MILP Optimization
Data-Driven Decision-Making

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Contents

1. Nurse planning

- Two types of nurses:
  - Full-time: work five consecutive days followed by two days off.
  - Part-time: work three consecutive days followed by four days off.

- Minimum number of nurses required per day:

Mon	Tue	Wed	Thu	Fri	Sat	Sun
17	13	15	19	14	16	11

- Wages:

Weekdays	Saturdays	Sundays
€ 250 / day	€ 315 / day	€ 375 / day
€ 150 / day	€ 185 / day	€ 225 / day

- Part-time nurses can cover at most 25% of total shifts.

$$X = \begin{bmatrix} x_1 & x_2 & x_3 & x_4 & x_5 & x_6 & x_7 \\ x_8 & x_9 & x_{10} & x_{11} & x_{12} & x_{13} & x_{14} \end{bmatrix}$$

x_i: Number of each kind of nurse that start working on each day of the week (Monday to Sunday).

$i = 1, \dots, 7$: Full time nurses.

$i = 8, \dots, 14$: Part time nurses.

Calculating cost per nurse: c_i per x_i

	…	Mon	Tus	Wen	Thu	Fri	Sat	Sun	Mon	Tus	Wen	Thu	…	$\sum_i w_i = c_i$	
x_1		250	250	250	250	250								1250	c_1
x_2			250	250	250	250	315							1315	c_2
x_3				250	250	250	315	375						1440	c_3
x_4					250	250	315	375	250					1440	c_4
x_5						250	315	375	250	250				1440	c_5
x_6							315	375	250	250	250			1440	c_6
x_7								375	250	250	250	250		1375	c_7
x_8		150	150	150										450	c_8
x_9			150	150	150									450	c_9
x_{10}				150	150	150								450	c_{10}
x_{11}					150	150	185							485	c_{11}
x_{12}						150	185	225						560	c_{12}
x_{13}							185	225	150					560	c_{13}
x_{14}								225	150	150				525	c_{14}

$$C = \begin{bmatrix} 1250 & 1315 & 1440 & 1440 & 1440 & 1440 & 1375 \\ 450 & 450 & 450 & 485 & 560 & 560 & 525 \end{bmatrix}$$

1.1 Model

Objective function:

$$Min\left(\sum_i c_i x_i\right)$$

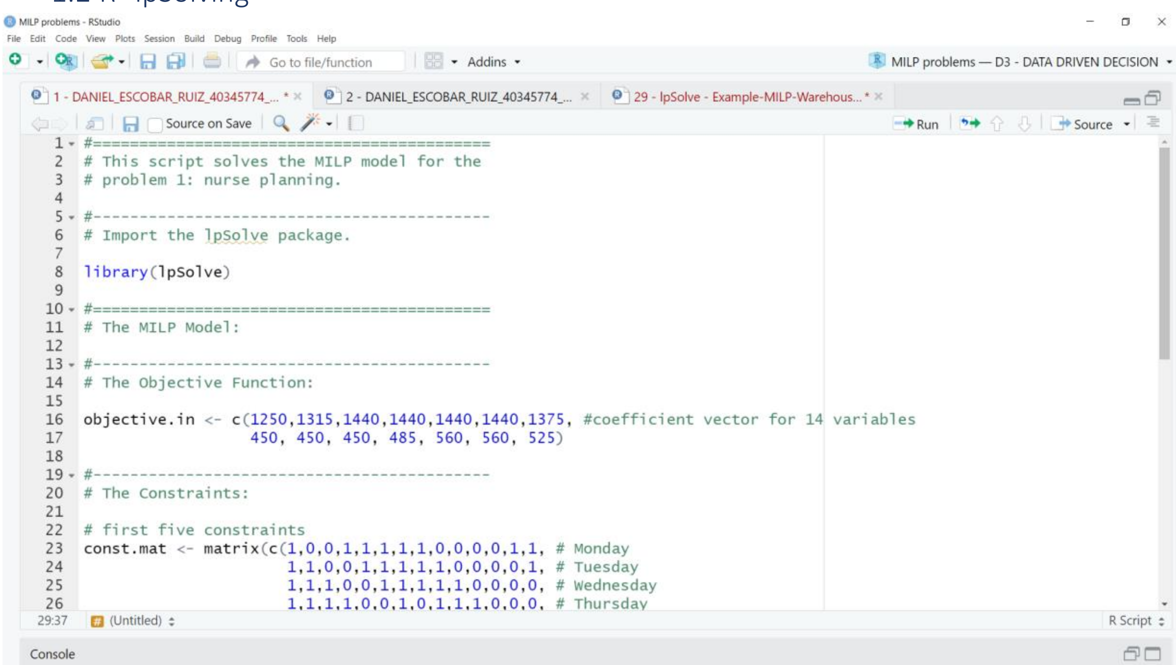
$$Min\begin{pmatrix}1250x_1 + 1315x_2 + 1440x_3 + 1440x_4 + 1440x_5 + 1440x_6 + 1375x_7 \\ +450x_8 + 450x_9 + 450x_{10} + 485x_{11} + 560x_{12} + 560x_{13} + 525x_{14}\end{pmatrix}$$

Subject to:

- $x_1 + x_4 + x_5 + x_6 + x_7 + x_8 + x_{13} + x_{14} \geq 17$, for Monday
- $x_1 + x_2 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{14} \geq 13$, for Tuesday
- $x_1 + x_2 + x_3 + x_6 + x_7 + x_8 + x_9 + x_{10} \geq 15$, for Wednesday
- $x_1 + x_2 + x_3 + x_4 + x_7 + x_9 + x_{10} + x_{11} \geq 19$, for Thursday
- $x_1 + x_2 + x_3 + x_4 + x_5 + x_{10} + x_{11} + x_{12} \geq 14$, for Friday
- $x_2 + x_3 + x_4 + x_5 + x_6 + x_{11} + x_{12} + x_{13} \geq 16$, for Saturday
- $x_3 + x_4 + x_5 + x_6 + x_7 + x_{12} + x_{13} + x_{14} \geq 11$, for Sunday
- $\sum_1^7 x_i - 3\sum_8^{14} x_i \geq 0$, Part-time nurses at most 25% of total
- $x_i \in \mathbb{Z}^+, i = (1, \dots, 14)$

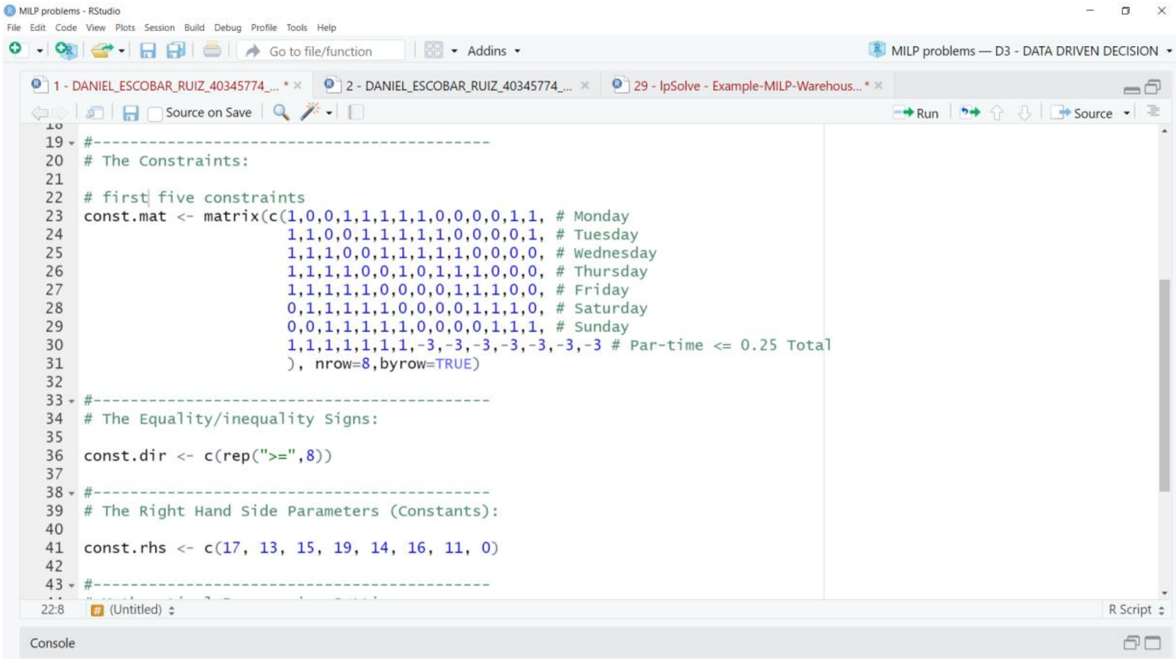
The problem has 8 restrictions

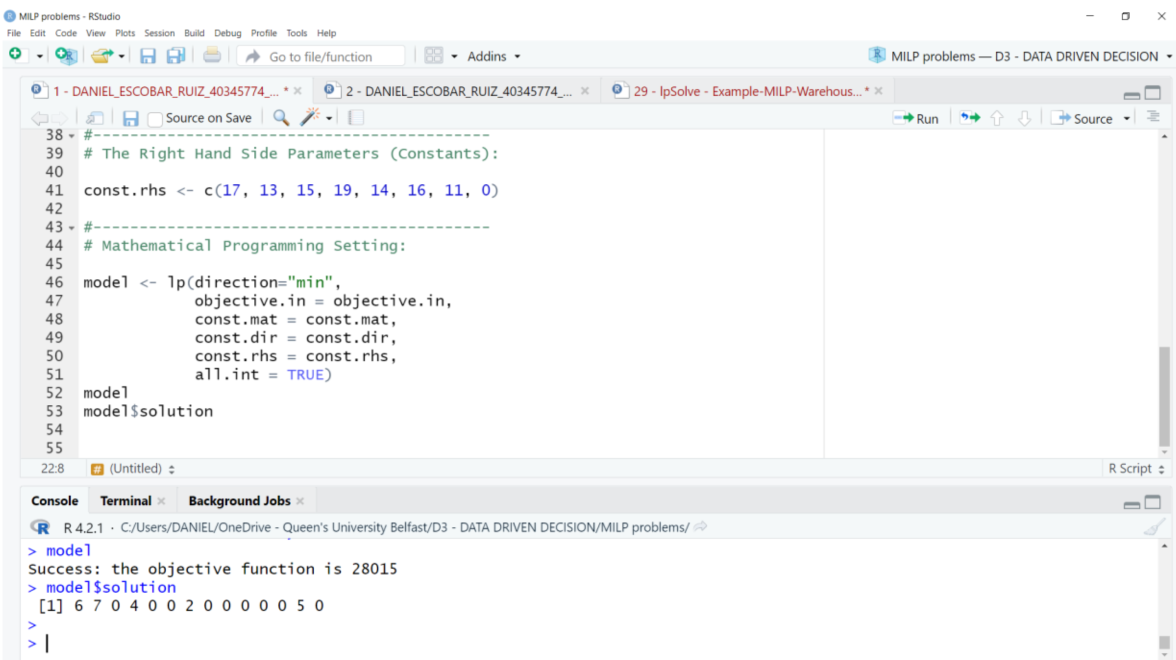
1.2 R- lpSolving



```
#===========================================
# This script solves the MILP model for the
# problem 1: nurse planning.

#-------------------------------------------
# Import the lpSolve package.

library(lpSolve)

#===========================================
# The MILP Model:

#-------------------------------------------
# The Objective Function:

objective.in <- c(1250,1315,1440,1440,1440,1440,1375, #coefficient vector for 14 variables
                  450, 450, 450, 485, 560, 560, 525)

#-------------------------------------------
# The Constraints:

# first five constraints
const.mat <- matrix(c(1,0,0,1,1,1,1,1,0,0,0,0,1,1, # Monday
                      1,1,0,0,1,1,1,1,1,0,0,0,0,1, # Tuesday
                      1,1,1,0,0,1,1,1,1,1,0,0,0,0, # Wednesday
                      1,1,1,1,0,0,1,0,1,1,1,0,0,0, # Thursday
```

I build the coefficient matrix for restrictions using a excel sheet by transforming the table of costs. (see Appendix 1).





1.3 Decision

The hospital gets the minimum cost of €28015 when they hire:

- $x_1 = 6$, full-time starting Mondays
- $x_2 = 7$, full time starting Tuesdays
- $x_4 = 4$, full time starting Thursdays
- $x_7 = 2$, full time starting Sundays
- $x_{13} = 5$, part time starting Saturdays

2. Chipset Logistics

Fabrics = $(F1, F2, F3)$

Distribution centres = $(D1, D2)$

Plants = $(P1, P2)$

26 relations as the next figure shows.

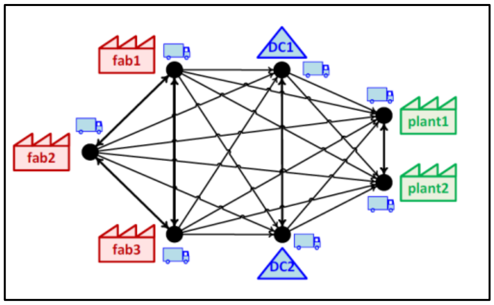


Table of costs: Per pack cost of shipment via the links (in €).

	F1	F2	F3	D1	D2	P1	P2
F1		100	60	100	100	400	400
F2	180		180	20	20	160	300
F3	8	160		20	10	200	240
D1					24	40	240
D2				16		40	240
P1							20
P2						140	

Since each link is a decision variable, the model has 26 decision variables. I keep double notation of letter and numbers for practical reasons.

Decision variables

	F1	F2	F3	D1	D2	P1	P2
F1		$x_{F1F2} = x_1$	$x_{F1F3} = x_2$	$x_{F1D1} = x_3$	$x_{F1D2} = x_4$	$x_{F1P1} = x_5$	$x_{F1P2} = x_6$
F2	$x_{F2F1} = x_7$		$x_{F2F3} = x_8$	$x_{F2D1} = x_9$	$x_{F2D2} = x_{10}$	$x_{F2P1} = x_{11}$	$x_{F2P2} = x_{12}$
F3	$x_{F3F1} = x_{13}$	$x_{F3F2} = x_{14}$		$x_{F3D1} = x_{15}$	$x_{F3D2} = x_{16}$	$x_{F3P1} = x_{17}$	$x_{F3P2} = x_{18}$
D1					$x_{D1D2} = x_{19}$	$x_{D1P1} = x_{20}$	$x_{D1P2} = x_{21}$
D2				$x_{D2D1} = x_{22}$		$x_{D2P1} = x_{23}$	$x_{D2P2} = x_{24}$
P1							$x_{P1P2} = x_{25}$
P2						$x_{P2P1} = x_{26}$	

From the previous tables, we get the following vectors:

$$C = [\,100,\ 60,\ 100,\ 100,\ 400,\ 400,\ 180,\ 180,\ 20,\ 20,\ 300,\ 8,\ 160,\ 20,\ 10,\ 200,\ 240,\ 24,\ 40,\ 240,\ 16,\ 40,\ 240,\ 20,\ 140\,]$$

$$X = [x_{F1F2}, \dots, x_{P2P1}] = [x_1, \dots, x_{26}\,]$$

2.1 Model

Objective function:

$$Min\left(\sum_i c_i x_i \right)$$

$$\begin{aligned} Min(&100x_{F1F2} + 60x_{F1F3} + 100x_{F1D1} + 100x_{F1D2} + 400x_{F1P1} + 400x_{F1P2} + 180x_{F2F1} \\ &+ 180x_{F2F3} + 20x_{F2D1} + 20x_{F2D2} + 160x_{F2P1} + 300x_{F2P2} + 8x_{F3F1} \\ &+ 160x_{F3F2} + 20x_{F3D1} + 10x_{F3D2} + 200x_{F3P1} + 240x_{F3P2} + 24x_{D1D2} \\ &+ 40x_{D1P1} + 240x_{D1P2} + 16x_{D2D1} + 40x_{D2P1} + 240x_{D2P2} + 20x_{P1P2} \\ &+ 140x_{P2P1}) \end{aligned}$$

$$\begin{aligned} Min(&100x_1 + 60x_2 + 100x_3 + 100x_4 + 400x_5 + 400x_6 + 180x_7 + 180x_8 + 20x_9 + 20x_{10} \\ &+ 160x_{11} + 300x_{12} + 8x_{13} + 160x_{14} + 20x_{15} + 10x_{16} + 200x_{17} + 240x_{18} \\ &+ 24x_{19} + 40x_{20} + 240x_{21} + 16x_{22} + 40x_{23} + 240x_{24} + 20x_{25} + 140x_{26}) \end{aligned}$$

Subject to:

- $x_{F1F2} + x_{F1F3} + x_{F1D1} + x_{F1D2} + x_{F1P1} + x_{F1P2} - x_{F2F1} \leq 400$,
  Fabric 1 produce at most 400k

- $-x_{F1F2} + x_{F2F1} + x_{F2F3} + x_{F2D1} + x_{F2D2} + x_{F2P1} + x_{F2P2} - x_{F3F2} \leq 600$,
  Fabric 2 produce at most 600K

- $-x_{F1F3} - x_{F2F3} + x_{F3F1} + x_{F3F2} + x_{F3D1} + x_{F3D2} + x_{F3P1} + x_{F3P2} \leq 200$,
  Fabric 2 produce at most 200K

- $-x_{F1P1} - x_{F2P1} - x_{F3P1} - x_{D1P1} - x_{D2P1} + x_{P1P2} - x_{P2P1} = 400$,
  Plant 1 demand exactly 400K

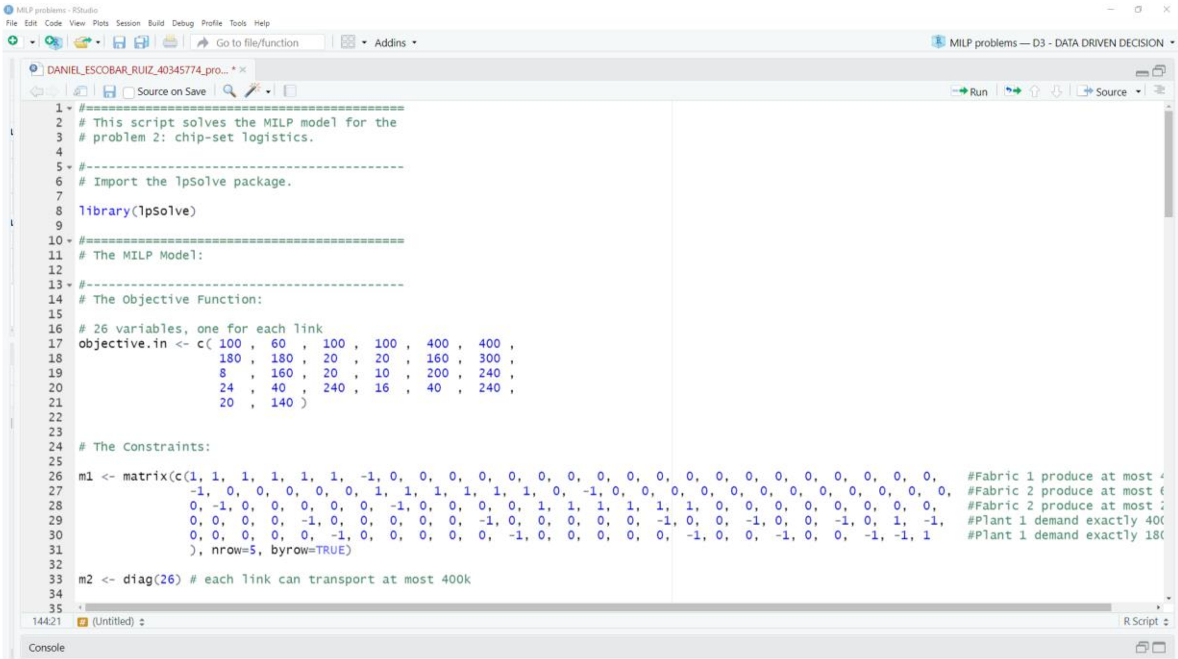
- $-x_{F1P2} - x_{F2P2} - x_{F3P2} - x_{D1P2} - x_{D2P2} - x_{P1P2} + x_{P2P1} = 180$,
  Plant 1 demand exactly 180K

- $x_i \ \leq 400$, $i = (1, \ldots, 26)$, each link can transport at most 400k

- $x_i \in \ \mathbb{Z}^+, i = (1, \ldots, 26)$

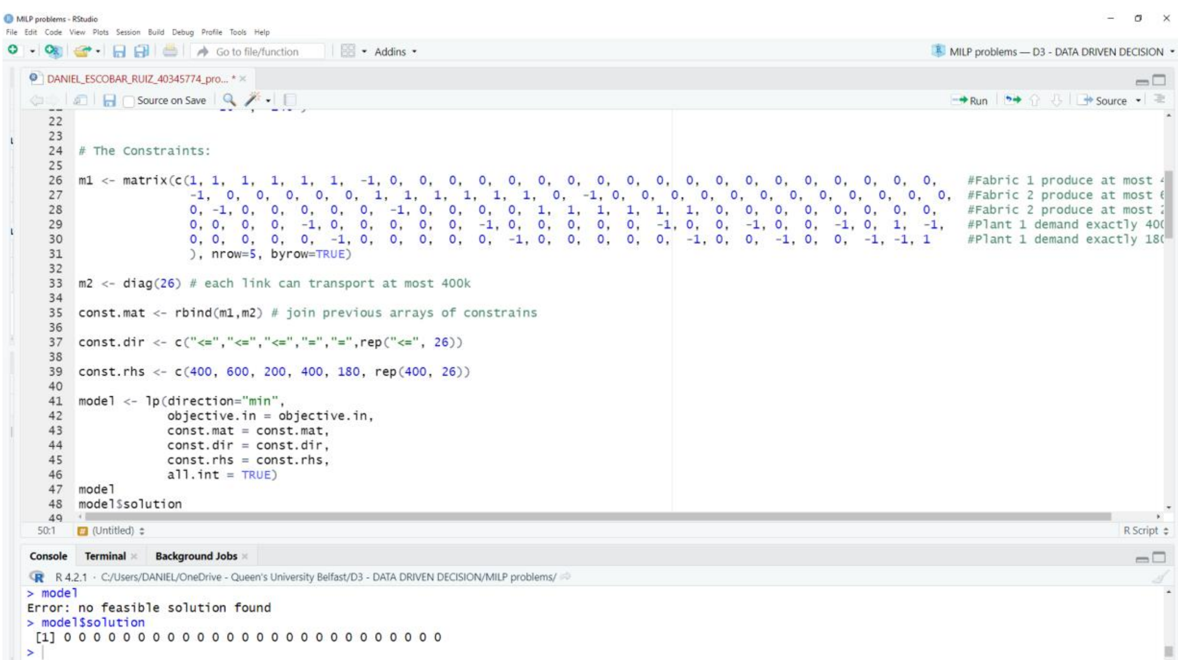
We have in total 31 restrictions, in addition positive integers limitation constrain.

2.2 R-lpSolving



```r
#===========================================
# This script solves the MILP model for the
# problem 2: chip-set logistics.

#-------------------------------------------
# Import the lpSolve package.

library(lpSolve)

#===========================================
# The MILP Model:

#-------------------------------------------
# The Objective Function:

# 26 variables, one for each link
objective.in <- c( 100 ,  60  ,  100 ,  100 ,  400 ,  400 ,
                   180 ,  180 ,  20  ,  20  ,  160 ,  300 ,
                   8   ,  160 ,  20  ,  10  ,  200 ,  240 ,
                   24  ,  40  ,  240 ,  16  ,  40  ,  240 ,
                   20  ,  140 )


# The Constraints:

m1 <- matrix(c(1, 1,  1,  1,  1,  1,  -1, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,    #Fabric 1 produce at most 
               -1,  0,  0,  0,  0,  0,  1,  1,  1,  1,  1,  1,  0,  -1, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  #Fabric 2 produce at most 
               0, -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  1,  1,  1,  1,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,   #Fabric 2 produce at most 
               0, 0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  -1, 0,  0,  -1, 0,  1,  -1,  #Plant 1 demand exactly 40
               0, 0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  -1, 0,  0,  -1, -1, 1    #Plant 1 demand exactly 18
               ), nrow=5, byrow=TRUE)

m2 <- diag(26) # each link can transport at most 400k

```

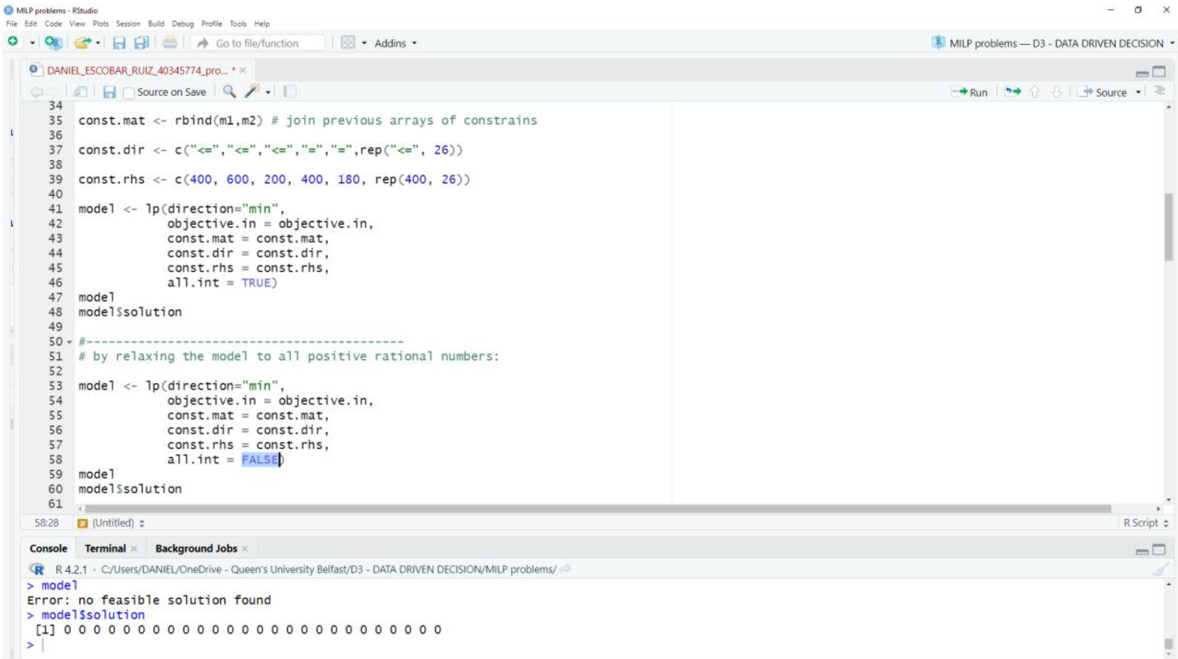
I created m1 and m2, then merged them to define the coefficient matrix for restrictions. Where m1 contains coefficients for the first five restrictions, and m2 contains the coefficients of restrictions regarding link capacities. Furthermore, m1 was created in excel table and simple copied and pasted on the R script (see Appendix 2).



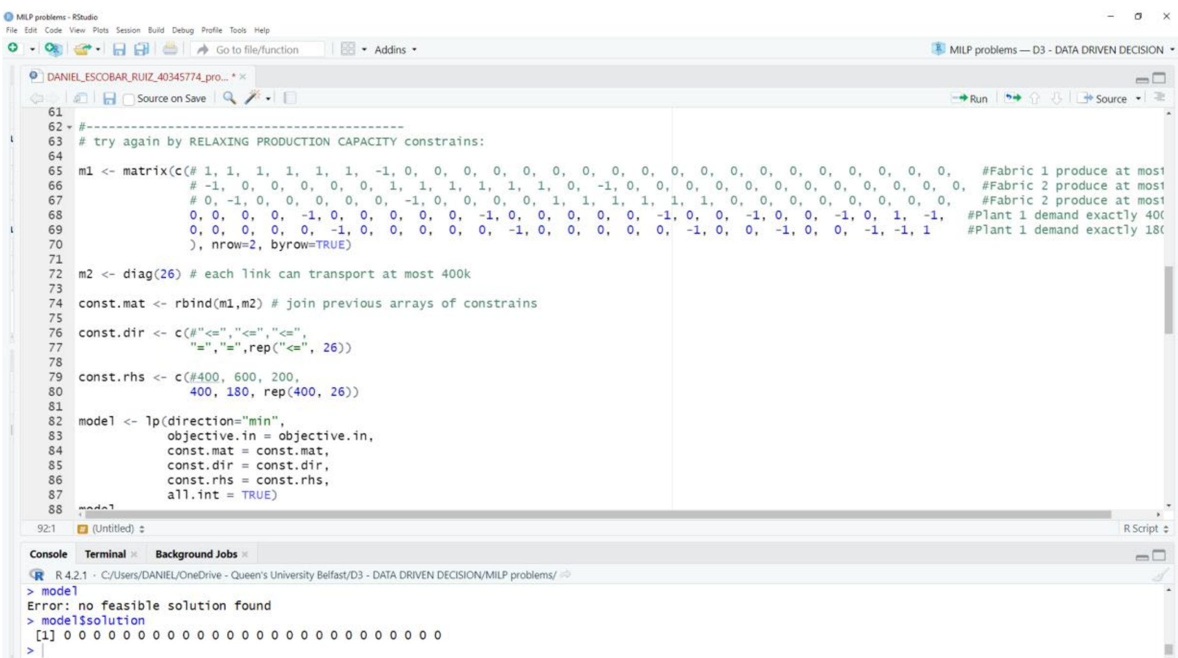
```r
# The Constraints:

m1 <- matrix(c(1, 1,  1,  1,  1,  1,  -1, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,    #Fabric 1 produce at most 
               -1,  0,  0,  0,  0,  0,  1,  1,  1,  1,  1,  1,  0,  -1, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  #Fabric 2 produce at most 
               0, -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  1,  1,  1,  1,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,   #Fabric 2 produce at most 
               0, 0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  -1, 0,  0,  -1, 0,  1,  -1,  #Plant 1 demand exactly 40
               0, 0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  0,  0,  0,  -1, 0,  0,  -1, 0,  0,  -1, -1, 1    #Plant 1 demand exactly 18
               ), nrow=5, byrow=TRUE)

m2 <- diag(26) # each link can transport at most 400k

const.mat <- rbind(m1,m2) # join previous arrays of constrains

const.dir <- c("<=","<=","<=","=","=",rep("<=", 26))

const.rhs <- c(400, 600, 200, 400, 180, rep(400, 26))

model <- lp(direction="min",
            objective.in = objective.in,
            const.mat = const.mat,
            const.dir = const.dir,
            const.rhs = const.rhs,
            all.int = TRUE)
model
model$solution
```

```
> model
Error: no feasible solution found
> model$solution
 [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
> 
```

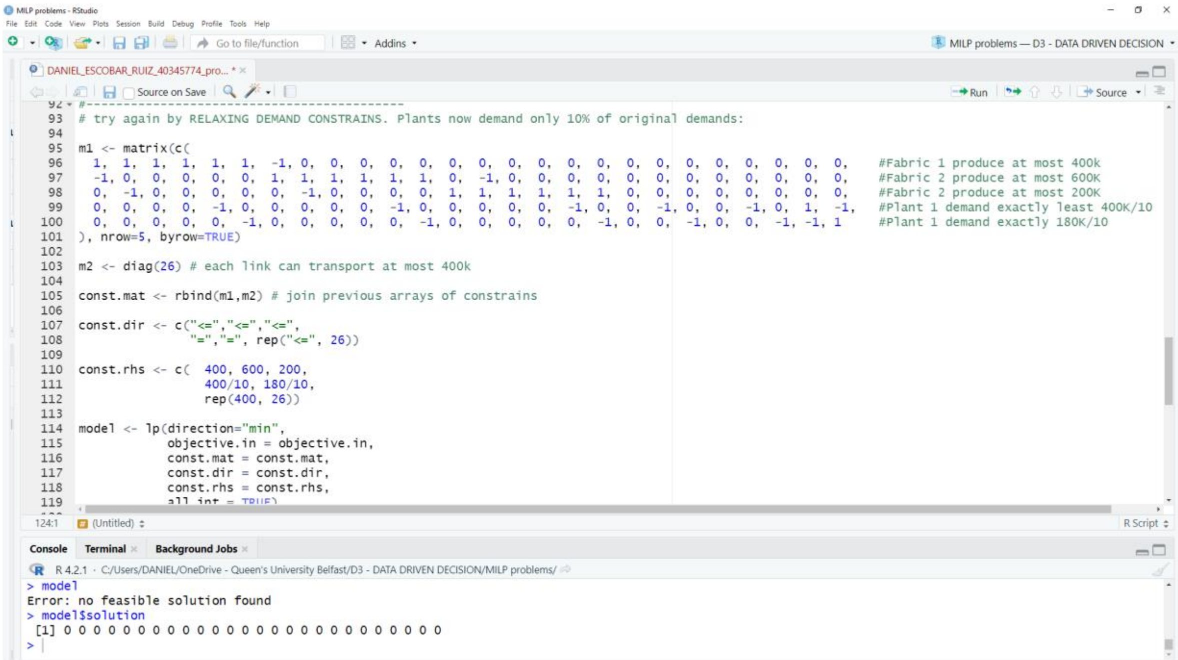
Solution is unfeasible, even if I relax the model by accepting all positives rational numbers as follows.



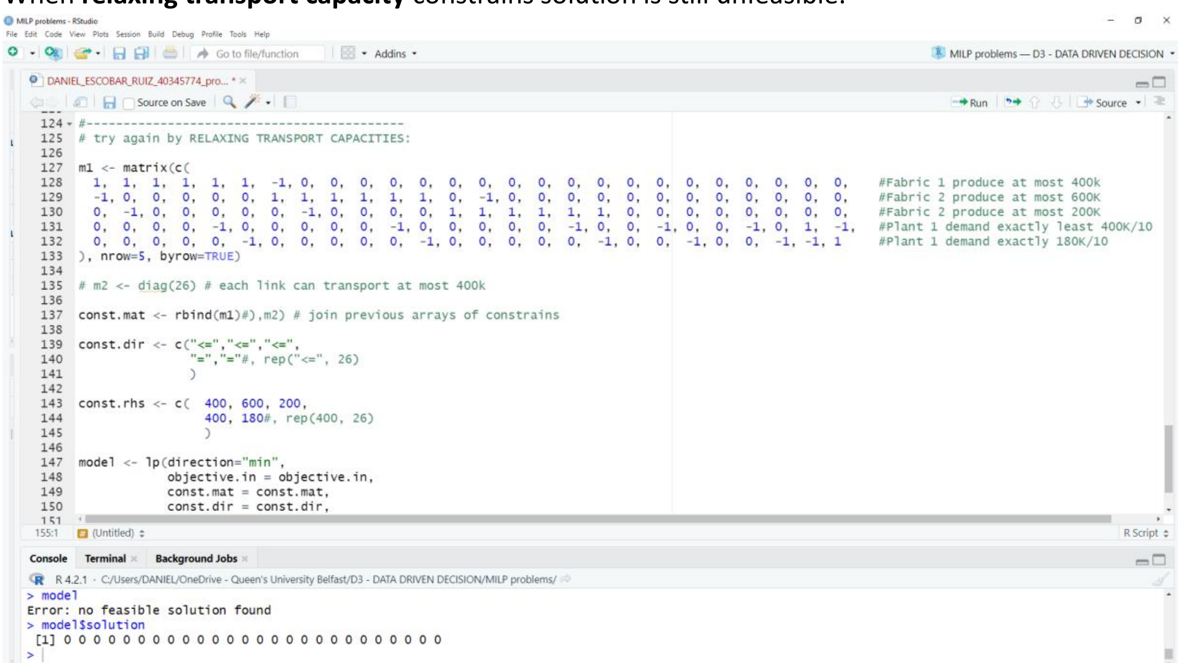
Then, I **relaxed production capacity** constraints. However, the solution still unfeasible.



Then I **relaxed demand constrains**. Despite plants decreasing plant demands by 10% of original, solution still unfeasible.



When **relaxing transport capacity** constrains solution is still unfeasible.



2.3 Decision

The company need to change the cost structure. As it is currently, the logistic model is nonviable, and the solution is unfeasible even when there are no limitations regarding production or transport capacity.

3. Ocean Internet Cables

Cables $i = (A, B)$

Plants $j = (1,2)$

Months $t = (1,2,3)$ = (Jan, Feb, Mar)

The problem request to devise a production schedule for each cable at each plant for each month.

P_{ijt}: production (in km) of cable i from plant j in month t.

month	cable	A	A	B	B
	plant	1	2	1	2
1		$P_{A11} = ?$	$P_{A21} = ?$	$P_{B11} = ?$	$P_{B21} = ?$
2		$P_{A12} = ?$	$P_{A22} = ?$	$P_{B12} = ?$	$P_{B22} = ?$
3		$P_{A13} = ?$	$P_{A23} = ?$	$P_{B13} = ?$	$P_{B23} = ?$

We are provided with a demand that must be fulfilled by each month for each cable.
D_{it}: deman (in km) of cable i in month t.

month\cable	A	B
1	$D_{A1} = 8000$	$D_{B1} = 2000$
2	$D_{A2} = 16000$	$D_{B2} = 10000$
3	$D_{A3} = 6000$	$D_{B3} = 10000$
	$\sum_t D_{At} = 30000$	$\sum_t D_{Bt} = 22000$

As the plants can produce more than demand required, at the end of the month we may have an excess of production for each cable for each plant.

E_{ijt}: excess of production for cable i in plant j for month t.

The excess production of the month enters inventory at the end of that month. Thus, production of February depends on excess of January, and so on for March. Furthermore, there are no holding inventory by the beginning and ending of the analysis.

$$E_{it} = \sum_j P_{ijt} - D_{it}$$

month\cable	A	B
0	$E_{A0} = 0$	$E_{B0} = 0$
1	$E_{A1} = ?$	$E_{B1} = ?$
2	$E_{A2} = ?$	$E_{B2} = ?$
3	$E_{A3} = 0$	$E_{B3} = 0$

The cost of holding inventory is ₽ 0.20

Each plant has different production rates per cable.

R_{ij}: production rate per hour per km for cable i in plant t.

Plant\cable	A	B
1	$R_{A1} = 0.3$	$R_{B1} = 0.24$
2	$R_{A2} = 0.32$	$R_{B2} = 0.28$

The cost per hour per plant for either cable or plant is ₽ 10. Then, $10R_{ij}$ is the cost per hour required to produced one km of cable i in plant j for every month.

The production requires hours of work and raw material.

W_i: cost of raw material for cable i.

cable	A	B
	$W_A = 6.2$	$W_B = 7.8$

Packing cost per km of either cable = ₽ 0.46. I **assume that each km of cable produced is immediately packed whether is to deliver or keep it as holding inventory.**

From the info above, the value of production per km depends on cost of hours required, cost of raw material, and packing cost.

V_{ij}: value (in ₽) per km produced of cable i from plant j for every month. These values are constant in time. (Matrix calculations in appendix 3)

$$V_{ij} = 10R_{ij} + W_i + 0.46$$

Plant\cable	A	B
1	$V_{A1} = 9.66$	$V_{B1} = 10.66$
2	$V_{A2} = 9.86$	$V_{B2} = 11.06$

Production is limited by hours availability for plants each month.

A_{it}: availability (in hours) of plant j in month t.

Month\Plant	1	2
1	$A_{11} = 1400$	$A_{21} = 3000$
2	$A_{12} = 600$	$A_{22} = 800$
3	$A_{13} = 2000$	$A_{23} = 600$

Since hour resources are limited and the entire demand must be fulfilled, we have the following **constrains**:

- The sum of hours used to produce both cables must be at most the available hours for each plant in each month.

$$\sum_i R_{ij}P_{ijt} \leq A_{jt}$$

- The sum of production and difference of excess in current and following period of both plants must be equal to the demand for each cable and each month.

$$\sum_j \left(\mathrm{P_{ijt}} + \mathrm{E_{ij(t-1)}} - E_{ijt}\right) = \mathrm{D_{it}}$$

- There should be no inventory at the end of March.

$$E_{ij(3)} = 0$$

equivalent to

$$\sum_j \left(P_{ij3} + E_{ij2}\right) = D_{i3}$$

Thus, the total production is equal to the total demand for each cable.

$$\sum_t \sum_j P_{ijt} = \sum_t D_{it}$$

S_i: selling price for cable i.

cable	A	B
	$S_A = 14$	$S_B = 18$

The profit is equal to the difference of the selling price and the value (cost) of all productions. The matrixial expression:

$$Profit = \boldsymbol{SP} - \boldsymbol{VP}$$

Equivalent to:

$$Profit \;= \sum_i \sum_j \sum_t \left(S_i P_{ijt} - V_{ij}P_{ijt} - 0.2E_{i(t-1)}\right)$$

3.1 Model

The problem requires to devise a production schedule for the maximum possible total profit. As the selling prices are fixed, the only way to maximize profit is by minimizing production costs.

The Generalized Model

Objective function:

$$\min\left(\sum_i\sum_j\sum_t\left(V_{ijt}P_{ijt}+0.2E_{i(t-1)}\right)\right)$$

Subject to:

- $\sum_i R_{ij}P_{ijt} \leq A_{jt}$ Available hours
- $\sum_j P_{ijt} + E_{i(t-1)} - E_{it} = D_{it}$ Fulfil demands
- $E_{i0} = E_{i3} = 0$ No excesses by the beginning and ending
- $P_{ijt}, E_{it} \in \mathbb{Z}^+$ Problem delimitation

Specified model

Objective function:

$$\min\begin{pmatrix} 9.66P_{A11}+9.86P_{A21}+10.66P_{B11}+11.06P_{B21}+ \\ 9.66P_{A12}+9.86P_{A22}+10.66P_{B12}+11.06P_{B22}+ \\ 9.66P_{A13}+9.86P_{A23}+10.66P_{B13}+11.06P_{B23}+ \\ 0.2E_{A0}+0.2E_{B0}+ \\ 0.2E_{A1}+0.2E_{B1}+ \\ 0.2E_{A2}+0.2E_{B2}+ \\ 0.2E_{A3}+0.2E_{B3} \end{pmatrix}$$

The model has 20 decision variables

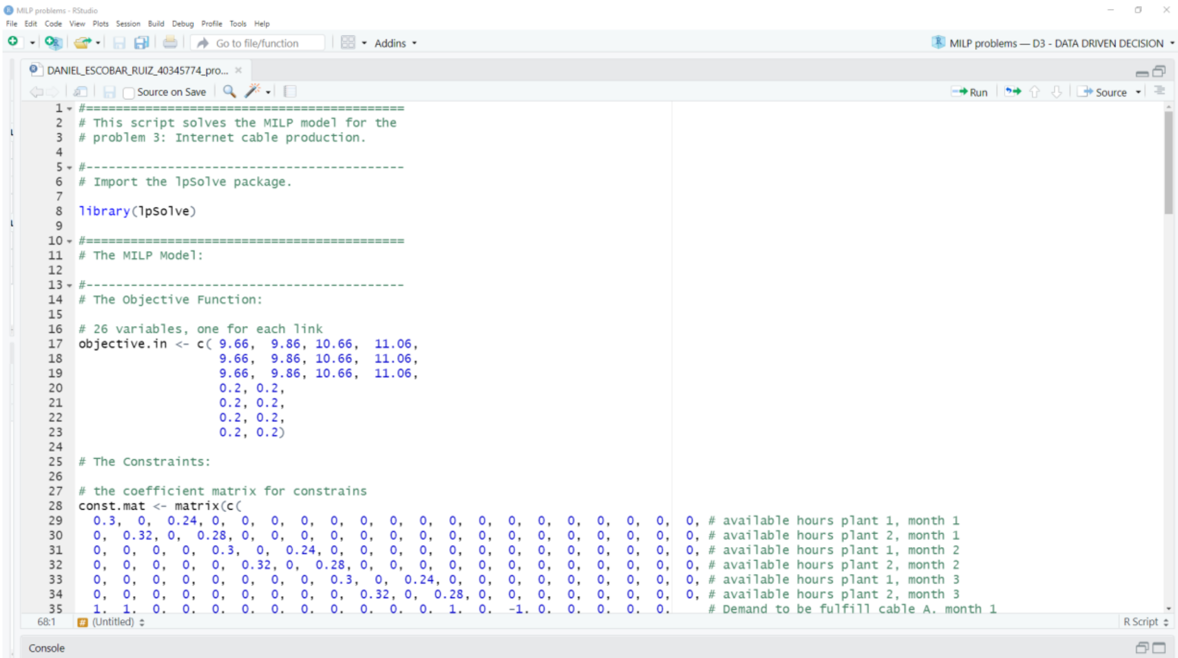
Subject to:

- Available hours of production A_{jt}
  - $0.3P_{A11}+0.24P_{B11} \leq 1400$ plant 1, month 1
  - $0.32P_{A21}+0.28P_{B21} \leq 3000$ plant 2, month 1
  - $0.3P_{A12}+0.24P_{B12} \leq 600$ plant 1, month 2
  - $0.32P_{A22}+0.28P_{B22} \leq 800$ plant 2, month 2
  - $0.3P_{A13}+0.24P_{B13} \leq 2000$ plant 1, month 3
  - $0.32P_{A23}+0.28P_{B23} \leq 600$ plant 2, month 3
- Demands D_it
  - $P_{A11}+P_{A21}+E_{A0}-E_{A1}=8000$ cable A, month 1
  - $P_{B11}+P_{B21}+E_{B0}-E_{B1}=2000$ cable B, month 1
  - $P_{A12}+P_{A22}+E_{A1}-E_{A2}=16000$ cable A, month 2
  - $P_{B12}+P_{B22}+E_{B1}-E_{B2}=10000$ cable B, month 2
  - $P_{A13}+P_{A23}+E_{A2}-E_{A3}=6000$ cable A, month 3
  - $P_{B13}+P_{B23}+E_{B2}-E_{B3}=10000$ cable B, month 3
- No excesses by the beginning and ending
  - $E_{A0}=0$
  - $E_{B0}=0$
  - $E_{A3}=0$

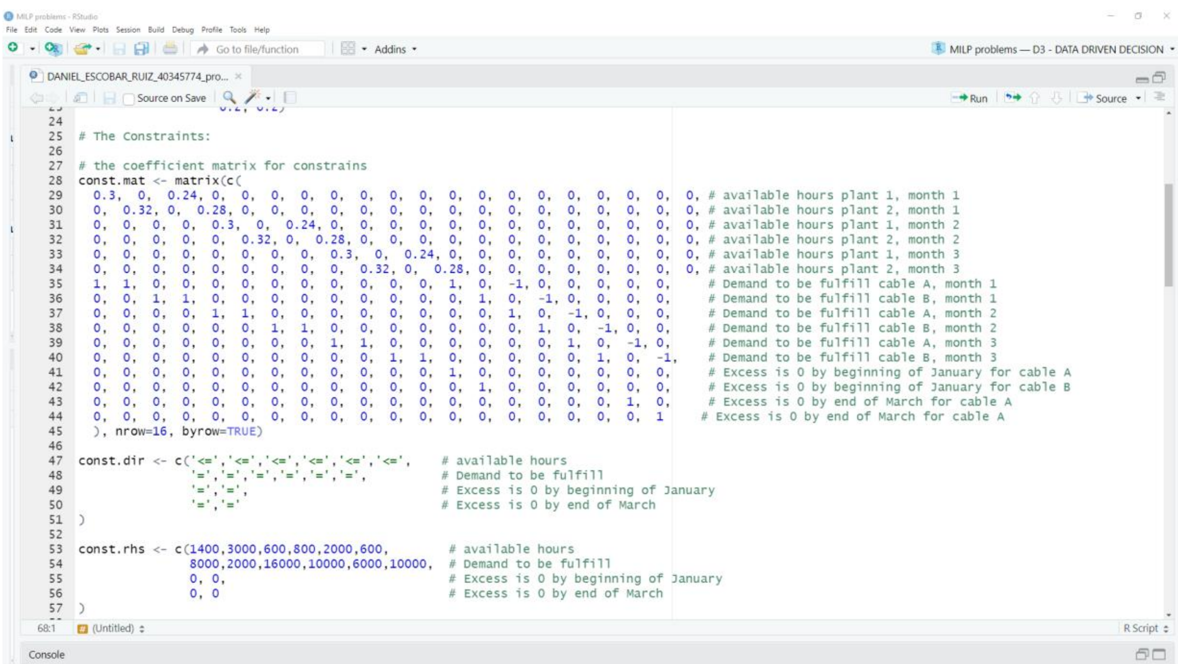
- $E_{B3} = 0$
- Problem delimitation
  - $P_{ijt}, E_{it} \in \mathbb{Z}^{+}, i = (A, B), j = (1,2), t = (1,2,3)$

The model has 16 constrains.

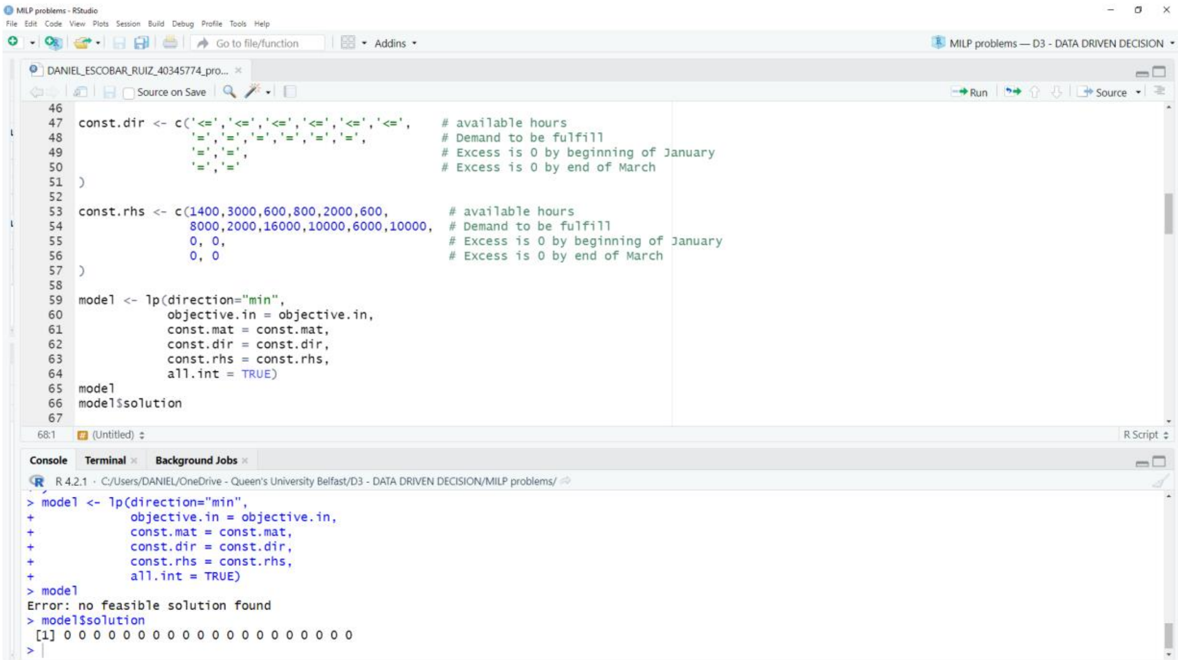
3.2 R – lpSolve



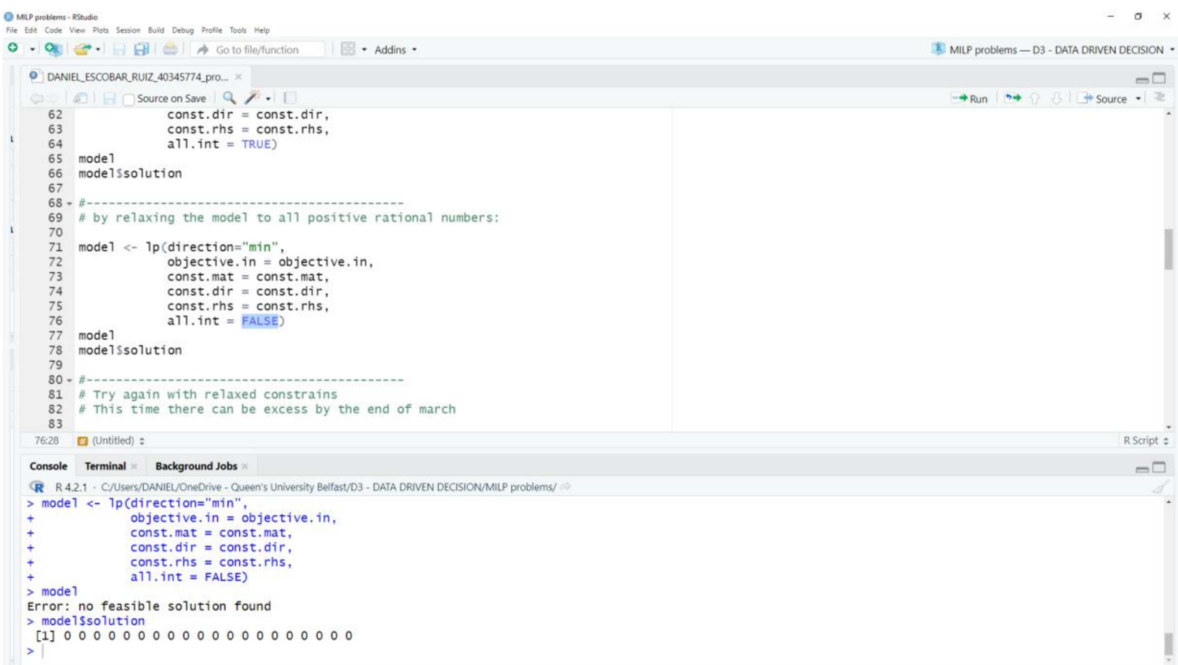
```r
#===========================================
# This script solves the MILP model for the
# problem 3: Internet cable production.

#-------------------------------------------
# Import the lpSolve package.

library(lpSolve)

#===========================================
# The MILP Model:

#-------------------------------------------
# The Objective Function:

# 26 variables, one for each link
objective.in <- c( 9.66,  9.86, 10.66,  11.06,
                   9.66,  9.86, 10.66,  11.06,
                   9.66,  9.86, 10.66,  11.06,
                   0.2, 0.2,
                   0.2, 0.2,
                   0.2, 0.2,
                   0.2, 0.2)

# The Constraints:

# the coefficient matrix for constrains
const.mat <- matrix(c(
  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 1
  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 1
  0,  0,  0,  0,  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 2
  0,  0,  0,  0,  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 2
  0,  0,  0,  0,  0,  0,  0,  0,  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 3
  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,  0,  0,     # Demand to be fulfill cable A, month 1
```



```r
# The Constraints:

# the coefficient matrix for constrains
const.mat <- matrix(c(
  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 1
  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 1
  0,  0,  0,  0,  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 2
  0,  0,  0,  0,  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 2
  0,  0,  0,  0,  0,  0,  0,  0,  0.3,  0,  0.24, 0,  0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 1, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0.32, 0,  0.28, 0,  0,  0,  0,  0,  0,  0,  0, # available hours plant 2, month 3
  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,  0,  0,     # Demand to be fulfill cable A, month 1
  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,  0,     # Demand to be fulfill cable B, month 1
  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,     # Demand to be fulfill cable A, month 2
  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,     # Demand to be fulfill cable B, month 2
  0,  0,  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,     # Demand to be fulfill cable A, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  1,  0,  -1,    # Demand to be fulfill cable B, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  0,  0,  0,  0,  0,  0,     # Excess is 0 by beginning of January for cable A
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  0,  0,  0,  0,  0,     # Excess is 0 by beginning of January for cable B
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,     # Excess is 0 by end of March for cable A
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1     # Excess is 0 by end of March for cable A
  ), nrow=16, byrow=TRUE)

const.dir <- c('<=','<=','<=','<=','<=','<=',    # available hours
               '=','=','=','=','=','=',          # Demand to be fulfill
               '=','=',                          # Excess is 0 by beginning of January
               '=','='                           # Excess is 0 by end of March
)

const.rhs <- c(1400,3000,600,800,2000,600,         # available hours
               8000,2000,16000,10000,6000,10000,  # Demand to be fulfill
               0, 0,                               # Excess is 0 by beginning of January
               0, 0                                # Excess is 0 by end of March
)
```

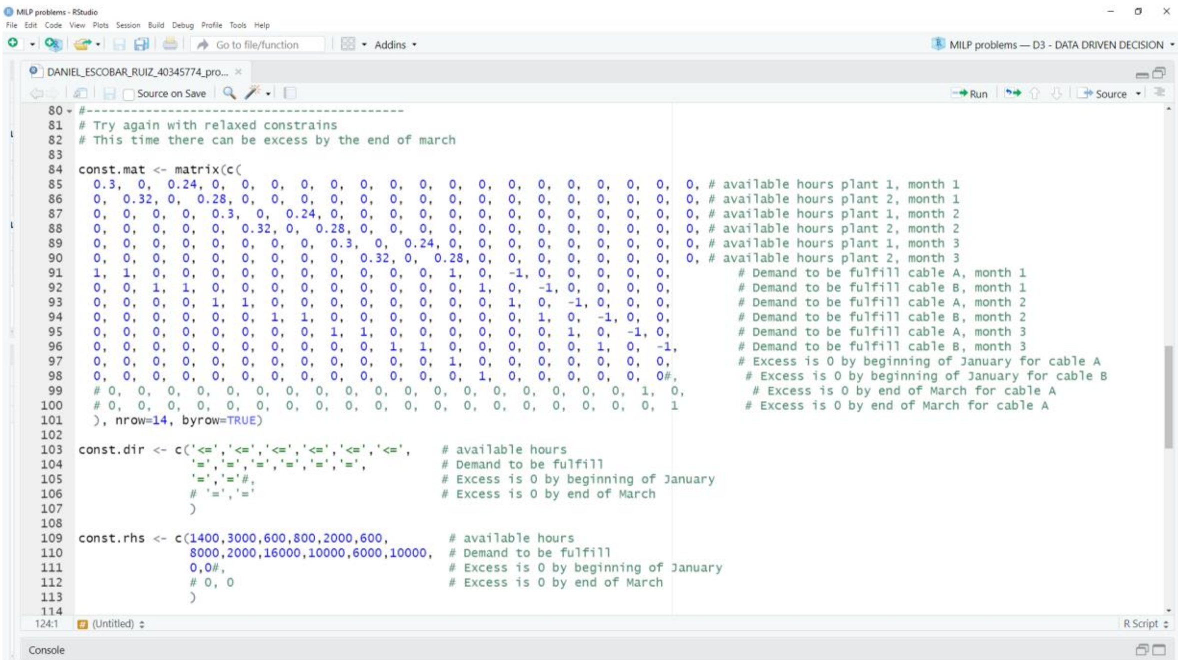


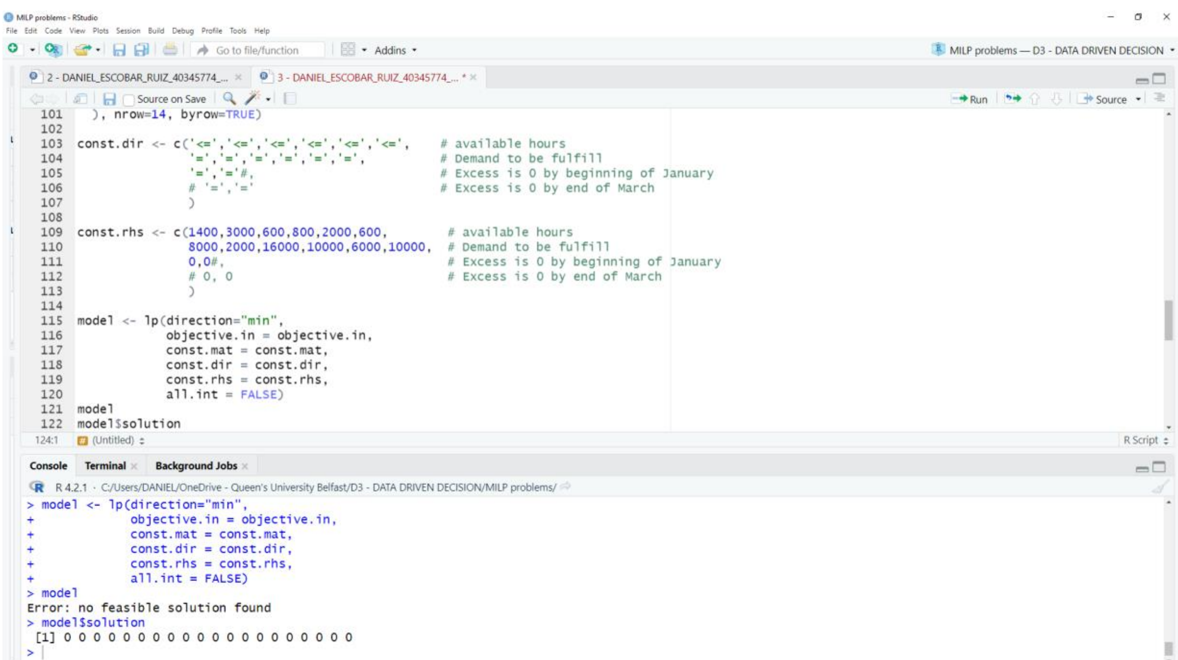
No feasible solution. Then tried with all positive real numbers. However, solution is still unfeasible.



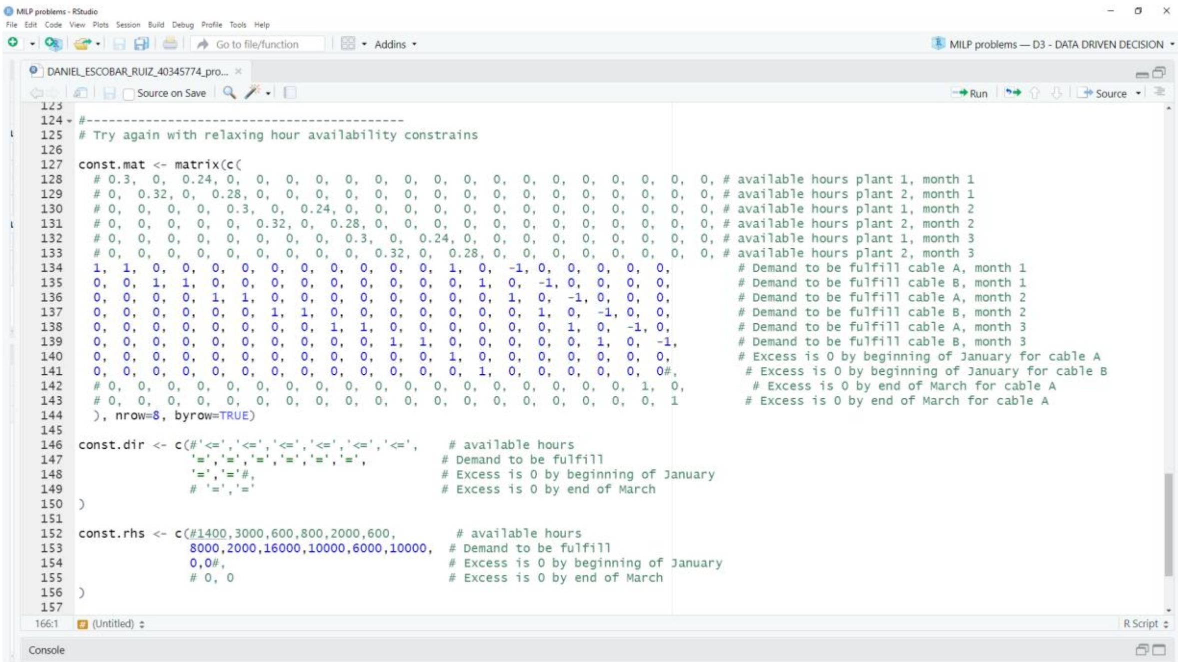
Then I relaxed constrains regarding excess of production at the end of march. So now

$$E_{i3} \geq 0$$

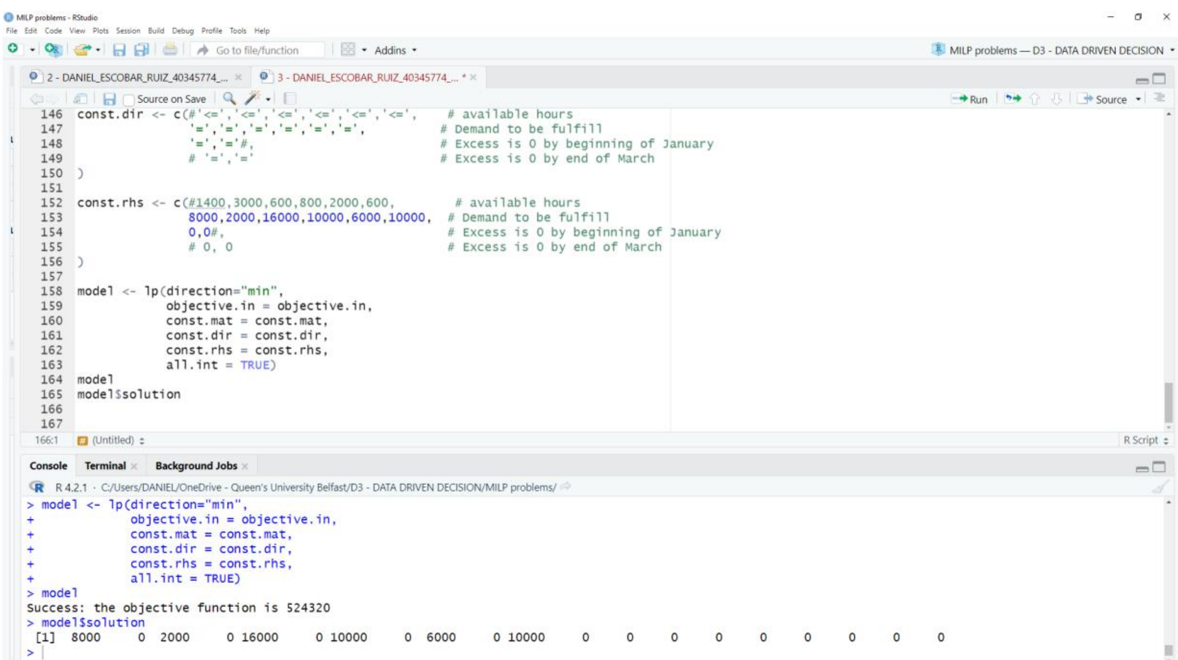




Solution is still unfeasible. Then Try again by relaxing constrain regarding available hours for production. This time, we get a solution.



```r
#-------------------------------------------
# Try again with relaxing hour availability constrains

const.mat <- matrix(c(
  # 0.3,  0,    0.24, 0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 1, month 1
  # 0,    0.32, 0,    0.28, 0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 2, month 1
  # 0,    0,    0,    0,    0.3,  0,    0.24, 0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 1, month 2
  # 0,    0,    0,    0,    0,    0.32, 0,    0.28, 0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 2, month 2
  # 0,    0,    0,    0,    0,    0,    0,    0,    0.3,  0,    0.24, 0,    0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 1, month 3
  # 0,    0,    0,    0,    0,    0,    0,    0,    0,    0.32, 0,    0.28, 0,    0,    0,    0,    0,    0,    0,    0, # available hours plant 2, month 3
  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,  0,  0,        # Demand to be fulfill cable A, month 1
  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,  0,        # Demand to be fulfill cable B, month 1
  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,  0,        # Demand to be fulfill cable A, month 2
  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,  0,        # Demand to be fulfill cable B, month 2
  0,  0,  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  0,  1,  0,  -1, 0,        # Demand to be fulfill cable A, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,  0,  1,  0,  -1,       # Demand to be fulfill cable B, month 3
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  0,  0,  0,  0,  0,  0,        # Excess is 0 by beginning of January for cable A
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,  0,  0,  0,  0,  0#,        # Excess is 0 by beginning of January for cable B
  # 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  0,        # Excess is 0 by end of March for cable A
  # 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  1         # Excess is 0 by end of March for cable A
  ), nrow=8, byrow=TRUE)

const.dir <- c(#'<=','<=','<=','<=','<=','<=',    # available hours
               '=','=','=','=','=','=',          # Demand to be fulfill
               '=','='#,                         # Excess is 0 by beginning of January
               # '=','='                         # Excess is 0 by end of March
)

const.rhs <- c(#1400,3000,600,800,2000,600,        # available hours
               8000,2000,16000,10000,6000,10000,  # Demand to be fulfill
               0,0#,                              # Excess is 0 by beginning of January
               # 0, 0                             # Excess is 0 by end of March
)
```



```r
const.dir <- c(#'<=','<=','<=','<=','<=','<=',    # available hours
               '=','=','=','=','=','=',          # Demand to be fulfill
               '=','='#,                         # Excess is 0 by beginning of January
               # '=','='                         # Excess is 0 by end of March
)

const.rhs <- c(#1400,3000,600,800,2000,600,        # available hours
               8000,2000,16000,10000,6000,10000,  # Demand to be fulfill
               0,0#,                              # Excess is 0 by beginning of January
               # 0, 0                             # Excess is 0 by end of March
)

model <- lp(direction="min",
            objective.in = objective.in,
            const.mat = const.mat,
            const.dir = const.dir,
            const.rhs = const.rhs,
            all.int = TRUE)
model
model$solution
```

```
> model <- lp(direction="min",
+             objective.in = objective.in,
+             const.mat = const.mat,
+             const.dir = const.dir,
+             const.rhs = const.rhs,
+             all.int = TRUE)
> model
Success: the objective function is 524320
> model$solution
 [1]  8000     0  2000     0 16000     0 10000     0  6000     0 10000     0     0     0     0     0     0     0     0     0
>
```

3.3 Decision

The company must increase the hours available for production for each cable if they pretend to fulfil the demand each month.

When the available hours are not restrictions. All the production is assigned to Plant 1, which make sense since the rate of required hours is lower for both cables.

The production plan goes as follows:

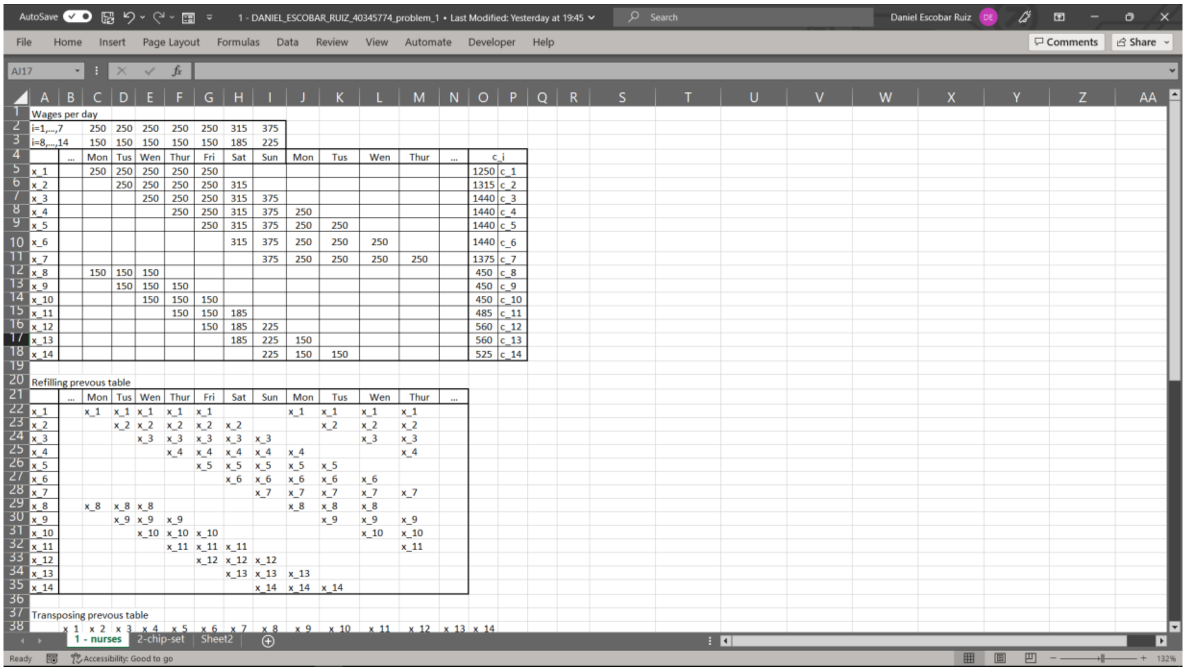
- $P_{A11} = 8000$
- $P_{B11} = 2000$
- $P_{A12} = 16000$
- $P_{B12} = 10000$
- $P_{A13} = 6000$
- $P_{B13} = 10000$

This production plan ensures:

- the demands each month,
- no excess of production and the end of march,
- Minimum cost of production ₽524,320, and
- Maximum profit $\sum_i \sum_j \sum_t \left(S_i P_{ijt} - V_{ij} P_{ijt} - 0.2 E_{i(t-1)}\right) = ₽379{,}680$

The company must increase production capacity (available hours), mainly in plant 1 where productivity if higher.

Appendix 1.



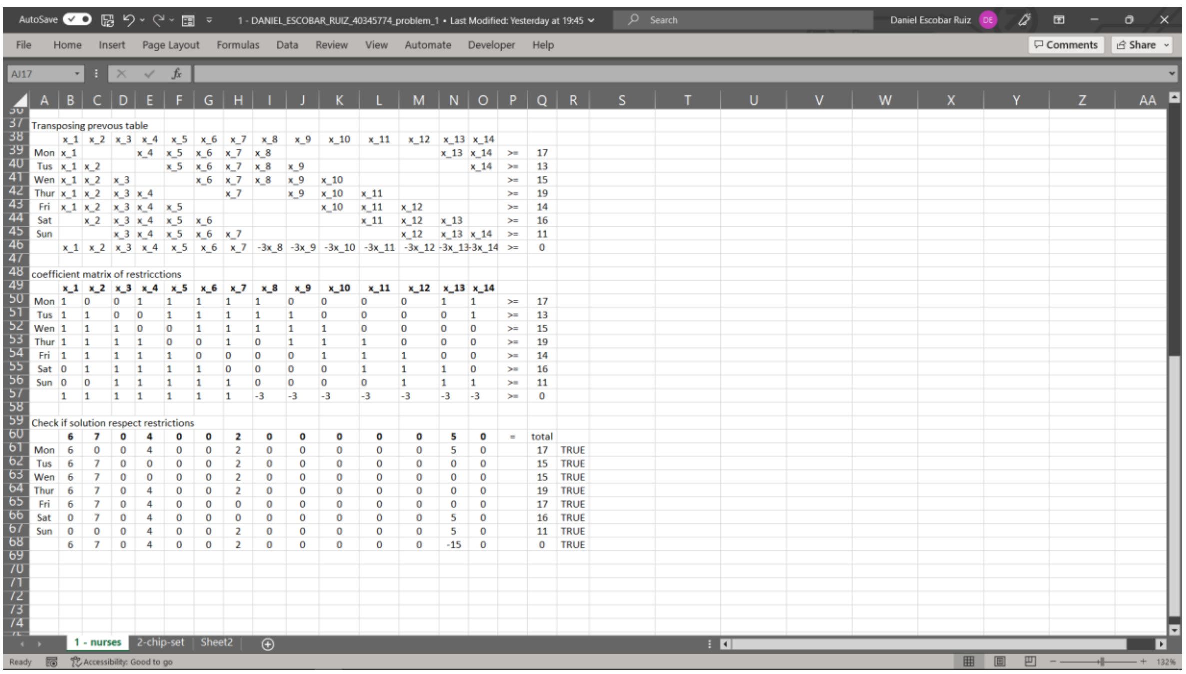
Wages per day

i=1,...,7	250	250	250	250	250	315	375
i=8,...,14	150	150	150	150	150	185	225

	...	Mon	Tus	Wen	Thur	Fri	Sat	Sun	Mon	Tus	Wen	Thur	...	c_i	
x_1		250	250	250	250	250								1250	c_1
x_2			250	250	250	250	315							1315	c_2
x_3				250	250	250	315	375						1440	c_3
x_4					250	250	315	375	250					1440	c_4
x_5						250	315	375	250	250				1440	c_5
x_6							315	375	250	250	250			1440	c_6
x_7								375	250	250	250	250		1375	c_7
x_8		150	150	150										450	c_8
x_9			150	150	150									450	c_9
x_10				150	150	150								450	c_10
x_11					150	150	185							485	c_11
x_12						150	185	225						560	c_12
x_13							185	225	150					560	c_13
x_14								225	150	150				525	c_14

Refilling prevous table

	...	Mon	Tus	Wen	Thur	Fri	Sat	Sun	Mon	Tus	Wen	Thur	...
x_1		x_1	x_1	x_1	x_1	x_1			x_1	x_1	x_1	x_1	
x_2			x_2	x_2	x_2	x_2	x_2			x_2	x_2	x_2	
x_3				x_3	x_3	x_3	x_3	x_3			x_3	x_3	
x_4					x_4	x_4	x_4	x_4	x_4			x_4	
x_5						x_5	x_5	x_5	x_5	x_5			
x_6							x_6	x_6	x_6	x_6	x_6		
x_7								x_7	x_7	x_7	x_7	x_7	
x_8		x_8	x_8	x_8					x_8	x_8	x_8		
x_9			x_9	x_9	x_9					x_9	x_9	x_9	
x_10				x_10	x_10	x_10					x_10	x_10	
x_11					x_11	x_11	x_11					x_11	
x_12						x_12	x_12	x_12					
x_13							x_13	x_13	x_13				
x_14								x_14	x_14	x_14			



Transposing prevous table

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_10	x_11	x_12	x_13	x_14		
Mon	x_1			x_4	x_5	x_6	x_7	x_8					x_13	x_14	>=	17
Tus	x_1	x_2			x_5	x_6	x_7	x_8	x_9					x_14	>=	13
Wen	x_1	x_2	x_3			x_6	x_7	x_8	x_9	x_10					>=	15
Thur	x_1	x_2	x_3	x_4			x_7		x_9	x_10	x_11				>=	19
Fri	x_1	x_2	x_3	x_4	x_5					x_10	x_11	x_12			>=	14
Sat		x_2	x_3	x_4	x_5	x_6					x_11	x_12	x_13		>=	16
Sun			x_3	x_4	x_5	x_6	x_7					x_12	x_13	x_14	>=	11
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	-3x_8	-3x_9	-3x_10	-3x_11	-3x_12	-3x_13	-3x_14	>=	0

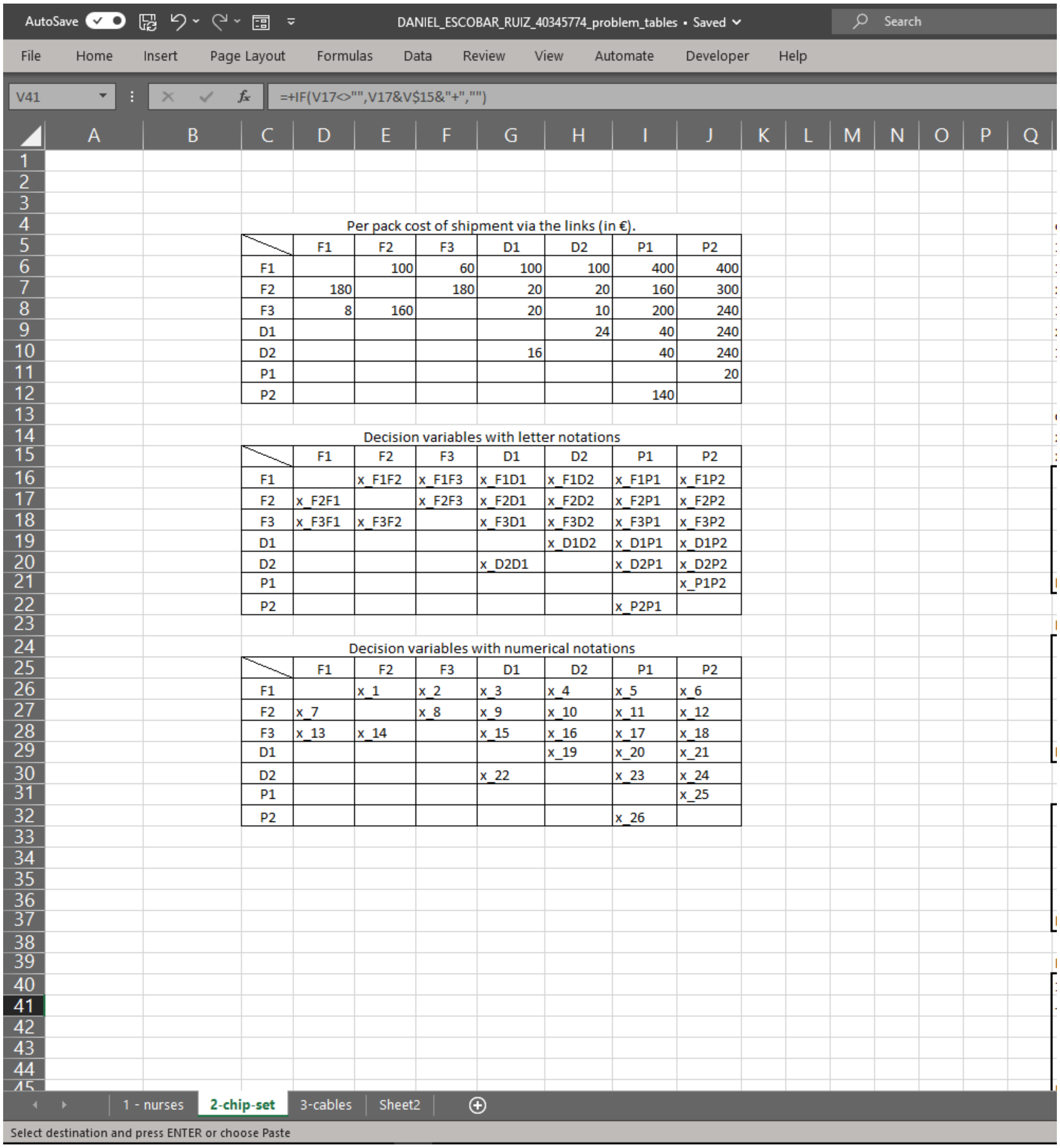
coefficient matrix of restricctions

	x_1	**x_2**	**x_3**	**x_4**	**x_5**	**x_6**	**x_7**	**x_8**	**x_9**	**x_10**	**x_11**	**x_12**	**x_13**	**x_14**		
Mon	1	0	0	1	1	1	1	1	0	0	0	0	1	1	>=	17
Tus	1	1	0	0	1	1	1	1	1	0	0	0	0	1	>=	13
Wen	1	1	1	0	0	1	1	1	1	1	0	0	0	0	>=	15
Thur	1	1	1	1	0	0	1	0	1	1	1	0	0	0	>=	19
Fri	1	1	1	1	1	0	0	0	0	1	1	1	0	0	>=	14
Sat	0	1	1	1	1	1	0	0	0	0	1	1	1	0	>=	16
Sun	0	0	1	1	1	1	1	0	0	0	0	1	1	1	>=	11
	1	1	1	1	1	1	1	-3	-3	-3	-3	-3	-3	-3	>=	0

Check if solution respect restrictions

	6	**7**	**0**	**4**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	=	total	
Mon	6	0	0	4	0	0	2	0	0	0	0	0	5	0		17	TRUE
Tus	6	7	0	0	0	0	2	0	0	0	0	0	0	0		15	TRUE
Wen	6	7	0	0	0	0	2	0	0	0	0	0	0	0		15	TRUE
Thur	6	7	0	4	0	0	2	0	0	0	0	0	0	0		19	TRUE
Fri	6	7	0	4	0	0	0	0	0	0	0	0	0	0		17	TRUE
Sat	0	7	0	4	0	0	0	0	0	0	0	0	5	0		16	TRUE
Sun	0	0	0	4	0	0	2	0	0	0	0	0	5	0		11	TRUE
	6	7	0	4	0	0	2	0	0	0	0	0	-15	0		0	TRUE

Appendix 2.



Per pack cost of shipment via the links (in €).

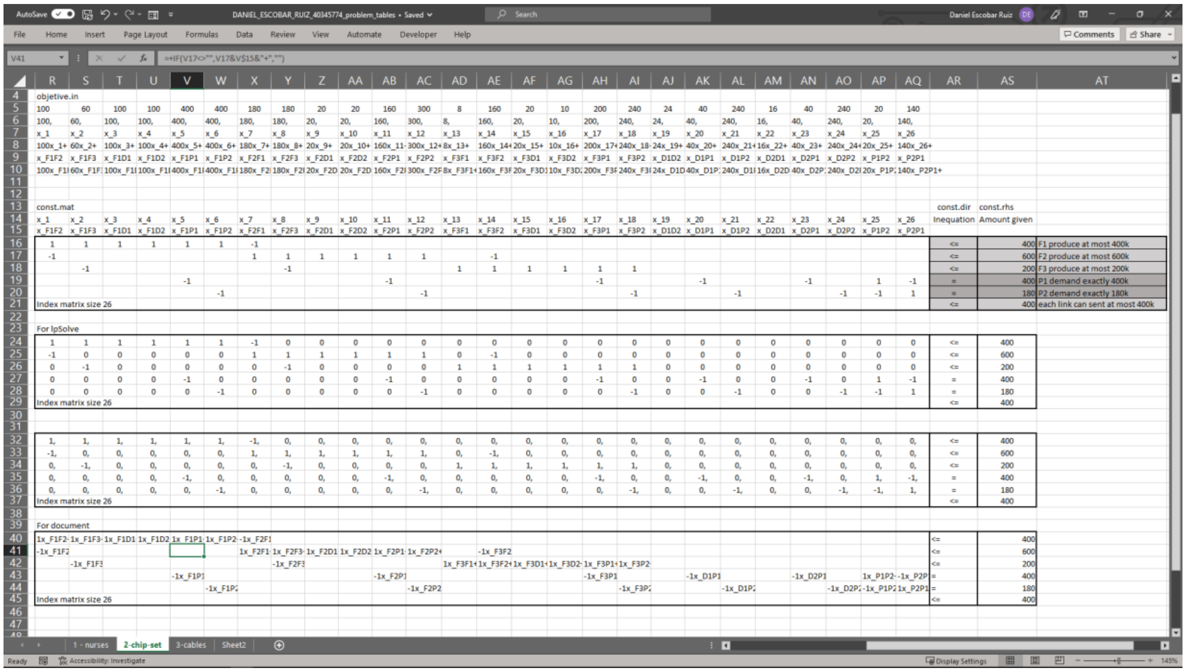
	F1	F2	F3	D1	D2	P1	P2
F1		100	60	100	100	400	400
F2	180		180	20	20	160	300
F3	8	160		20	10	200	240
D1					24	40	240
D2				16		40	240
P1							20
P2						140	

Decision variables with letter notations

	F1	F2	F3	D1	D2	P1	P2
F1		x_F1F2	x_F1F3	x_F1D1	x_F1D2	x_F1P1	x_F1P2
F2	x_F2F1		x_F2F3	x_F2D1	x_F2D2	x_F2P1	x_F2P2
F3	x_F3F1	x_F3F2		x_F3D1	x_F3D2	x_F3P1	x_F3P2
D1					x_D1D2	x_D1P1	x_D1P2
D2				x_D2D1		x_D2P1	x_D2P2
P1							x_P1P2
P2						x_P2P1	

Decision variables with numerical notations

	F1	F2	F3	D1	D2	P1	P2
F1		x_1	x_2	x_3	x_4	x_5	x_6
F2	x_7		x_8	x_9	x_10	x_11	x_12
F3	x_13	x_14		x_15	x_16	x_17	x_18
D1					x_19	x_20	x_21
D2				x_22		x_23	x_24
P1							x_25
P2						x_26	



	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT
4	objetive.in																												
5	100	60	100	100	400	400	180	180	20	20	160	300	8	160	20	10	200	240	24	40	240	16	40	240	20	140			
6	100,	60,	100,	100,	400,	400,	180,	180,	20,	20,	160,	300,	8,	160,	20,	10,	200,	240,	24,	40,	240,	16,	40,	240,	20,	140,			
7	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_10	x_11	x_12	x_13	x_14	x_15	x_16	x_17	x_18	x_19	x_20	x_21	x_22	x_23	x_24	x_25	x_26			
8	100x_1+	60x_2+	100x_3+	100x_4+	400x_5+	400x_6+	180x_7+	180x_8+	20x_9+	20x_10+	160x_11-	300x_12+	8x_13+	160x_14+	20x_15+	10x_16+	200x_17+	240x_18-	24x_19+	40x_20+	240x_21+	16x_22+	40x_23+	240x_24+	20x_25+	140x_26+			
9	x_F1F2	x_F1F3	x_F1D1	x_F1D2	x_F1P1	x_F1P2	x_F2F1	x_F2F3	x_F2D1	x_F2D2	x_F2P1	x_F2P2	x_F3F1	x_F3F2	x_F3D1	x_F3D2	x_F3P1	x_F3P2	x_D1D2	x_D1P1	x_D1P2	x_D2D1	x_D2P1	x_D2P2	x_P1P2	x_P2P1			
10	100x_F1	60x_F1F	100x_F1	100x_F1	400x_F1	400x_F1	180x_F2	180x_F2	20x_F2D	20x_F2D	160x_F2	300x_F2F	8x_F3F1	160x_F3F	20x_F3D1	10x_F3D	200x_F3F	240x_F3	24x_D1D	40x_D1P	240x_D1	16x_D2D	40x_D2P	240x_D2	20x_P1P	140x_P2P1+			
11																													
12																													
13	const.mat																										const.dir	const.rhs	
14	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_10	x_11	x_12	x_13	x_14	x_15	x_16	x_17	x_18	x_19	x_20	x_21	x_22	x_23	x_24	x_25	x_26	Inequation	Amount given	
15	x_F1F2	x_F1F3	x_F1D1	x_F1D2	x_F1P1	x_F1P2	x_F2F1	x_F2F3	x_F2D1	x_F2D2	x_F2P1	x_F2P2	x_F3F1	x_F3F2	x_F3D1	x_F3D2	x_F3P1	x_F3P2	x_D1D2	x_D1P1	x_D1P2	x_D2D1	x_D2P1	x_D2P2	x_P1P2	x_P2P1			
16	1	1	1	1	1	1	-1																				<=	400	F1 produce at most 400k
17	-1						1	1	1	1	1	1		-1													<=	600	F2 produce at most 600k
18		-1						-1					1	1	1	1	1	1									<=	200	F3 produce at most 200k
19					-1						-1						-1			-1			-1		1	-1	=	400	P1 demand exactly 400k
20						-1						-1						-1			-1			-1	-1	1	=	180	P2 demand exactly 180k
21	Index matrix size 26																										<=	400	each link can sent at most 400k
22																													
23	For lpSolve																												
24	1	1	1	1	1	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<=	400	
25	-1	0	0	0	0	0	1	1	1	1	1	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	<=	600	
26	0	-1	0	0	0	0	0	-1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	<=	200	
27	0	0	0	0	-1	0	0	0	0	0	-1	0	0	0	0	0	-1	0	0	-1	0	0	-1	0	1	-1	=	400	
28	0	0	0	0	0	-1	0	0	0	0	0	-1	0	0	0	0	0	-1	0	0	-1	0	0	-1	-1	1	=	180	
29	Index matrix size 26																										<=	400	
30																													
31																													
32	1,	1,	1,	1,	1,	1,	-1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	<=	400	
33	-1,	0,	0,	0,	0,	0,	1,	1,	1,	1,	1,	1,	0,	-1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	<=	600	
34	0,	-1,	0,	0,	0,	0,	0,	-1,	0,	0,	0,	0,	1,	1,	1,	1,	1,	1,	0,	0,	0,	0,	0,	0,	0,	0,	<=	200	
35	0,	0,	0,	0,	-1,	0,	0,	0,	0,	0,	-1,	0,	0,	0,	0,	0,	-1,	0,	0,	-1,	0,	0,	-1,	0,	1,	-1,	=	400	
36	0,	0,	0,	0,	0,	-1,	0,	0,	0,	0,	0,	-1,	0,	0,	0,	0,	0,	-1,	0,	0,	-1,	0,	0,	-1,	-1,	1,	=	180	
37	Index matrix size 26																										<=	400	
38																													
39	For document																												
40	1x_F1F2-	1x_F1F3-	1x_F1D1	1x_F1D2	1x_F1P1-	1x_F1P2-	-1x_F2F1																				<=	400	
41	-1x_F1F2						1x_F2F1-	1x_F2F3-	1x_F2D1	1x_F2D2	1x_F2P1-	1x_F2P2+		-1x_F3F2													<=	600	
42		-1x_F1F3						-1x_F2F3					1x_F3F1+	1x_F3F2+	1x_F3D1+	1x_F3D2-	1x_F3P1+	1x_F3P2-									<=	200	
43					-1x_F1P1						-1x_F2P1						-1x_F3P1			-1x_D1P1			-1x_D2P1		1x_P1P2-	-1x_P2P1	=	400	
44						-1x_F1P2						-1x_F2P2						-1x_F3P2			-1x_D1P2			-1x_D2P2	-1x_P1P2	1x_P2P1	=	180	
45	Index matrix size 26																										<=	400	

Appendix 3.

P_ijt					
month	cable	A	A	B	B
	plant	1	2	1	2
	1	P_A11=?	P_A21=?	P_B11=?	P_B21=?
	2	P_A12=?	P_A22=?	P_B12=?	P_B22=?
	3	P_A13=?	P_A23=?	P_B13=?	P_B23=?

D_it		
month\cable	A	B
1	8,000	2,000
2	16,000	10,000
3	6,000	10,000
Total	30,000	22,000

D_it		
month\cable	A	B
1	D_A1=8000	D_B1=2000
2	D_A2=16000	D_B2=10000
3	D_A3=6000	D_B3=10000
	SUM(D_At)=3(	SUM(D_Bt)=22000

R_ji		
Plant\cable	A	B
1	0.30	0.24
2	0.32	0.28

A_ij		
Plant\cable	A	B
1	R_A1=0.3	R_B1=0.24
2	R_A2=0.32	R_B2=0.28

W_i		
plant	A	B
	6.2	7.8

W_i		
cable	A	B
	W_A=6.2	W_B=7.8

V_ij = 10R_ji + W_i + 0.46		
Plant\cable	A	B
1	9.66	10.66
2	9.86	11.06

V_ij = 10R_ji + W_i + 0.46		
Plant\cable	A	B
1	V_A1=9.66	V_B1=10.66
2	V_A2=9.86	V_B2=11.06

AutoSave DANIEL_ESCOBAR_RUIZ_40345774_problem_tables • Last Modified: 56m ago Search

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G39 =+"A_"&G$37&$F39&"="&C39

V_ij = 10R_ji + W_i + 0.46		
Plant\cable	A	B
1	9.66	10.66
2	9.86	11.06

V_ij = 10R_ji + W_i + 0.46		
Plant\cable	A	B
1	V_A1=9.66	V_B1=10.66
2	V_A2=9.86	V_B2=11.06

S_i		
cable	A	B
	14	18

S_i		
cable	A	B
	S_A=14	S_B=18

A_ij		
month\plant	1	2
1	1,400	3,000
2	600	800
3	2,000	600

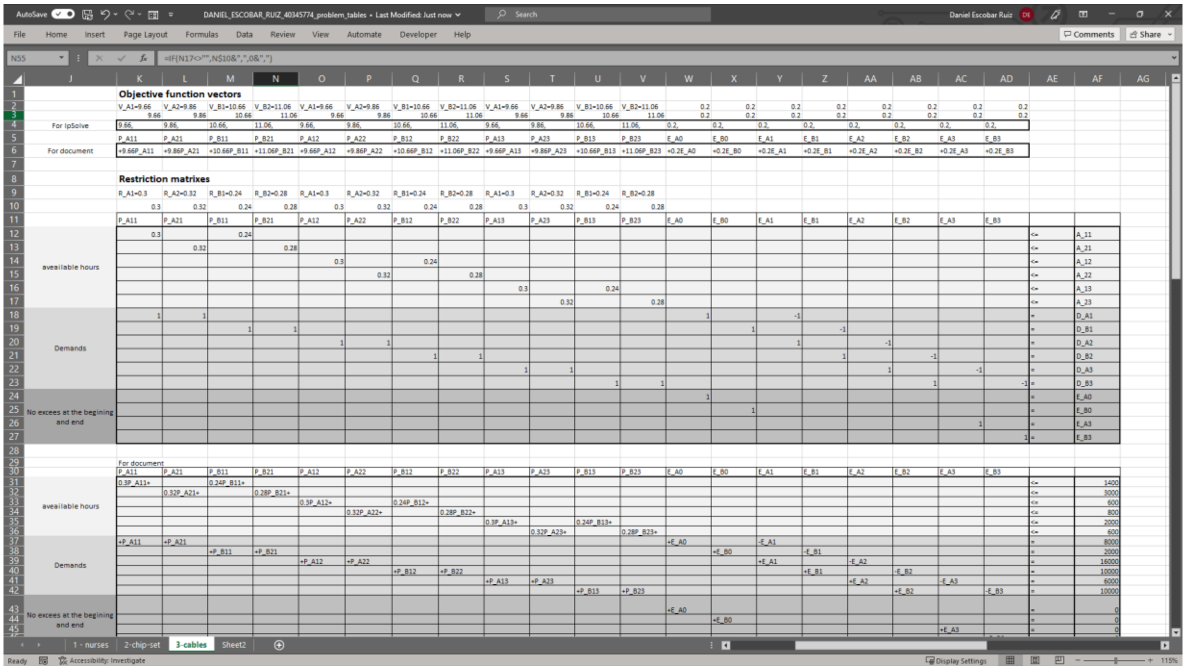
A_ij		
Month\Plant	1	2
1	A_11=1400	A_21=3000
2	A_12=600	A_22=800
3	A_13=2000	A_23=600

E_it		
month\cable	A	B
0	0	0
1	?	?
2	?	?
3	0	0

E_it		
month\cable	A	B
0	E_A0=0	E_B0=0
1	E_A1=?	E_B1=?
2	E_A2=?	E_B2=?
3	E_A3=0	E_B3=0

1 - nurses 2-chip-set 3-cables Sheet2

Ready Accessibility: Investigate



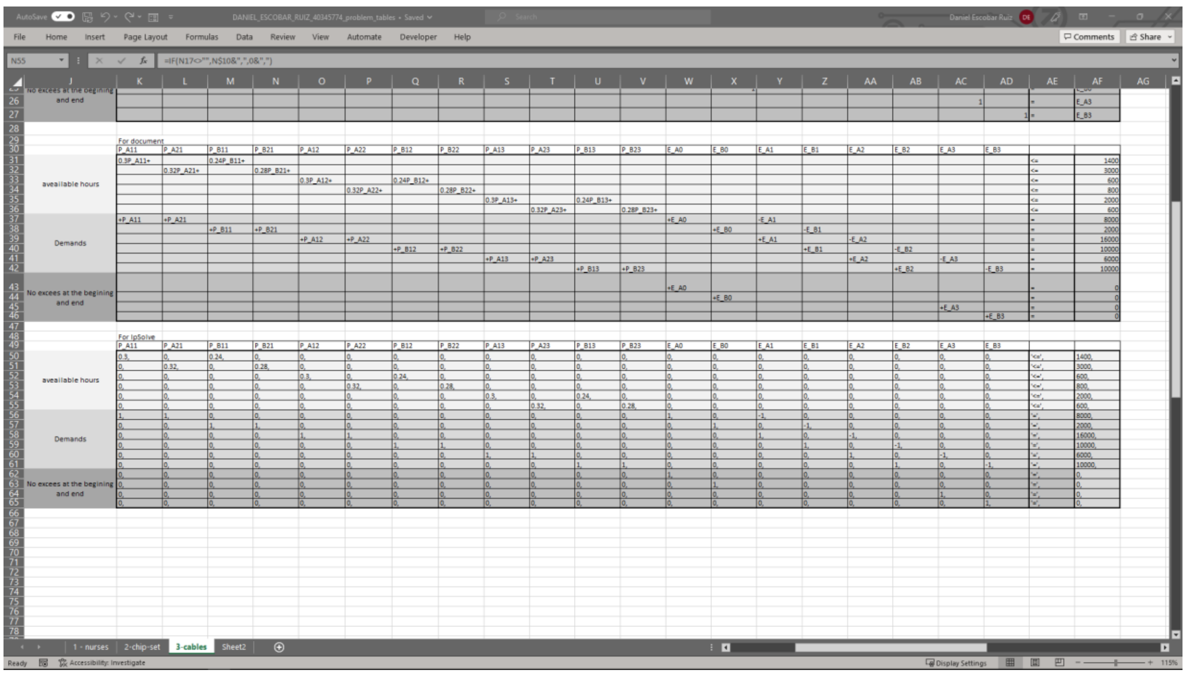
	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3
Objective function vectors	V_A1=9.66	V_A2=9.86	V_B1=10.66	V_B2=11.06	V_A1=9.66	V_A2=9.86	V_B1=10.66	V_B2=11.06	V_A1=9.66	V_A2=9.86	V_B1=10.66	V_B2=11.06	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	9.66	9.86	10.66	11.06	9.66	9.86	10.66	11.06	9.66	9.86	10.66	11.06	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
For lpSolve	9.66,	9.86,	10.66,	11.06,	9.66,	9.86,	10.66,	11.06,	9.66,	9.86,	10.66,	11.06,	0.2,	0.2,	0.2,	0.2,	0.2,	0.2,	0.2,	0.2,
	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3
For document	+9.66P_A11	+9.86P_A21	+10.66P_B11	+11.06P_B21	+9.66P_A12	+9.86P_A22	+10.66P_B12	+11.06P_B22	+9.66P_A13	+9.86P_A23	+10.66P_B13	+11.06P_B23	+0.2E_A0	+0.2E_B0	+0.2E_A1	+0.2E_B1	+0.2E_A2	+0.2E_B2	+0.2E_A3	+0.2E_B3

Restriction matrixes

	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3		
	R_A1=0.3	R_A2=0.32	R_B1=0.24	R_B2=0.28	R_A1=0.3	R_A2=0.32	R_B1=0.24	R_B2=0.28	R_A1=0.3	R_A2=0.32	R_B1=0.24	R_B2=0.28										
	0.3	0.32	0.24	0.28	0.3	0.32	0.24	0.28	0.3	0.32	0.24	0.28										
aveailable hours	0.3		0.24																		<=	A_11
		0.32		0.28																	<=	A_21
					0.3		0.24														<=	A_12
						0.32		0.28													<=	A_22
									0.3		0.24										<=	A_13
										0.32		0.28									<=	A_23
Demands	1	1											1		-1						=	D_A1
			1	1										1		-1					=	D_B1
					1	1									1		-1				=	D_A2
							1	1								1		-1			=	D_B2
									1	1							1		-1		=	D_A3
											1	1						1		-1	=	D_B3
No excees at the begining and end													1								=	E_A0
														1							=	E_B0
																			1		=	E_A3
																				1	=	E_B3

For document

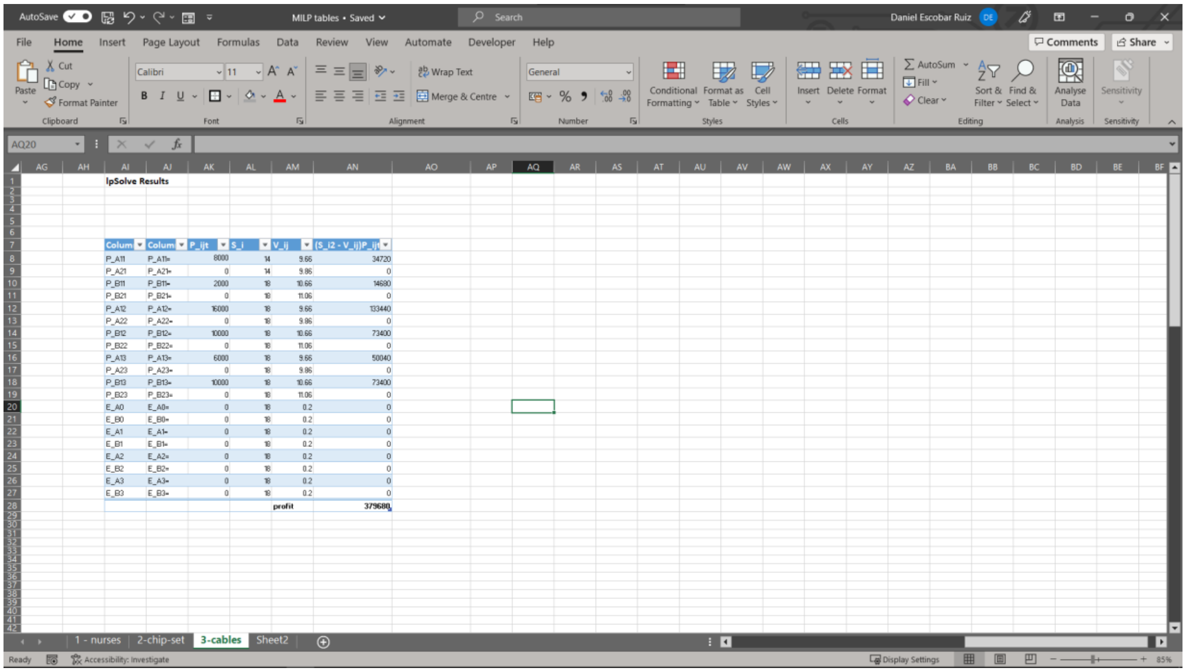
	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3		
aveailable hours	0.3P_A11+		0.24P_B11+																		<=	1400
		0.32P_A21+		0.28P_B21+																	<=	3000
					0.3P_A12+		0.24P_B12+														<=	600
						0.32P_A22+		0.28P_B22+													<=	800
									0.3P_A13+		0.24P_B13+										<=	2000
										0.32P_A23+		0.28P_B23+									<=	600
Demands	+P_A11	+P_A21											+E_A0		-E_A1						=	8000
			+P_B11	+P_B21										+E_B0		-E_B1					=	2000
					+P_A12	+P_A22									+E_A1		-E_A2				=	16000
							+P_B12	+P_B22								+E_B1		-E_B2			=	10000
									+P_A13	+P_A23							+E_A2		-E_A3		=	6000
											+P_B13	+P_B23						+E_B2		-E_B3	=	10000
No excees at the begining and end													+E_A0								=	0
														+E_B0							=	0
																			+E_A3		=	0



	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3		
No excees at the begining and end																				+E_B3	=	0

For lpSolve

	P_A11	P_A21	P_B11	P_B21	P_A12	P_A22	P_B12	P_B22	P_A13	P_A23	P_B13	P_B23	E_A0	E_B0	E_A1	E_B1	E_A2	E_B2	E_A3	E_B3		
aveailable hours	0.3,	0,	0.24,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	1400,
	0,	0.32,	0,	0.28,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	3000,
	0,	0,	0,	0,	0.3,	0,	0.24,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	600,
	0,	0,	0,	0,	0,	0.32,	0,	0.28,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	800,
	0,	0,	0,	0,	0,	0,	0,	0,	0.3,	0,	0.24,	0,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	2000,
	0,	0,	0,	0,	0,	0,	0,	0,	0,	0.32,	0,	0.28,	0,	0,	0,	0,	0,	0,	0,	0,	'<=',	600,
Demands	1,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	-1,	0,	0,	0,	0,	0,	'=',	8000,
	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	-1,	0,	0,	0,	0,	'=',	2000,
	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	-1,	0,	0,	0,	'=',	16000,
	0,	0,	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,	0,	1,	0,	-1,	0,	0,	'=',	10000,
	0,	0,	0,	0,	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,	1,	0,	-1,	0,	'=',	6000,
	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	1,	0,	-1,	'=',	10000,
No excees at the begining and end	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,	0,	'=',	0,
	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,	'=',	0,
	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	'=',	0,
	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	'=',	0,



lpSolve Results

Colum	Colum	P_ijt	S_i	V_ij	(S_i2 - V_ij)P_ijt
P_A11	P_A11=	8000	14	9.66	34720
P_A21	P_A21=	0	14	9.86	0
P_B11	P_B11=	2000	18	10.66	14680
P_B21	P_B21=	0	18	11.06	0
P_A12	P_A12=	16000	18	9.66	133440
P_A22	P_A22=	0	18	9.86	0
P_B12	P_B12=	10000	18	10.66	73400
P_B22	P_B22=	0	18	11.06	0
P_A13	P_A13=	6000	18	9.66	50040
P_A23	P_A23=	0	18	9.86	0
P_B13	P_B13=	10000	18	10.66	73400
P_B23	P_B23=	0	18	11.06	0
E_A0	E_A0=	0	18	0.2	0
E_B0	E_B0=	0	18	0.2	0
E_A1	E_A1=	0	18	0.2	0
E_B1	E_B1=	0	18	0.2	0
E_A2	E_A2=	0	18	0.2	0
E_B2	E_B2=	0	18	0.2	0
E_A3	E_A3=	0	18	0.2	0
E_B3	E_B3=	0	18	0.2	0
				profit	379680