0  0e+00  0
## L4     0   0    0     0 -1e+00  1.00e+00 0e+00         0  0  0e+00  1 -1e+00  0
## L5     0   0    0     0 -5e-01  5.00e-01 0e+00         0  0  0e+00  0  0e+00  1
## S7     0   0    0     0  0e+00  0.00e+00 0e+00         0  0  0e+00  0  0e+00  0
## S8     0   0    0     0  0e+00  0.00e+00 0e+00         0  0  0e+00  0  0e+00  0
## S9    -1   0    0     0 -5e+04  5.00e+04 0e+00         0  0  0e+00  0  0e+00  0
## Z    100   0    0     0  9e+06  9.91e+08 1e+06 999000000  0  1e+09  0  1e+09  0
##          A5     L6     A6 S7 S8 S9      b
## t11'  0e+00  0e+00  0e+00  0  0  0  1e+00
## t3''  0e+00 -5e+04  5e+04  0  0  0  0e+00
## t10   0e+00  0e+00  0e+00  0  0  0  0e+00
## L3    0e+00  0e+00  0e+00  0  0  0  0e+00
## L4    0e+00  0e+00  0e+00  0  0  0  0e+00
## L5   -1e+00 -5e-01  5e-01  0  0  0  0e+00
## S7    0e+00  0e+00  0e+00  1  0  0  1e+04
## S8    0e+00  0e+00  0e+00  0  1  0  1e+04
## S9    0e+00  5e+04 -5e+04  0  0  1  1e+04
## Z     1e+09  0e+00  1e+09  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 8"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 7"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 8"
##            t1'      t1''    t2'   t2'' t3' t3'' t4    xt5     t6  t7  t8  t9
## t11'  -0.00002  2.00e-05  0e+00  0e+00   0    0  0  0e+00  0e+00   0   0   0
## t3''   1.00000 -1.00e+00  0e+00  0e+00  -1    1  0  0e+00  0e+00   0   0   0
```

```
## t4     0.00001 -1.00e-05  0e+00  0e+00   0    0  1  0e+00  0e+00   0   0   0
## L3    -0.00002  2.00e-05  1e-05 -1e-05   0    0  0 -1e+00  0e+00   0   0   0
## L4    -0.00002  2.00e-05  2e-05 -2e-05   0    0  0  0e+00  0e+00   0   0   0
## L5    -0.00001  1.00e-05  0e+00  0e+00   0    0  0  0e+00 -1e+00   0   0   0
## S7    -1.00000  1.00e+00  0e+00  0e+00   0    0  0  0e+00  0e+00  -1   0   0
## S8     0.00000  0.00e+00 -1e+00  1e+00   0    0  0  0e+00  0e+00   0  -1   0
## S9    -1.00000  1.00e+00  0e+00  0e+00   0    0  0  0e+00  0e+00   0   0  -1
## Z    195.00000 -1.95e+02  0e+00  0e+00   0    0  0  1e+06  2e+06 100 100 100
##           t10 t11' t11''     L1        A1       L2         A2 L3     A3 L4
## t11' -1.0e+00    1    -1      0         0 -1.0e+00  1.000e+00  0  0e+00  0
## t3''  5.0e+04    0     0      0         0  5.0e+04 -5.000e+04  0  0e+00  0
## t4    1.0e+00    0     0     -1         1  1.0e+00 -1.000e+00  0  0e+00  0
## L3   -1.0e+00    0     0      0         0 -1.0e+00  1.000e+00  1 -1e+00  0
## L4   -1.0e+00    0     0      0         0 -1.0e+00  1.000e+00  0  0e+00  1
## L5   -5.0e-01    0     0      0         0 -5.0e-01  5.000e-01  0  0e+00  0
## S7    0.0e+00    0     0      0         0  0.0e+00  0.000e+00  0  0e+00  0
## S8    0.0e+00    0     0      0         0  0.0e+00  0.000e+00  0  0e+00  0
## S9   -5.0e+04    0     0      0         0 -5.0e+04  5.000e+04  0  0e+00  0
## Z     8.5e+06    0     0 500000 999500000  9.5e+06  9.905e+08  0  1e+09  0
##          A4 L5     A5     L6     A6 S7 S8 S9      b
## t11'  0e+00  0  0e+00  0e+00  0e+00  0  0  0  1e+00
## t3''  0e+00  0  0e+00 -5e+04  5e+04  0  0  0  0e+00
## t4    0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L3    0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L4   -1e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L5    0e+00  1 -1e+00 -5e-01  5e-01  0  0  0  0e+00
## S7    0e+00  0  0e+00  0e+00  0e+00  1  0  0  1e+04
## S8    0e+00  0  0e+00  0e+00  0e+00  0  1  0  1e+04
## S9    0e+00  0  0e+00  5e+04 -5e+04  0  0  1  1e+04
## Z     1e+09  0  1e+09  0e+00  1e+09  0  0  0 -1e+07
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 9"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 2"
## [1] "Pivot row: 4"
## [1] "New tableau at the end of iteration 9"
##      t1' t1''      t2'      t2'' t3' t3'' t4       xt5     t6  t7  t8  t9
## t11'   0    0 -0.00001   0.00001   0    0  0  1.00e+00  0e+00   0   0   0
## t3''   0    0  0.50000  -0.50000  -1    1  0 -5.00e+04  0e+00   0   0   0
## t4     0    0  0.00000   0.00000   0    0  1 -5.00e-01  0e+00   0   0   0
## t1''  -1    1  0.50000  -0.50000   0    0  0 -5.00e+04  0e+00   0   0   0
## L4     0    0  0.00001  -0.00001   0    0  0  1.00e+00  0e+00   0   0   0
## L5     0    0  0.00000   0.00000   0    0  0  5.00e-01 -1e+00   0   0   0
## S7     0    0 -0.50000   0.50000   0    0  0  5.00e+04  0e+00  -1   0   0
## S8     0    0 -1.00000   1.00000   0    0  0  0.00e+00  0e+00   0  -1   0
## S9     0    0 -0.50000   0.50000   0    0  0  5.00e+04  0e+00   0   0  -1
## Z      0    0 97.50000 -97.50000   0    0  0 -8.75e+06  2e+06 100 100 100
##           t10 t11' t11''     L1        A1       L2          A2        L3
## t11'  0.00e+00    1    -1      0         0  0.0e+00         0.0      -1.0
## t3''  0.00e+00    0     0      0         0  0.0e+00         0.0   50000.0
## t4    5.00e-01    0     0     -1         1  5.0e-01        -0.5       0.5
## t1'' -5.00e+04    0     0      0         0 -5.0e+04     50000.0   50000.0
## L4    0.00e+00    0     0      0         0  0.0e+00         0.0      -1.0
## L5    0.00e+00    0     0      0         0  0.0e+00         0.0      -0.5
```

```
## S7    5.00e+04    0     0      0         0  5.0e+04     -50000.0  -50000.0
## S8    0.00e+00    0     0      0         0  0.0e+00          0.0       0.0
## S9    0.00e+00    0     0      0         0  0.0e+00          0.0  -50000.0
## Z    -1.25e+06    0     0 500000 999500000 -2.5e+05 1000250000.0 9750000.0
##               A3 L4     A4 L5     A5     L6     A6 S7 S8 S9      b
## t11'         1.0  0  0e+00  0  0e+00  0e+00  0e+00  0  0  0  1e+00
## t3''    -50000.0  0  0e+00  0  0e+00 -5e+04  5e+04  0  0  0  0e+00
## t4         -0.5  0  0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## t1''    -50000.0  0  0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L4          1.0  1 -1e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L5          0.5  0  0e+00  1 -1e+00 -5e-01  5e-01  0  0  0  0e+00
## S7      50000.0  0  0e+00  0  0e+00  0e+00  0e+00  1  0  0  1e+04
## S8          0.0  0  0e+00  0  0e+00  0e+00  0e+00  0  1  0  1e+04
## S9      50000.0  0  0e+00  0  0e+00  5e+04 -5e+04  0  0  1  1e+04
## Z    990250000.0  0  1e+09  0  1e+09  0e+00  1e+09  0  0  0 -1e+07
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 10"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 8"
## [1] "Pivot row: 5"
## [1] "New tableau at the end of iteration 10"
##      t1' t1''       t2'      t2'' t3' t3'' t4 xt5     t6  t7  t8  t9       t10
## t11'   0    0  -0.00002  2.00e-05   0    0  0   0  0e+00   0   0   0  0.00e+00
## t3''   0    0   1.00000 -1.00e+00  -1    1  0   0  0e+00   0   0   0  0.00e+00
## t4     0    0   0.00001 -1.00e-05   0    0  1   0  0e+00   0   0   0  5.00e-01
## t1''  -1    1   1.00000 -1.00e+00   0    0  0   0  0e+00   0   0   0 -5.00e+04
## xt5    0    0   0.00001 -1.00e-05   0    0  0   1  0e+00   0   0   0  0.00e+00
## L5     0    0  -0.00001  1.00e-05   0    0  0   0 -1e+00   0   0   0  0.00e+00
## S7     0    0  -1.00000  1.00e+00   0    0  0   0  0e+00  -1   0   0  5.00e+04
## S8     0    0  -1.00000  1.00e+00   0    0  0   0  0e+00   0  -1   0  0.00e+00
## S9     0    0  -1.00000  1.00e+00   0    0  0   0  0e+00   0   0  -1  0.00e+00
## Z      0    0 185.00000 -1.85e+02   0    0  0   0  2e+06 100 100 100 -1.25e+06
##      t11' t11''     L1        A1       L2           A2     L3       A3
## t11'    1    -1      0         0  0.0e+00          0.0  0e+00 0.00e+00
## t3''    0     0      0         0  0.0e+00          0.0  0e+00 0.00e+00
## t4      0     0     -1         1  5.0e-01         -0.5  0e+00 0.00e+00
## t1''    0     0      0         0 -5.0e+04      50000.0  0e+00 0.00e+00
## xt5     0     0      0         0  0.0e+00          0.0 -1e+00 1.00e+00
## L5      0     0      0         0  0.0e+00          0.0  0e+00 0.00e+00
## S7      0     0      0         0  5.0e+04     -50000.0  0e+00 0.00e+00
## S8      0     0      0         0  0.0e+00          0.0  0e+00 0.00e+00
## S9      0     0      0         0  0.0e+00          0.0  0e+00 0.00e+00
## Z       0     0 500000 999500000 -2.5e+05 1000250000.0  1e+06 9.99e+08
##             L4          A4 L5     A5     L6     A6 S7 S8 S9      b
## t11'      -1.0         1.0  0  0e+00  0e+00  0e+00  0  0  0  1e+00
## t3''   50000.0    -50000.0  0  0e+00 -5e+04  5e+04  0  0  0  0e+00
## t4         0.5        -0.5  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## t1''   50000.0    -50000.0  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## xt5        1.0        -1.0  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L5        -0.5         0.5  1 -1e+00 -5e-01  5e-01  0  0  0  0e+00
## S7    -50000.0     50000.0  0  0e+00  0e+00  0e+00  1  0  0  1e+04
## S8         0.0         0.0  0  0e+00  0e+00  0e+00  0  1  0  1e+04
## S9    -50000.0     50000.0  0  0e+00  5e+04 -5e+04  0  0  1  1e+04
## Z    8750000.0 991250000.0  0  1e+09  0e+00  1e+09  0  0  0 -1e+07
```

```
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 11"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 13"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 11"
##      t1' t1''      t2'     t2'' t3' t3''      t4 xt5     t6  t7  t8  t9 t10
## t11'   0    0 -2.0e-05  2.0e-05   0    0       0   0  0e+00   0   0   0   0
## t3''   0    0  1.0e+00 -1.0e+00  -1    1       0   0  0e+00   0   0   0   0
## t10    0    0  2.0e-05 -2.0e-05   0    0       2   0  0e+00   0   0   0   1
## t1''  -1    1  2.0e+00 -2.0e+00   0    0  100000   0  0e+00   0   0   0   0
## xt5    0    0  1.0e-05 -1.0e-05   0    0       0   1  0e+00   0   0   0   0
## L5     0    0 -1.0e-05  1.0e-05   0    0       0   0 -1e+00   0   0   0   0
## S7     0    0 -2.0e+00  2.0e+00   0    0 -100000   0  0e+00  -1   0   0   0
## S8     0    0 -1.0e+00  1.0e+00   0    0       0   0  0e+00   0  -1   0   0
## S9     0    0 -1.0e+00  1.0e+00   0    0       0   0  0e+00   0   0  -1   0
## Z      0    0  2.1e+02 -2.1e+02   0    0 2500000   0  2e+06 100 100 100   0
##      t11' t11''     L1          A1    L2         A2     L3       A3     L4
## t11'    1    -1  0e+00           0 0e+00          0  0e+00 0.00e+00 -1e+00
## t3''    0     0  0e+00           0 0e+00          0  0e+00 0.00e+00  5e+04
## t10     0     0 -2e+00           2 1e+00         -1  0e+00 0.00e+00  1e+00
## t1''    0     0 -1e+05      100000 0e+00          0  0e+00 0.00e+00  1e+05
## xt5     0     0  0e+00           0 0e+00          0 -1e+00 1.00e+00  1e+00
## L5      0     0  0e+00           0 0e+00          0  0e+00 0.00e+00 -5e-01
## S7      0     0  1e+05    -100000 0e+00          0  0e+00 0.00e+00 -1e+05
## S8      0     0  0e+00           0 0e+00          0  0e+00 0.00e+00  0e+00
## S9      0     0  0e+00           0 0e+00          0  0e+00 0.00e+00 -5e+04
## Z       0     0 -2e+06 1002000000 1e+06 999000000  1e+06 9.99e+08  1e+07
##            A4 L5     A5     L6     A6 S7 S8 S9      b
## t11'  1.0e+00  0  0e+00  0e+00  0e+00  0  0  0  1e+00
## t3'' -5.0e+04  0  0e+00 -5e+04  5e+04  0  0  0  0e+00
## t10  -1.0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## t1'' -1.0e+05  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## xt5  -1.0e+00  0  0e+00  0e+00  0e+00  0  0  0  0e+00
## L5    5.0e-01  1 -1e+00 -5e-01  5e-01  0  0  0  0e+00
## S7    1.0e+05  0  0e+00  0e+00  0e+00  1  0  0  1e+04
## S8    0.0e+00  0  0e+00  0e+00  0e+00  0  1  0  1e+04
## S9    5.0e+04  0  0e+00  5e+04 -5e+04  0  0  1  1e+04
## Z     9.9e+08  0  1e+09  0e+00  1e+09  0  0  0 -1e+07
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 12"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 16"
## [1] "Pivot row: 7"
## [1] "New tableau at the end of iteration 12"
##      t1' t1''      t2'     t2'' t3' t3''     t4 xt5     t6     t7  t8  t9 t10
## t11'   0    0 -2.0e-05  2.0e-05   0    0      0   0  0e+00  0e+00   0   0   0
## t3''   0    0  1.0e+00 -1.0e+00  -1    1      0   0  0e+00  0e+00   0   0   0
## t10    0    0 -2.0e-05  2.0e-05   0    0      0   0  0e+00 -2e-05   0   0   1
## t1''  -1    1  0.0e+00  0.0e+00   0    0      0   0  0e+00 -1e+00   0   0   0
## xt5    0    0  1.0e-05 -1.0e-05   0    0      0   1  0e+00  0e+00   0   0   0
## L5     0    0 -1.0e-05  1.0e-05   0    0      0   0 -1e+00  0e+00   0   0   0
## L1     0    0 -2.0e-05  2.0e-05   0    0     -1   0  0e+00 -1e-05   0   0   0
## S8     0    0 -1.0e+00  1.0e+00   0    0      0   0  0e+00  0e+00  -1   0   0
```

```
## S9     0    0 -1.0e+00  1.0e+00   0    0      0   0  0e+00  0e+00   0  -1   0
## Z      0    0  1.7e+02 -1.7e+02   0    0 500000   0  2e+06  8e+01 100 100   0
##      t11' t11'' L1     A1    L2        A2     L3       A3     L4        A4 L5
## t11'    1    -1  0  0e+00 0e+00         0  0e+00 0.00e+00 -1e+00  1.00e+00  0
## t3''    0     0  0  0e+00 0e+00         0  0e+00 0.00e+00  5e+04 -5.00e+04  0
## t10     0     0  0  0e+00 1e+00        -1  0e+00 0.00e+00 -1e+00  1.00e+00  0
## t1''    0     0  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.00e+00  0
## xt5     0     0  0  0e+00 0e+00         0 -1e+00 1.00e+00  1e+00 -1.00e+00  0
## L5      0     0  0  0e+00 0e+00         0  0e+00 0.00e+00 -5e-01  5.00e-01  1
## L1      0     0  1 -1e+00 0e+00         0  0e+00 0.00e+00 -1e+00  1.00e+00  0
## S8      0     0  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.00e+00  0
## S9      0     0  0  0e+00 0e+00         0  0e+00 0.00e+00 -5e+04  5.00e+04  0
## Z       0     0  0  1e+09 1e+06 999000000  1e+06 9.99e+08  8e+06  9.92e+08  0
##          A5     L6     A6    S7 S8 S9        b
## t11'  0e+00  0e+00  0e+00 0e+00  0  0  1.0e+00
## t3''  0e+00 -5e+04  5e+04 0e+00  0  0  0.0e+00
## t10   0e+00  0e+00  0e+00 2e-05  0  0  2.0e-01
## t1''  0e+00  0e+00  0e+00 1e+00  0  0  1.0e+04
## xt5   0e+00  0e+00  0e+00 0e+00  0  0  0.0e+00
## L5   -1e+00 -5e-01  5e-01 0e+00  0  0  0.0e+00
## L1    0e+00  0e+00  0e+00 1e-05  0  0  1.0e-01
## S8    0e+00  0e+00  0e+00 0e+00  1  0  1.0e+04
## S9    0e+00  5e+04 -5e+04 0e+00  0  1  1.0e+04
## Z     1e+09  0e+00  1e+09 2e+01  0  0 -9.8e+06
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 13"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 4"
## [1] "Pivot row: 6"
## [1] "New tableau at the end of iteration 13"
##      t1' t1'' t2' t2'' t3' t3''     t4 xt5       t6     t7  t8  t9 t10 t11'
## t11'   0    0   0    0   0    0      0   0  2.0e+00  0e+00   0   0   0    1
## t3''   0    0   0    0  -1    1      0   0 -1.0e+05  0e+00   0   0   0    0
## t10    0    0   0    0   0    0      0   0  2.0e+00 -2e-05   0   0   1    0
## t1''  -1    1   0    0   0    0      0   0  0.0e+00 -1e+00   0   0   0    0
## xt5    0    0   0    0   0    0      0   1 -1.0e+00  0e+00   0   0   0    0
## t2''   0    0  -1    1   0    0      0   0 -1.0e+05  0e+00   0   0   0    0
## L1     0    0   0    0   0    0     -1   0  2.0e+00 -1e-05   0   0   0    0
## S8     0    0   0    0   0    0      0   0  1.0e+05  0e+00  -1   0   0    0
## S9     0    0   0    0   0    0      0   0  1.0e+05  0e+00   0  -1   0    0
## Z      0    0   0    0   0    0 500000   0 -1.5e+07  8e+01 100 100   0    0
##      t11'' L1     A1    L2        A2     L3       A3     L4          A4
## t11'    -1  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00
## t3''     0  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00
## t10      0  0  0e+00 1e+00        -1  0e+00 0.00e+00  0e+00  0.0000e+00
## t1''     0  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00
## xt5      0  0  0e+00 0e+00         0 -1e+00 1.00e+00  5e-01 -5.0000e-01
## t2''     0  0  0e+00 0e+00         0  0e+00 0.00e+00 -5e+04  5.0000e+04
## L1       0  1 -1e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00
## S8       0  0  0e+00 0e+00         0  0e+00 0.00e+00  5e+04 -5.0000e+04
## S9       0  0  0e+00 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00
## Z        0  0  1e+09 1e+06 999000000  1e+06 9.99e+08 -5e+05  1.0005e+09
##            L5        A5       L6          A6    S7 S8 S9        b
## t11'       -2         2  1.0e+00 -1.0000e+00 0e+00  0  0  1.0e+00
```

```
## t3''   100000   -100000 -1.0e+05  1.0000e+05 0e+00  0  0  0.0e+00
## t10        -2         2  1.0e+00 -1.0000e+00 2e-05  0  0  2.0e-01
## t1''        0         0  0.0e+00  0.0000e+00 1e+00  0  0  1.0e+04
## xt5         1        -1 -5.0e-01  5.0000e-01 0e+00  0  0  0.0e+00
## t2''   100000   -100000 -5.0e+04  5.0000e+04 0e+00  0  0  0.0e+00
## L1         -2         2  1.0e+00 -1.0000e+00 1e-05  0  0  1.0e-01
## S8    -100000    100000  5.0e+04 -5.0000e+04 0e+00  1  0  1.0e+04
## S9    -100000    100000  1.0e+05 -1.0000e+05 0e+00  0  1  1.0e+04
## Z    17000000 983000000 -8.5e+06  1.0085e+09 2e+01  0  0 -9.8e+06
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 14"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 9"
## [1] "Pivot row: 7"
## [1] "New tableau at the end of iteration 14"
##      t1' t1'' t2' t2'' t3' t3''     t4 xt5 t6     t7  t8  t9 t10 t11' t11''
## t11'   0    0   0    0   0    0  1e+00   0  0  1e-05   0   0   0    1    -1
## t3''   0    0   0    0  -1    1 -5e+04   0  0 -5e-01   0   0   0    0     0
## t10    0    0   0    0   0    0  1e+00   0  0 -1e-05   0   0   1    0     0
## t1''  -1    1   0    0   0    0  0e+00   0  0 -1e+00   0   0   0    0     0
## xt5    0    0   0    0   0    0 -5e-01   1  0  0e+00   0   0   0    0     0
## t2''   0    0  -1    1   0    0 -5e+04   0  0 -5e-01   0   0   0    0     0
## t6     0    0   0    0   0    0 -5e-01   0  1  0e+00   0   0   0    0     0
## S8     0    0   0    0   0    0  5e+04   0  0  5e-01  -1   0   0    0     0
## S9     0    0   0    0   0    0  5e+04   0  0  5e-01   0  -1   0    0     0
## Z      0    0   0    0   0    0 -7e+06   0  0  5e+00 100 100   0    0     0
##            L1          A1    L2         A2     L3       A3     L4          A4
## t11' -1.0e+00  1.000e+00 0e+00          0  0e+00 0.00e+00  0e+00  0.0000e+00
## t3''  5.0e+04 -5.000e+04 0e+00          0  0e+00 0.00e+00  0e+00  0.0000e+00
## t10  -1.0e+00  1.000e+00 1e+00         -1  0e+00 0.00e+00  0e+00  0.0000e+00
## t1''  0.0e+00  0.000e+00 0e+00          0  0e+00 0.00e+00  0e+00  0.0000e+00
## xt5   5.0e-01 -5.000e-01 0e+00          0 -1e+00 1.00e+00  5e-01 -5.0000e-01
## t2''  5.0e+04 -5.000e+04 0e+00          0  0e+00 0.00e+00 -5e+04  5.0000e+04
## t6    5.0e-01 -5.000e-01 0e+00          0  0e+00 0.00e+00  0e+00  0.0000e+00
## S8   -5.0e+04  5.000e+04 0e+00          0  0e+00 0.00e+00  5e+04 -5.0000e+04
## S9   -5.0e+04  5.000e+04 0e+00          0  0e+00 0.00e+00  0e+00  0.0000e+00
## Z     7.5e+06  9.925e+08 1e+06 999000000  1e+06 9.99e+08 -5e+05  1.0005e+09
##          L5       A5     L6          A6       S7 S8 S9         b
## t11'  0e+00 0.00e+00  0e+00  0.000e+00 -0.00001  0  0  9.00e-01
## t3''  0e+00 0.00e+00 -5e+04  5.000e+04  0.50000  0  0  5.00e+03
## t10   0e+00 0.00e+00  0e+00  0.000e+00  0.00001  0  0  1.00e-01
## t1''  0e+00 0.00e+00  0e+00  0.000e+00  1.00000  0  0  1.00e+04
## xt5   0e+00 0.00e+00  0e+00  0.000e+00  0.00000  0  0  5.00e-02
## t2''  0e+00 0.00e+00  0e+00  0.000e+00  0.50000  0  0  5.00e+03
## t6   -1e+00 1.00e+00  5e-01 -5.000e-01  0.00000  0  0  5.00e-02
## S8    0e+00 0.00e+00  0e+00  0.000e+00 -0.50000  1  0  5.00e+03
## S9    0e+00 0.00e+00  5e+04 -5.000e+04 -0.50000  0  1  5.00e+03
## Z     2e+06 9.98e+08 -1e+06  1.001e+09 95.00000  0  0 -9.05e+06
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 15"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 7"
## [1] "Pivot row: 9"
## [1] "New tableau at the end of iteration 15"
```

```
##      t1' t1'' t2' t2'' t3' t3'' t4 xt5 t6       t7  t8     t9 t10 t11' t11''
## t11'   0    0   0    0   0    0  0   0  0  0.00000   0  2e-05   0    1    -1
## t3''   0    0   0    0  -1    1  0   0  0  0.00000   0 -1e+00   0    0     0
## t10    0    0   0    0   0    0  0   0  0 -0.00002   0  2e-05   1    0     0
## t1''  -1    1   0    0   0    0  0   0  0 -1.00000   0  0e+00   0    0     0
## xt5    0    0   0    0   0    0  0   1  0  0.00000   0 -1e-05   0    0     0
## t2''   0    0  -1    1   0    0  0   0  0  0.00000   0 -1e+00   0    0     0
## t6     0    0   0    0   0    0  0   0  1  0.00000   0 -1e-05   0    0     0
## S8     0    0   0    0   0    0  0   0  0  0.00000  -1  1e+00   0    0     0
## t4     0    0   0    0   0    0  1   0  0  0.00001   0 -2e-05   0    0     0
## Z      0    0   0    0   0    0  0   0  0 75.00000 100 -4e+01   0    0     0
##          L1        A1    L2        A2     L3       A3     L4          A4     L5
## t11'      0         0 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00  0e+00
## t3''      0         0 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00  0e+00
## t10       0         0 1e+00        -1  0e+00 0.00e+00  0e+00  0.0000e+00  0e+00
## t1''      0         0 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00  0e+00
## xt5       0         0 0e+00         0 -1e+00 1.00e+00  5e-01 -5.0000e-01  0e+00
## t2''      0         0 0e+00         0  0e+00 0.00e+00 -5e+04  5.0000e+04  0e+00
## t6        0         0 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00 -1e+00
## S8        0         0 0e+00         0  0e+00 0.00e+00  5e+04 -5.0000e+04  0e+00
## t4       -1         1 0e+00         0  0e+00 0.00e+00  0e+00  0.0000e+00  0e+00
## Z    500000 999500000 1e+06 999000000  1e+06 9.99e+08 -5e+05  1.0005e+09  2e+06
##             A5     L6        A6       S7 S8       S9         b
## t11' 0.00e+00 -1e+00  1.00e+00  0.00000  0 -2.0e-05  8.00e-01
## t3'' 0.00e+00  0e+00  0.00e+00  0.00000  0  1.0e+00  1.00e+04
## t10  0.00e+00 -1e+00  1.00e+00  0.00002  0 -2.0e-05  0.00e+00
## t1'' 0.00e+00  0e+00  0.00e+00  1.00000  0  0.0e+00  1.00e+04
## xt5  0.00e+00  5e-01 -5.00e-01  0.00000  0  1.0e-05  1.00e-01
## t2'' 0.00e+00  5e+04 -5.00e+04  0.00000  0  1.0e+00  1.00e+04
## t6   1.00e+00  1e+00 -1.00e+00  0.00000  0  1.0e-05  1.00e-01
## S8   0.00e+00 -5e+04  5.00e+04  0.00000  1 -1.0e+00  0.00e+00
## t4   0.00e+00  1e+00 -1.00e+00 -0.00001  0  2.0e-05  1.00e-01
## Z    9.98e+08  6e+06  9.94e+08 25.00000  0  1.4e+02 -8.35e+06
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 16"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 22"
## [1] "Pivot row: 8"
## [1] "New tableau at the end of iteration 16"
##      t1' t1'' t2' t2'' t3' t3'' t4 xt5 t6       t7     t8     t9 t10 t11' t11''
## t11'   0    0   0    0   0    0  0   0  0  0.00000  0e+00  2e-05   0    1    -1
## t3''   0    0   0    0  -1    1  0   0  0  0.00000  0e+00 -1e+00   0    0     0
## t10    0    0   0    0   0    0  0   0  0 -0.00002  0e+00  2e-05   1    0     0
## t1''  -1    1   0    0   0    0  0   0  0 -1.00000  0e+00  0e+00   0    0     0
## xt5    0    0   0    0   0    0  0   1  0  0.00000  1e-05 -2e-05   0    0     0
## t2''   0    0  -1    1   0    0  0   0  0  0.00000 -1e+00  0e+00   0    0     0
## t6     0    0   0    0   0    0  0   0  1  0.00000  0e+00 -1e-05   0    0     0
## L4     0    0   0    0   0    0  0   0  0  0.00000 -2e-05  2e-05   0    0     0
## t4     0    0   0    0   0    0  1   0  0  0.00001  0e+00 -2e-05   0    0     0
## Z      0    0   0    0   0    0  0   0  0 75.00000  9e+01 -3e+01   0    0     0
##          L1        A1    L2        A2     L3       A3 L4     A4     L5       A5
## t11'      0         0 0e+00         0  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
## t3''      0         0 0e+00         0  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
## t10       0         0 1e+00        -1  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
```

```
## t1''      0         0 0e+00         0  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
## xt5       0         0 0e+00         0 -1e+00 1.00e+00  0  0e+00  0e+00 0.00e+00
## t2''      0         0 0e+00         0  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
## t6        0         0 0e+00         0  0e+00 0.00e+00  0  0e+00 -1e+00 1.00e+00
## L4        0         0 0e+00         0  0e+00 0.00e+00  1 -1e+00  0e+00 0.00e+00
## t4       -1         1 0e+00         0  0e+00 0.00e+00  0  0e+00  0e+00 0.00e+00
## Z    500000 999500000 1e+06 999000000  1e+06 9.99e+08  0  1e+09  2e+06 9.98e+08
##           L6        A6       S7     S8       S9         b
## t11'      -1         1  0.00000  0e+00 -2.0e-05  8.00e-01
## t3''       0         0  0.00000  0e+00  1.0e+00  1.00e+04
## t10       -1         1  0.00002  0e+00 -2.0e-05  0.00e+00
## t1''       0         0  1.00000  0e+00  0.0e+00  1.00e+04
## xt5        1        -1  0.00000 -1e-05  2.0e-05  1.00e-01
## t2''       0         0  0.00000  1e+00  0.0e+00  1.00e+04
## t6         1        -1  0.00000  0e+00  1.0e-05  1.00e-01
## L4        -1         1  0.00000  2e-05 -2.0e-05  0.00e+00
## t4         1        -1 -0.00001  0e+00  2.0e-05  1.00e-01
## Z    5500000 994500000 25.00000  1e+01  1.3e+02 -8.35e+06
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 17"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 12"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 17"
##      t1' t1'' t2' t2'' t3' t3'' t4 xt5 t6       t7     t8 t9      t10 t11'
## t11'   0    0   0    0   0    0  0   0  0  0.00002  0e+00  0 -1.0e+00    1
## t3''   0    0   0    0  -1    1  0   0  0 -1.00000  0e+00  0  5.0e+04    0
## t9     0    0   0    0   0    0  0   0  0 -1.00000  0e+00  1  5.0e+04    0
## t1''  -1    1   0    0   0    0  0   0  0 -1.00000  0e+00  0  0.0e+00    0
## xt5    0    0   0    0   0    0  0   1  0 -0.00002  1e-05  0  1.0e+00    0
## t2''   0    0  -1    1   0    0  0   0  0  0.00000 -1e+00  0  0.0e+00    0
## t6     0    0   0    0   0    0  0   0  1 -0.00001  0e+00  0  5.0e-01    0
## L4     0    0   0    0   0    0  0   0  0  0.00002 -2e-05  0 -1.0e+00    0
## t4     0    0   0    0   0    0  1   0  0 -0.00001  0e+00  0  1.0e+00    0
## Z      0    0   0    0   0    0  0   0  0 45.00000  9e+01  0  1.5e+06    0
##      t11''     L1        A1       L2          A2     L3       A3 L4     A4
## t11'    -1      0         0 -1.0e+00  1.000e+00  0e+00 0.00e+00  0  0e+00
## t3''     0      0         0  5.0e+04 -5.000e+04  0e+00 0.00e+00  0  0e+00
## t9       0      0         0  5.0e+04 -5.000e+04  0e+00 0.00e+00  0  0e+00
## t1''     0      0         0  0.0e+00  0.000e+00  0e+00 0.00e+00  0  0e+00
## xt5      0      0         0  1.0e+00 -1.000e+00 -1e+00 1.00e+00  0  0e+00
## t2''     0      0         0  0.0e+00  0.000e+00  0e+00 0.00e+00  0  0e+00
## t6       0      0         0  5.0e-01 -5.000e-01  0e+00 0.00e+00  0  0e+00
## L4       0      0         0 -1.0e+00  1.000e+00  0e+00 0.00e+00  1 -1e+00
## t4       0     -1         1  1.0e+00 -1.000e+00  0e+00 0.00e+00  0  0e+00
## Z        0 500000 999500000  2.5e+06  9.975e+08  1e+06 9.99e+08  0  1e+09
##          L5       A5     L6        A6       S7     S8  S9         b
## t11'  0e+00 0.00e+00  0e+00  0.00e+00 -0.00002  0e+00   0  8.00e-01
## t3''  0e+00 0.00e+00 -5e+04  5.00e+04  1.00000  0e+00   0  1.00e+04
## t9    0e+00 0.00e+00 -5e+04  5.00e+04  1.00000  0e+00  -1  0.00e+00
## t1''  0e+00 0.00e+00  0e+00  0.00e+00  1.00000  0e+00   0  1.00e+04
## xt5   0e+00 0.00e+00  0e+00  0.00e+00  0.00002 -1e-05   0  1.00e-01
## t2''  0e+00 0.00e+00  0e+00  0.00e+00  0.00000  1e+00   0  1.00e+04
## t6   -1e+00 1.00e+00  5e-01 -5.00e-01  0.00001  0e+00   0  1.00e-01
```

```
## L4    0e+00 0.00e+00  0e+00  0.00e+00 -0.00002  2e-05   0  0.00e+00
## t4    0e+00 0.00e+00  0e+00  0.00e+00  0.00001  0e+00   0  1.00e-01
## Z     2e+06 9.98e+08  4e+06  9.96e+08 55.00000  1e+01 100 -8.35e+06
## [1] "------------------------------------------------------------------------"
## [1] "Status: End"
## [1] "------------------------------------------------------------------------"

##      t1' t1'' t2' t2'' t3' t3'' t4 xt5 t6       t7     t8 t9      t10 t11'
## t11'   0    0   0    0   0    0  0   0  0  0.00002  0e+00  0 -1.0e+00    1
## t3''   0    0   0    0  -1    1  0   0  0 -1.00000  0e+00  0  5.0e+04    0
## t9     0    0   0    0   0    0  0   0  0 -1.00000  0e+00  1  5.0e+04    0
## t1''  -1    1   0    0   0    0  0   0  0 -1.00000  0e+00  0  0.0e+00    0
## xt5    0    0   0    0   0    0  0   1  0 -0.00002  1e-05  0  1.0e+00    0
## t2''   0    0  -1    1   0    0  0   0  0  0.00000 -1e+00  0  0.0e+00    0
## t6     0    0   0    0   0    0  0   0  1 -0.00001  0e+00  0  5.0e-01    0
## L4     0    0   0    0   0    0  0   0  0  0.00002 -2e-05  0 -1.0e+00    0
## t4     0    0   0    0   0    0  1   0  0 -0.00001  0e+00  0  1.0e+00    0
## Z      0    0   0    0   0    0  0   0  0 45.00000  9e+01  0  1.5e+06    0
##      t11''     L1        A1       L2         A2     L3       A3 L4     A4
## t11'    -1      0         0 -1.0e+00  1.000e+00  0e+00 0.00e+00  0  0e+00
## t3''     0      0         0  5.0e+04 -5.000e+04  0e+00 0.00e+00  0  0e+00
## t9       0      0         0  5.0e+04 -5.000e+04  0e+00 0.00e+00  0  0e+00
## t1''     0      0         0  0.0e+00  0.000e+00  0e+00 0.00e+00  0  0e+00
## xt5      0      0         0  1.0e+00 -1.000e+00 -1e+00 1.00e+00  0  0e+00
## t2''     0      0         0  0.0e+00  0.000e+00  0e+00 0.00e+00  0  0e+00
## t6       0      0         0  5.0e-01 -5.000e-01  0e+00 0.00e+00  0  0e+00
## L4       0      0         0 -1.0e+00  1.000e+00  0e+00 0.00e+00  1 -1e+00
## t4       0     -1         1  1.0e+00 -1.000e+00  0e+00 0.00e+00  0  0e+00
## Z        0 500000 999500000  2.5e+06  9.975e+08  1e+06 9.99e+08  0  1e+09
##          L5       A5     L6        A6       S7     S8  S9         b
## t11'  0e+00 0.00e+00  0e+00  0.00e+00 -0.00002  0e+00   0  8.00e-01
## t3''  0e+00 0.00e+00 -5e+04  5.00e+04  1.00000  0e+00   0  1.00e+04
## t9    0e+00 0.00e+00 -5e+04  5.00e+04  1.00000  0e+00  -1  0.00e+00
## t1''  0e+00 0.00e+00  0e+00  0.00e+00  1.00000  0e+00   0  1.00e+04
## xt5   0e+00 0.00e+00  0e+00  0.00e+00  0.00002 -1e-05   0  1.00e-01
## t2''  0e+00 0.00e+00  0e+00  0.00e+00  0.00000  1e+00   0  1.00e+04
## t6   -1e+00 1.00e+00  5e-01 -5.00e-01  0.00001  0e+00   0  1.00e-01
## L4    0e+00 0.00e+00  0e+00  0.00e+00 -0.00002  2e-05   0  0.00e+00
## t4    0e+00 0.00e+00  0e+00  0.00e+00  0.00001  0e+00   0  1.00e-01
## Z     2e+06 9.98e+08  4e+06  9.96e+08 55.00000  1e+01 100 -8.35e+06
```

———————————————- Question 5C ———————————————

#12 ## Build and show question 5C

This is where you insert question 5C: - Change the 'min_max_5c', 'Number_of_constraints_5c' and 'Number_of_variables_5c' variables. - Change the coefficients of the objective function in the 'objective_coefs_5c' variable. - Add all your constraints using 'add.constraint()'. - Give names to your constraints and your decision variables in 'RowNames_5c' and 'ColNames_5c'.

```
### ------ Create the model ------ ###

min_max_5c <- 1  # -1 = minimum problem, 1 = maximum problem
Number_of_constraints_5c <- 11  # Change to the number of constraints
Number_of_variables_5c <- 9  # Change to the number of variables

lp_5c_model <- make.lp(0, Number_of_variables_5c)

### ------ Set the objective function ------ ###

objective_coefs_5c <- c(1, 1, 1, 1, 1, 1,-10000,-10000,-10000) # Fill the variables' coefficients in th
set.objfn(lp_5c_model, objective_coefs_5c)

### ------ Add all constraints ------ ###

add.constraint(lp_5c_model, c(-0.00001, -0.000015, 0, 0, 0, 0,1,0,0), "=", 0)
add.constraint(lp_5c_model, c(0, 0, -0.00001, -0.000015, 0, 0,0,1,0), "=", 0)
add.constraint(lp_5c_model , c(0, 0, 0, 0, -0.00001, -0.000015,0,0,1), "=", 0)
add.constraint(lp_5c_model, c(1, 0, 0, 0, 0, 0,0,0,0), "<=", 500000)
add.constraint(lp_5c_model, c(0, 0, 1, 0, 0, 0,0,0,0), "<=", 1000000)
add.constraint(lp_5c_model, c(0, 0, 0, 0, 1, 0,0,0,0), "<=", 1000000)
add.constraint(lp_5c_model, c(0, 0, 0, 0, 0, 0,1,0,0), "<=", 120)
add.constraint(lp_5c_model, c(0, 0, 0, 0, 0, 0,0,1,0), "<=", 120)
add.constraint(lp_5c_model, c(0, 0, 0, 0, 0, 0,0,0,1), "<=", 120)
add.constraint(lp_5c_model, c(0, 1, 0, 1, 0, 1,0,0,0), ">=", 4000000)
add.constraint(lp_5c_model, c(1, 1, 1, 1, 1, 1,0,0,0), "=", 10000000)

### ------ Set the names of the constraints and variables ------ ###

RowNames_5c <- c("st1", "st2", "st3", "st4", "st5", "st6", "st7", "st8", "st9","st10","st11") # Give na
ColNames_5c <- c("x11", "X21", "X12", "X22", "X13", "X23","y1","y2","y3") # Give names to the variables
dimnames(lp_5c_model) <- list(RowNames_5c, ColNames_5c) # Assign constraints and variables names

### ------ Show and solve the model ------ ###

if (min_max_5c == 1){
  l <- lp.control(lp_5c_model, sense = "max")
}

lp_5c_model # Show the model
```

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

```
print("The solution's code is: ")
```

```
## [1] "The solution's code is: "
```

```
solve(lp_5c_model) # Solve the linear problem
```

```
## [1] 0
```

Status Codes: 0: “optimal solution found” 1: “the model is sub-optimal” 2: “the model is infeasible” 3: “the model is unbounded” 4: “the model is degenerate” 5: “numerical failure encountered” 6: “process aborted” 7: “timeout”

#13 ## Show the solution of question 5C

```
### -------- Set the coefs matrix (A) and the constraints relations - don't change! -------- ###

c_5c <-  objective_coefs_5c  # Get objective function coefficients
b_5c <-  get.rhs(lp_5c_model) # Get RHS
A_5c <- matrix(nrow = Number_of_constraints_5c, ncol = Number_of_variables_5c, byrow = TRUE) # Initiali
relations_5c <- c() # Constraints directions

for (i in 1 :Number_of_constraints_5c){
  for (j in 1 :Number_of_variables_5c){
    A_5c[i,j] <- get.mat(lp_5c_model,i,j)
  }
  relations_5c <- append(relations_5c, get.constr.type(lp_5c_model, i))
}

### -------- Find S_star -------- ###

tab_5c <- simplexR(A_5c, b_5c, c_5c, sense = min_max_5c, relation = relations_5c, Col_Names = ColNames_5
s_star_5c <- matrix(nrow = Number_of_constraints_5c, ncol = Number_of_constraints_5c, byrow = TRUE)
ind = 1
for (i in 1:dim(tab_5c)[2]){
  if (grepl("A", colnames(tab_5c)[i], fixed = TRUE) || (grepl("S", colnames(tab_5c)[i], fixed = TRUE))){
    s_star_5c[ , ind] <- tab_5c[1:Number_of_constraints_5c, i]
    ind <- ind + 1
  }
}


Show_Solution(lp_5c_model, Number_of_variables_5c, Number_of_constraints_5c, objective_coefs_5c, ColNam
```

```
## [1] "The number of iterations was:  11"
## [1] "-------------------------------------------------------------------------"
## [1] "The optimal solution is:  8625000"
## [1] "-------------------------------------------------------------------------"
## [1] "                                                                         "
## [1] "The optimal values of the decision variables and their reduced costs are:"
## [1] "                                                                         "
##     Optimal Value Reduced Cost
## x11      500000.0            0
## X21     7500000.0            0
## X12     1000000.0            0
## X22           0.0            0
## X13     1000000.0            0
## X23           0.0            0
## y1          117.5            0
## y2           10.0            0
## y3           10.0            0
## [1] "                                                                         "
## [1] "The optimal values of the Slacks and their dual prices are:"
```

```
## [1] "                                                                                "
##     Optimal Value Dual Price
## A1        0.0e+00   -1.0e+04
## A2        0.0e+00   -1.0e+04
## A3        0.0e+00   -1.0e+04
## S4        0.0e+00    5.0e-02
## S5        0.0e+00    5.0e-02
## S6        0.0e+00    5.0e-02
## S7        2.5e+00    0.0e+00
## S8        1.1e+02    0.0e+00
## S9        1.1e+02    0.0e+00
## L10       3.5e+06    0.0e+00
## A11       0.0e+00    8.5e-01
## [1] "--------------------------------------------------------------------------------"
## [1] "                                                                                "
## [1] "Ranges In Which The Basis Is Unchanged:"
## [1] "                                                                                "
## [1] "Ranges Of Objective Function Coefficients:"
## [1] "                                                                                "
##     Current Coef Coef From     Coef Till
## x11            1   9.5e-01  1.000000e+30
## X21            1   1.0e+00  1.050000e+00
## X12            1   9.5e-01  1.000000e+30
## X22            1  -1.0e+30  1.000000e+00
## X13            1   9.5e-01  1.000000e+30
## X23            1  -1.0e+30  1.000000e+00
## y1        -10000  -1.0e+04 -6.666667e+03
## y2        -10000  -1.5e+04 -1.000000e+04
## y3        -10000  -1.5e+04 -1.000000e+04
## [1] "                                                                                "
## [1] "Ranges Of RHS:"
## [1] "                                                                                "
##       Current RHS RHS From RHS Till
##  [1,]     0.0e+00      -80  4.0e+01
##  [2,]     0.0e+00      -10  1.1e+02
##  [3,]     0.0e+00      -10  1.1e+02
##  [4,]     5.0e+05        0  4.0e+06
##  [5,]     1.0e+06        0  4.5e+06
##  [6,]     1.0e+06        0  4.5e+06
##  [7,]     1.2e+02       80  1.2e+02
##  [8,]     1.2e+02       10  1.2e+02
##  [9,]     1.2e+02       10  1.2e+02
## [10,]     4.0e+06  4000000  7.5e+06
## [11,]     1.0e+07  6500000  1.4e+07
```

#14 ## Show the simplex tables of the dual problem - Run but do not change.

**** If you have a minimum problem - multiply the optimal solution by (-1)! ****

```
### -------- Show simplex tables -------- ###

simplexR(A_5c, b_5c, c_5c, sense = min_max_5c, relation = relations_5c, Col_Names = ColNames_5c, p_flag
```

```
## [1] "Start constructing Simplex Tableau"
```

```
## [1] "Tableau constructed"
## [1] "Artificial variable 'A' added at column  10 and row  1  -> phase I algorithm required"
## [2] "Artificial variable 'A' added at column  11 and row  2  -> phase I algorithm required"
## [3] "Artificial variable 'A' added at column  12 and row  3  -> phase I algorithm required"
## [4] "Artificial variable 'A' added at column  20 and row  10  -> phase I algorithm required"
## [5] "Artificial variable 'A' added at column  21 and row  11  -> phase I algorithm required"
## [1] "BigM-method is used, with bigM = 1e+09"
## [1] "Initial Tableau (Tableau 0)"
##             x11           X21         X12           X22         X13
## A1  -1.0000e-05 -1.000000e-05  0.0000e+00  0.000000e+00  0.0000e+00
## A2   0.0000e+00  0.000000e+00 -1.0000e-05 -1.000000e-05  0.0000e+00
## A3   0.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00 -1.0000e-05
## S4   1.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00  0.0000e+00
## S5   0.0000e+00  0.000000e+00  1.0000e+00  0.000000e+00  0.0000e+00
## S6   0.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00  1.0000e+00
## S7   0.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00  0.0000e+00
## S8   0.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00  0.0000e+00
## S9   0.0000e+00  0.000000e+00  0.0000e+00  0.000000e+00  0.0000e+00
## A10  0.0000e+00  1.000000e+00  0.0000e+00  1.000000e+00  0.0000e+00
## A11  1.0000e+00  1.000000e+00  1.0000e+00  1.000000e+00  1.0000e+00
## Z   -9.9999e+08 -1.999985e+09 -9.9999e+08 -1.999985e+09 -9.9999e+08
##              X23         y1         y2         y3 A1 A2 A3 S4 S5 S6 S7 S8 S9
## A1   0.000000e+00          1          0          0  1  0  0  0  0  0  0  0  0
## A2   0.000000e+00          0          1          0  0  1  0  0  0  0  0  0  0
## A3  -1.000000e-05          0          0          1  0  0  1  0  0  0  0  0  0
## S4   0.000000e+00          0          0          0  0  0  0  1  0  0  0  0  0
## S5   0.000000e+00          0          0          0  0  0  0  0  1  0  0  0  0
## S6   0.000000e+00          0          0          0  0  0  0  0  0  1  0  0  0
## S7   0.000000e+00          1          0          0  0  0  0  0  0  0  1  0  0
## S8   0.000000e+00          0          1          0  0  0  0  0  0  0  0  1  0
## S9   0.000000e+00          0          0          1  0  0  0  0  0  0  0  0  1
## A10  1.000000e+00          0          0          0  0  0  0  0  0  0  0  0  0
## A11  1.000000e+00          0          0          0  0  0  0  0  0  0  0  0  0
## Z   -1.999985e+09 -999990000 -999990000 -999990000  0  0  0  0  0  0  0  0  0
##        L10 A10 A11        b
## A1   0e+00   0   0  0.0e+00
## A2   0e+00   0   0  0.0e+00
## A3   0e+00   0   0  0.0e+00
## S4   0e+00   0   0  5.0e+05
## S5   0e+00   0   0  1.0e+06
## S6   0e+00   0   0  1.0e+06
## S7   0e+00   0   0  1.2e+02
## S8   0e+00   0   0  1.2e+02
## S9   0e+00   0   0  1.2e+02
## A10 -1e+00   1   0  4.0e+06
## A11  0e+00   0   1  1.0e+07
## Z    1e+09   0   0 -1.4e+16
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 1"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 2"
## [1] "Pivot row: 10"
## [1] "New tableau at the end of iteration 1"
##             x11 X21         X12    X22         X13    X23         y1         y2
```

```
## A1  -1.0000e-05   0  0.0000e+00  1e-05  0.0000e+00  1e-05          1          0
## A2   0.0000e+00   0 -1.0000e-05 -1e-05  0.0000e+00  0e+00          0          1
## A3   0.0000e+00   0  0.0000e+00  0e+00 -1.0000e-05 -1e-05          0          0
## S4   1.0000e+00   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          0
## S5   0.0000e+00   0  1.0000e+00  0e+00  0.0000e+00  0e+00          0          0
## S6   0.0000e+00   0  0.0000e+00  0e+00  1.0000e+00  0e+00          0          0
## S7   0.0000e+00   0  0.0000e+00  0e+00  0.0000e+00  0e+00          1          0
## S8   0.0000e+00   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          1
## S9   0.0000e+00   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          0
## X21  0.0000e+00   1  0.0000e+00  1e+00  0.0000e+00  1e+00          0          0
## A11  1.0000e+00   0  1.0000e+00  0e+00  1.0000e+00  0e+00          0          0
## Z   -9.9999e+08   0 -9.9999e+08  0e+00 -9.9999e+08  0e+00 -999990000 -999990000
##             y3 A1 A2 A3 S4 S5 S6 S7 S8 S9          L10           A10 A11
## A1           0  1  0  0  0  0  0  0  0  0 -1.00000e-05  1.000000e-05   0
## A2           0  0  1  0  0  0  0  0  0  0  0.00000e+00  0.000000e+00   0
## A3           1  0  0  1  0  0  0  0  0  0  0.00000e+00  0.000000e+00   0
## S4           0  0  0  0  1  0  0  0  0  0  0.00000e+00  0.000000e+00   0
## S5           0  0  0  0  0  1  0  0  0  0  0.00000e+00  0.000000e+00   0
## S6           0  0  0  0  0  0  1  0  0  0  0.00000e+00  0.000000e+00   0
## S7           0  0  0  0  0  0  0  1  0  0  0.00000e+00  0.000000e+00   0
## S8           0  0  0  0  0  0  0  0  1  0  0.00000e+00  0.000000e+00   0
## S9           1  0  0  0  0  0  0  0  0  1  0.00000e+00  0.000000e+00   0
## X21          0  0  0  0  0  0  0  0  0  0 -1.00000e+00  1.000000e+00   0
## A11          0  0  0  0  0  0  0  0  0  0  1.00000e+00 -1.000000e+00   1
## Z   -999990000  0  0  0  0  0  0  0  0  0 -9.99985e+08  1.999985e+09   0
##                b
## A1   6.00000e+01
## A2   0.00000e+00
## A3   0.00000e+00
## S4   5.00000e+05
## S5   1.00000e+06
## S6   1.00000e+06
## S7   1.20000e+02
## S8   1.20000e+02
## S9   1.20000e+02
## X21  4.00000e+06
## A11  6.00000e+06
## Z   -6.00006e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 2"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 1"
## [1] "Pivot row: 4"
## [1] "New tableau at the end of iteration 2"
##     x11 X21         X12    X22         X13    X23         y1         y2
## A1    0   0  0.0000e+00  1e-05  0.0000e+00  1e-05          1          0
## A2    0   0 -1.0000e-05 -1e-05  0.0000e+00  0e+00          0          1
## A3    0   0  0.0000e+00  0e+00 -1.0000e-05 -1e-05          0          0
## x11   1   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          0
## S5    0   0  1.0000e+00  0e+00  0.0000e+00  0e+00          0          0
## S6    0   0  0.0000e+00  0e+00  1.0000e+00  0e+00          0          0
## S7    0   0  0.0000e+00  0e+00  0.0000e+00  0e+00          1          0
## S8    0   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          1
## S9    0   0  0.0000e+00  0e+00  0.0000e+00  0e+00          0          0
```

```
## X21   0   1  0.0000e+00  1e+00  0.0000e+00  1e+00          0          0
## A11   0   0  1.0000e+00  0e+00  1.0000e+00  0e+00          0          0
## Z     0   0 -9.9999e+08  0e+00 -9.9999e+08  0e+00 -999990000 -999990000
##             y3 A1 A2 A3          S4 S5 S6 S7 S8 S9          L10           A10
## A1           0  1  0  0  1.0000e-05  0  0  0  0  0 -1.00000e-05  1.000000e-05
## A2           0  0  1  0  0.0000e+00  0  0  0  0  0  0.00000e+00  0.000000e+00
## A3           1  0  0  1  0.0000e+00  0  0  0  0  0  0.00000e+00  0.000000e+00
## x11          0  0  0  0  1.0000e+00  0  0  0  0  0  0.00000e+00  0.000000e+00
## S5           0  0  0  0  0.0000e+00  1  0  0  0  0  0.00000e+00  0.000000e+00
## S6           0  0  0  0  0.0000e+00  0  1  0  0  0  0.00000e+00  0.000000e+00
## S7           0  0  0  0  0.0000e+00  0  0  1  0  0  0.00000e+00  0.000000e+00
## S8           0  0  0  0  0.0000e+00  0  0  0  1  0  0.00000e+00  0.000000e+00
## S9           1  0  0  0  0.0000e+00  0  0  0  0  1  0.00000e+00  0.000000e+00
## X21          0  0  0  0  0.0000e+00  0  0  0  0  0 -1.00000e+00  1.000000e+00
## A11          0  0  0  0 -1.0000e+00  0  0  0  0  0  1.00000e+00 -1.000000e+00
## Z   -999990000  0  0  0  9.9999e+08  0  0  0  0  0 -9.99985e+08  1.999985e+09
##     A11             b
## A1    0  6.500000e+01
## A2    0  0.000000e+00
## A3    0  0.000000e+00
## x11   0  5.000000e+05
## S5    0  1.000000e+06
## S6    0  1.000000e+06
## S7    0  1.200000e+02
## S8    0  1.200000e+02
## S9    0  1.200000e+02
## X21   0  4.000000e+06
## A11   1  5.500000e+06
## Z     0 -5.500065e+15
## [1] "-------------------------------------------------------------------------"
## [1] "Iteration 3"
## [1] "-------------------------------------------------------------------------"
## [1] "Pivot column: 3"
## [1] "Pivot row: 5"
## [1] "New tableau at the end of iteration 3"
##     x11 X21 X12    X22          X13    X23          y1          y2          y3 A1
## A1    0   0   0  1e-05  0.0000e+00  1e-05           1           0           0  1
## A2    0   0   0 -1e-05  0.0000e+00  0e+00           0           1           0  0
## A3    0   0   0  0e+00 -1.0000e-05 -1e-05           0           0           1  0
## x11   1   0   0  0e+00  0.0000e+00  0e+00           0           0           0  0
## X12   0   0   1  0e+00  0.0000e+00  0e+00           0           0           0  0
## S6    0   0   0  0e+00  1.0000e+00  0e+00           0           0           0  0
## S7    0   0   0  0e+00  0.0000e+00  0e+00           1           0           0  0
## S8    0   0   0  0e+00  0.0000e+00  0e+00           0           1           0  0
## S9    0   0   0  0e+00  0.0000e+00  0e+00           0           0           1  0
## X21   0   1   0  1e+00  0.0000e+00  1e+00           0           0           0  0
## A11   0   0   0  0e+00  1.0000e+00  0e+00           0           0           0  0
## Z     0   0   0  0e+00 -9.9999e+08  0e+00 -999990000 -999990000 -999990000  0
##     A2 A3          S4          S5 S6 S7 S8 S9          L10           A10 A11
## A1   0  0  1.0000e-05  0.0000e+00  0  0  0  0 -1.00000e-05  1.000000e-05   0
## A2   1  0  0.0000e+00  1.0000e-05  0  0  0  0  0.00000e+00  0.000000e+00   0
## A3   0  1  0.0000e+00  0.0000e+00  0  0  0  0  0.00000e+00  0.000000e+00   0
## x11  0  0  1.0000e+00  0.0000e+00  0  0  0  0  0.00000e+00  0.000000e+00   0
## X12  0  0  0.0000e+00  1.0000e+00  0  0  0  0  0.00000e+00  0.000000e+00   0
```

```
## S6   0  0  0.0000e+00  0.0000e+00  1  0  0  0  0.00000e+00  0.000000e+00   0
## S7   0  0  0.0000e+00  0.0000e+00  0  1  0  0  0.00000e+00  0.000000e+00   0
## S8   0  0  0.0000e+00  0.0000e+00  0  0  1  0  0.00000e+00  0.000000e+00   0
## S9   0  0  0.0000e+00  0.0000e+00  0  0  0  1  0.00000e+00  0.000000e+00   0
## X21  0  0  0.0000e+00  0.0000e+00  0  0  0  0 -1.00000e+00  1.000000e+00   0
## A11  0  0 -1.0000e+00 -1.0000e+00  0  0  0  0  1.00000e+00 -1.000000e+00   1
## Z    0  0  9.9999e+08  9.9999e+08  0  0  0  0 -9.99985e+08  1.999985e+09   0
##                b
## A1   6.500000e+01
## A2   1.000000e+01
## A3   0.000000e+00
## x11  5.000000e+05
## X12  1.000000e+06
## S6   1.000000e+06
## S7   1.200000e+02
## S8   1.200000e+02
## S9   1.200000e+02
## X21  4.000000e+06
## A11  4.500000e+06
## Z   -4.500075e+15
## [1] "-------------------------------------------------------------------------"
## [1] "Iteration 4"
## [1] "-------------------------------------------------------------------------"
## [1] "Pivot column: 5"
## [1] "Pivot row: 6"
## [1] "New tableau at the end of iteration 4"
##     x11 X21 X12    X22 X13    X23         y1         y2         y3 A1 A2 A3
## A1    0   0   0  1e-05   0  1e-05          1          0          0  1  0  0
## A2    0   0   0 -1e-05   0  0e+00          0          1          0  0  1  0
## A3    0   0   0  0e+00   0 -1e-05          0          0          1  0  0  1
## x11   1   0   0  0e+00   0  0e+00          0          0          0  0  0  0
## X12   0   0   1  0e+00   0  0e+00          0          0          0  0  0  0
## X13   0   0   0  0e+00   1  0e+00          0          0          0  0  0  0
## S7    0   0   0  0e+00   0  0e+00          1          0          0  0  0  0
## S8    0   0   0  0e+00   0  0e+00          0          1          0  0  0  0
## S9    0   0   0  0e+00   0  0e+00          0          0          1  0  0  0
## X21   0   1   0  1e+00   0  1e+00          0          0          0  0  0  0
## A11   0   0   0  0e+00   0  0e+00          0          0          0  0  0  0
## Z     0   0   0  0e+00   0  0e+00 -999990000 -999990000 -999990000  0  0  0
##              S4          S5          S6 S7 S8 S9          L10           A10 A11
## A1   1.0000e-05  0.0000e+00  0.0000e+00  0  0  0 -1.00000e-05  1.000000e-05   0
## A2   0.0000e+00  1.0000e-05  0.0000e+00  0  0  0  0.00000e+00  0.000000e+00   0
## A3   0.0000e+00  0.0000e+00  1.0000e-05  0  0  0  0.00000e+00  0.000000e+00   0
## x11  1.0000e+00  0.0000e+00  0.0000e+00  0  0  0  0.00000e+00  0.000000e+00   0
## X12  0.0000e+00  1.0000e+00  0.0000e+00  0  0  0  0.00000e+00  0.000000e+00   0
## X13  0.0000e+00  0.0000e+00  1.0000e+00  0  0  0  0.00000e+00  0.000000e+00   0
## S7   0.0000e+00  0.0000e+00  0.0000e+00  1  0  0  0.00000e+00  0.000000e+00   0
## S8   0.0000e+00  0.0000e+00  0.0000e+00  0  1  0  0.00000e+00  0.000000e+00   0
## S9   0.0000e+00  0.0000e+00  0.0000e+00  0  0  1  0.00000e+00  0.000000e+00   0
## X21  0.0000e+00  0.0000e+00  0.0000e+00  0  0  0 -1.00000e+00  1.000000e+00   0
## A11 -1.0000e+00 -1.0000e+00 -1.0000e+00  0  0  0  1.00000e+00 -1.000000e+00   1
## Z    9.9999e+08  9.9999e+08  9.9999e+08  0  0  0 -9.99985e+08  1.999985e+09   0
##                b
## A1   6.500000e+01
```

```
## A2   1.000000e+01
## A3   1.000000e+01
## x11  5.000000e+05
## X12  1.000000e+06
## X13  1.000000e+06
## S7   1.200000e+02
## S8   1.200000e+02
## S9   1.200000e+02
## X21  4.000000e+06
## A11  3.500000e+06
## Z   -3.500085e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 5"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 7"
## [1] "Pivot row: 1"
## [1] "New tableau at the end of iteration 5"
##     x11 X21 X12         X22 X13         X23 y1         y2         y3        A1
## y1    0   0   0     0.00001   0     0.00001  1          0          0         1
## A2    0   0   0    -0.00001   0     0.00000  0          1          0         0
## A3    0   0   0     0.00000   0    -0.00001  0          0          1         0
## x11   1   0   0     0.00000   0     0.00000  0          0          0         0
## X12   0   0   1     0.00000   0     0.00000  0          0          0         0
## X13   0   0   0     0.00000   1     0.00000  0          0          0         0
## S7    0   0   0    -0.00001   0    -0.00001  0          0          0        -1
## S8    0   0   0     0.00000   0     0.00000  0          1          0         0
## S9    0   0   0     0.00000   0     0.00000  0          0          1         0
## X21   0   1   0     1.00000   0     1.00000  0          0          0         0
## A11   0   0   0     0.00000   0     0.00000  0          0          0         0
## Z     0   0   0 14999.85000   0 14999.85000  0 -999990000 -999990000 999990000
##     A2 A3     S4          S5          S6 S7 S8 S9    L10    A10 A11
## y1   0  0  1e-05  0.0000e+00  0.0000e+00  0  0  0 -1e-05  1e-05   0
## A2   1  0  0e+00  1.0000e-05  0.0000e+00  0  0  0  0e+00  0e+00   0
## A3   0  1  0e+00  0.0000e+00  1.0000e-05  0  0  0  0e+00  0e+00   0
## x11  0  0  1e+00  0.0000e+00  0.0000e+00  0  0  0  0e+00  0e+00   0
## X12  0  0  0e+00  1.0000e+00  0.0000e+00  0  0  0  0e+00  0e+00   0
## X13  0  0  0e+00  0.0000e+00  1.0000e+00  0  0  0  0e+00  0e+00   0
## S7   0  0 -1e-05  0.0000e+00  0.0000e+00  1  0  0  1e-05 -1e-05   0
## S8   0  0  0e+00  0.0000e+00  0.0000e+00  0  1  0  0e+00  0e+00   0
## S9   0  0  0e+00  0.0000e+00  0.0000e+00  0  0  1  0e+00  0e+00   0
## X21  0  0  0e+00  0.0000e+00  0.0000e+00  0  0  0 -1e+00  1e+00   0
## A11  0  0 -1e+00 -1.0000e+00 -1.0000e+00  0  0  0  1e+00 -1e+00   1
## Z    0  0  1e+09  9.9999e+08  9.9999e+08  0  0  0 -1e+09  2e+09   0
##               b
## y1   6.50000e+01
## A2   1.00000e+01
## A3   1.00000e+01
## x11  5.00000e+05
## X12  1.00000e+06
## X13  1.00000e+06
## S7   5.50000e+01
## S8   1.20000e+02
## S9   1.20000e+02
## X21  4.00000e+06
```

```
## A11  3.50000e+06
## Z   -3.50002e+15
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 6"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 19"
## [1] "Pivot row: 11"
## [1] "New tableau at the end of iteration 6"
##     x11 X21 X12         X22 X13         X23 y1         y2         y3        A1
## y1    0   0   0     0.00001   0     0.00001  1          0          0         1
## A2    0   0   0    -0.00001   0     0.00000  0          1          0         0
## A3    0   0   0     0.00000   0    -0.00001  0          0          1         0
## x11   1   0   0     0.00000   0     0.00000  0          0          0         0
## X12   0   0   1     0.00000   0     0.00000  0          0          0         0
## X13   0   0   0     0.00000   1     0.00000  0          0          0         0
## S7    0   0   0    -0.00001   0    -0.00001  0          0          0        -1
## S8    0   0   0     0.00000   0     0.00000  0          1          0         0
## S9    0   0   0     0.00000   0     0.00000  0          0          1         0
## X21   0   1   0     1.00000   0     1.00000  0          0          0         0
## L10   0   0   0     0.00000   0     0.00000  0          0          0         0
## Z     0   0   0 14999.85000   0 14999.85000  0 -999990000 -999990000 999990000
##     A2 A3    S4          S5          S6 S7 S8 S9 L10    A10    A11
## y1   0  0  0.00    -0.00001    -0.00001  0  0  0   0  0e+00  1e-05
## A2   1  0  0.00     0.00001     0.00000  0  0  0   0  0e+00  0e+00
## A3   0  1  0.00     0.00000     0.00001  0  0  0   0  0e+00  0e+00
## x11  0  0  1.00     0.00000     0.00000  0  0  0   0  0e+00  0e+00
## X12  0  0  0.00     1.00000     0.00000  0  0  0   0  0e+00  0e+00
## X13  0  0  0.00     0.00000     1.00000  0  0  0   0  0e+00  0e+00
## S7   0  0  0.00     0.00001     0.00001  1  0  0   0  0e+00 -1e-05
## S8   0  0  0.00     0.00000     0.00000  0  1  0   0  0e+00  0e+00
## S9   0  0  0.00     0.00000     0.00000  0  0  1   0  0e+00  0e+00
## X21  0  0 -1.00    -1.00000    -1.00000  0  0  0   0  0e+00  1e+00
## L10  0  0 -1.00    -1.00000    -1.00000  0  0  0   1 -1e+00  1e+00
## Z    0  0  0.05 -9999.85000 -9999.85000  0  0  0   0  1e+09  1e+09
##                 b
## y1   1.175000e+02
## A2   1.000000e+01
## A3   1.000000e+01
## x11  5.000000e+05
## X12  1.000000e+06
## X13  1.000000e+06
## S7   2.500000e+00
## S8   1.200000e+02
## S9   1.200000e+02
## X21  7.500000e+06
## L10  3.500000e+06
## Z   -1.999117e+10
## [1] "------------------------------------------------------------------------"
## [1] "Iteration 7"
## [1] "------------------------------------------------------------------------"
## [1] "Pivot column: 8"
## [1] "Pivot row: 2"
## [1] "New tableau at the end of iteration 7"
##     x11 X21 X12    X22 X13         X23 y1 y2         y3        A1        A2 A3
```

```
## y1    0   0   0  1e-05   0     0.00001  1  0          0         1         0  0
## y2    0   0   0 -1e-05   0     0.00000  0  1          0         0         1  0
## A3    0   0   0  0e+00   0    -0.00001  0  0          1         0         0  1
## x11   1   0   0  0e+00   0     0.00000  0  0          0         0         0  0
## X12   0   0   1  0e+00   0     0.00000  0  0          0         0         0  0
## X13   0   0   0  0e+00   1     0.00000  0  0          0         0         0  0
## S7    0   0   0 -1e-05   0    -0.00001  0  0          0        -1         0  0
## S8    0   0   0  1e-05   0     0.00000  0  0          0         0        -1  0
## S9    0   0   0  0e+00   0     0.00000  0  0          1         0         0  0
## X21   0   1   0  1e+00   0     1.00000  0  0          0         0         0  0
## L10   0   0   0  0e+00   0     0.00000  0  0          0         0         0  0
## Z     0   0   0  0e+00   0 14999.85000  0  0 -999990000 999990000 999990000  0
##        S4     S5          S6 S7 S8 S9 L10    A10    A11             b
## y1   0.00 -1e-05    -0.00001  0  0  0   0  0e+00  1e-05         117.5
## y2   0.00  1e-05     0.00000  0  0  0   0  0e+00  0e+00          10.0
## A3   0.00  0e+00     0.00001  0  0  0   0  0e+00  0e+00          10.0
## x11  1.00  0e+00     0.00000  0  0  0   0  0e+00  0e+00      500000.0
## X12  0.00  1e+00     0.00000  0  0  0   0  0e+00  0e+00     1000000.0
## X13  0.00  0e+00     1.00000  0  0  0   0  0e+00  0e+00     1000000.0
## S7   0.00  1e-05     0.00001  1  0  0   0  0e+00 -1e-05           2.5
## S8   0.00 -1e-05     0.00000  0  1  0   0  0e+00  0e+00         110.0
## S9   0.00  0e+00     0.00000  0  0  1   0  0e+00  0e+00         120.0
## X21 -1.00 -1e+00    -1.00000  0  0  0   0  0e+00  1e+00     7500000.0
## L10 -1.00 -1e+00    -1.00000  0  0  0   1 -1e+00  1e+00     3500000.0
## Z    0.05  5e-02 -9999.85000  0  0  0   0  1e+09  1e+09 -9991274999.0
## [1] "--------------------------------------------------------------------------"
## [1] "Iteration 8"
## [1] "--------------------------------------------------------------------------"
## [1] "Pivot column: 9"
## [1] "Pivot row: 3"
## [1] "New tableau at the end of iteration 8"
##     x11 X21 X12    X22 X13    X23 y1 y2 y3        A1        A2        A3    S4
## y1    0   0   0  1e-05   0  1e-05  1  0  0         1         0         0  0.00
## y2    0   0   0 -1e-05   0  0e+00  0  1  0         0         1         0  0.00
## y3    0   0   0  0e+00   0 -1e-05  0  0  1         0         0         1  0.00
## x11   1   0   0  0e+00   0  0e+00  0  0  0         0         0         0  1.00
## X12   0   0   1  0e+00   0  0e+00  0  0  0         0         0         0  0.00
## X13   0   0   0  0e+00   1  0e+00  0  0  0         0         0         0  0.00
## S7    0   0   0 -1e-05   0 -1e-05  0  0  0        -1         0         0  0.00
## S8    0   0   0  1e-05   0  0e+00  0  0  0         0        -1         0  0.00
## S9    0   0   0  0e+00   0  1e-05  0  0  0         0         0        -1  0.00
## X21   0   1   0  1e+00   0  1e+00  0  0  0         0         0         0 -1.00
## L10   0   0   0  0e+00   0  0e+00  0  0  0         0         0         0 -1.00
## Z     0   0   0  0e+00   0  0e+00  0  0  0 999990000 999990000 999990000  0.05
##         S5     S6 S7 S8 S9 L10    A10    A11          b
## y1  -1e-05 -1e-05  0  0  0   0  0e+00  1e-05     117.5
## y2   1e-05  0e+00  0  0  0   0  0e+00  0e+00      10.0
## y3   0e+00  1e-05  0  0  0   0  0e+00  0e+00      10.0
## x11  0e+00  0e+00  0  0  0   0  0e+00  0e+00  500000.0
## X12  1e+00  0e+00  0  0  0   0  0e+00  0e+00 1000000.0
## X13  0e+00  1e+00  0  0  0   0  0e+00  0e+00 1000000.0
## S7   1e-05  1e-05  1  0  0   0  0e+00 -1e-05       2.5
## S8  -1e-05  0e+00  0  1  0   0  0e+00  0e+00     110.0
## S9   0e+00 -1e-05  0  0  1   0  0e+00  0e+00     110.0
```

```
## X21 -1e+00 -1e+00  0  0  0   0  0e+00  1e+00 7500000.0
## L10 -1e+00 -1e+00  0  0  0   1 -1e+00  1e+00 3500000.0
## Z    5e-02  5e-02  0  0  0   0  1e+09  1e+09 8625001.0
## [1] "------------------------------------------------------------------------"
## [1] "Status: End"
## [1] "------------------------------------------------------------------------"
```

```
##     x11 X21 X12    X22 X13    X23 y1 y2 y3        A1        A2        A3    S4
## y1    0   0   0  1e-05   0  1e-05  1  0  0         1         0         0  0.00
## y2    0   0   0 -1e-05   0  0e+00  0  1  0         0         1         0  0.00
## y3    0   0   0  0e+00   0 -1e-05  0  0  1         0         0         1  0.00
## x11   1   0   0  0e+00   0  0e+00  0  0  0         0         0         0  1.00
## X12   0   0   1  0e+00   0  0e+00  0  0  0         0         0         0  0.00
## X13   0   0   0  0e+00   1  0e+00  0  0  0         0         0         0  0.00
## S7    0   0   0 -1e-05   0 -1e-05  0  0  0        -1         0         0  0.00
## S8    0   0   0  1e-05   0  0e+00  0  0  0         0        -1         0  0.00
## S9    0   0   0  0e+00   0  1e-05  0  0  0         0         0        -1  0.00
## X21   0   1   0  1e+00   0  1e+00  0  0  0         0         0         0 -1.00
## L10   0   0   0  0e+00   0  0e+00  0  0  0         0         0         0 -1.00
## Z     0   0   0  0e+00   0  0e+00  0  0  0 999990000 999990000 999990000  0.05
##         S5     S6 S7 S8 S9 L10    A10    A11          b
## y1  -1e-05 -1e-05  0  0  0   0  0e+00  1e-05     117.5
## y2   1e-05  0e+00  0  0  0   0  0e+00  0e+00      10.0
## y3   0e+00  1e-05  0  0  0   0  0e+00  0e+00      10.0
## x11  0e+00  0e+00  0  0  0   0  0e+00  0e+00  500000.0
## X12  1e+00  0e+00  0  0  0   0  0e+00  0e+00 1000000.0
## X13  0e+00  1e+00  0  0  0   0  0e+00  0e+00 1000000.0
## S7   1e-05  1e-05  1  0  0   0  0e+00 -1e-05       2.5
## S8  -1e-05  0e+00  0  1  0   0  0e+00  0e+00     110.0
## S9   0e+00 -1e-05  0  0  1   0  0e+00  0e+00     110.0
## X21 -1e+00 -1e+00  0  0  0   0  0e+00  1e+00 7500000.0
## L10 -1e+00 -1e+00  0  0  0   1 -1e+00  1e+00 3500000.0
## Z    5e-02  5e-02  0  0  0   0  1e+09  1e+09 8625001.0
```