A summary of the project in English is available here:

The question posed to us requires reducing the cost of student transportation services by appropriately allocating them to schools. In the table below, the number of students in a given area is specified, along with the percentage of students in each grade. The cost of school transportation from each area to each school is also determined. Each grade can constitute 30 to 36 percent of the total population of a school. Students from a specific area and grade can be assigned to one school or another. Note that the dashed line in the table indicates that students from that area cannot be allocated to the specified school.

Transportation cost per student			Area	Total students' population	Percentage of 7th grade	Percentage of 8th grade	Percentage of 9th grade
Scholl no.1	Scholl no.2	Scholl no.3					
300	0	700	1	450	32	38	30
-	400	500	2	600	37	28	35
600	300	200	3	550	30	32	28
200	500	-	4	350	28	40	32
0	-	400	5	500	39	34	27
500	300	0	6	450	34	28	38
900	1100	1000	Schools' capacity				

Solution (By Sajjad Abed):

Model:

$$Min\ Z = \sum_{i=1}^{6}\sum_{k=1}^{3}\left(C_{i,k} * \sum_{j=7}^{9} S_{i,j,k}\right)$$

$s.t.$

$$\sum_{k=1}^{3} S_{i,j,k} = P_{i,j} * N_i \qquad for\ i\ in(1-6)\ , j\ in\ (7-9)$$

$$\sum_{i=1}^{6}\sum_{j=7}^{9} S_{i,j,k} \leq Cap_k \qquad for\ k\ in(1-3)$$

$$0.3 * \sum_{i=1}^{6}\sum_{jj=7}^{9} S_{i,jj,k} \leq \sum_{i=1}^{6} S_{i,j,k} \qquad for\ k\ in(1-3)\ , j\ in\ (7-9)$$

$$\sum_{i=1}^{6} S_{i,j,k} \leq 0.36 * \sum_{i=1}^{6}\sum_{jj=7}^{9} S_{i,jj,k} \qquad for\ i\ in(1-6)\ , j\ in\ (7-9)$$

$$S_{2,j,1} = S_{4,j,3} = S_{5,j,2} = 0 \qquad for\ j\ in\ (7-9)$$

$$0 \leq S_{i,j,k}$$

$$S_{i,j,k}\ \ (int)$$

In which:

Number of students from region i and grade j assigned to school k (Variable): $S_{i,j,k}$
Cost of assigning a student from region i to school k (Parameter): $C_{i,k}$
Percentage of students from region i studying in grade j (Parameter): $P_{i,j}$
Number of students in region i (Parameter): N_i
Capacity of school k (Parameter): Cap_k
Additionally, indices i, j, and k represent the region, grade, and school, respectively.

CPlex code:

OR2_Project.mod | OR2_Project.dat | OR2_Project.ops

```
/*********************************************
 * OPL 12.9.0.0 Data
 * Author: sabed
 * Creation Date: Nov 19, 2021 at 4:31:53 PM
 *********************************************/

SheetConnection connex ("data.xlsx");

Cap from SheetRead (connex,"data!B3:B5");
P from SheetRead (connex,"data!E3:G8");
C from SheetRead (connex,"data!E11:G16");
N from SheetRead (connex,"data!B10:B15");

someSet to SheetWrite (connex, "Result!B2:E55");
```

School	Capacity
1	900
2	1100
3	1000

Area	Numbers (N)
1	450
2	600
3	550
4	350
5	500
6	450

	Percentage of students (P)		
Area	School 1	School 2	School 3
1	0.32	0.38	0.3
2	0.37	0.28	0.35
3	0.3	0.32	0.38
4	0.28	0.4	0.32
5	0.39	0.34	0.27
6	0.34	0.28	0.38

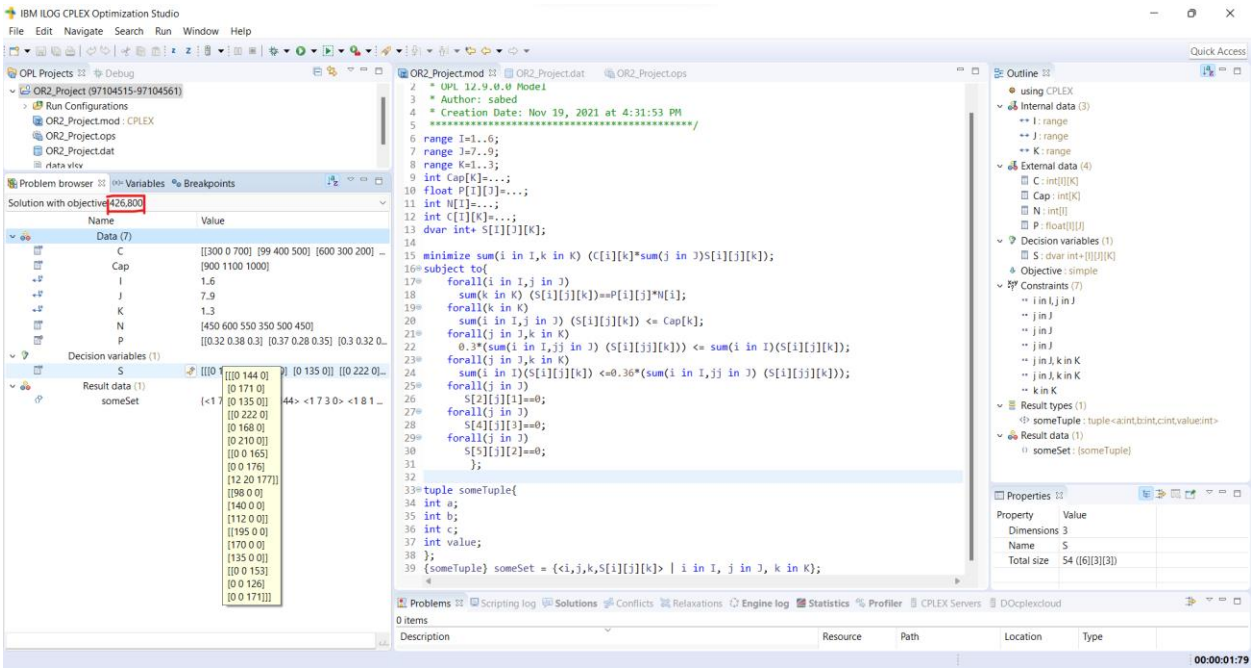
	Transportation Cost (C)		
Area	School 1	School 2	School 3
1	300	0	700
2	99	400	500
3	600	300	200
4	200	500	99
5	0	99	400
6	500	300	0

.mod code:

OR2_Project.mod | OR2_Project.dat | OR2_Project.ops

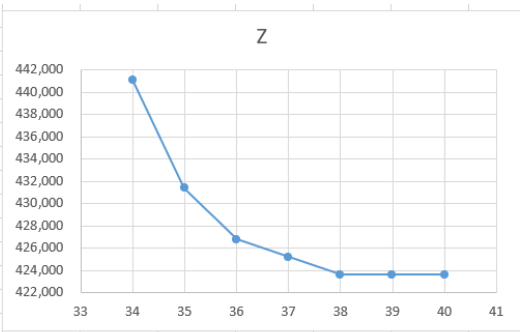
```
 * OPL 12.9.0.0 Model
 * Author: sabed
 * Creation Date: Nov 19, 2021 at 4:31:53 PM
 *********************************************/
range I=1..6;
range J=7..9;
range K=1..3;
int Cap[K]=...;
float P[I][J]=...;
int N[I]=...;
int C[I][K]=...;
dvar int+ S[I][J][K];

minimize sum(i in I,k in K) (C[i][k]*sum(j in J)S[i][j][k]);
subject to{
    forall(i in I,j in J)
      sum(k in K) (S[i][j][k])==P[i][j]*N[i];
    forall(k in K)
      sum(i in I,j in J) (S[i][j][k]) <= Cap[k];
    forall(j in J,k in K)
      0.3*(sum(i in I,jj in J) (S[i][jj][k])) <= sum(i in I)(S[i][j][k]);
    forall(j in J,k in K)
      sum(i in I)(S[i][j][k]) <=0.36*(sum(i in I,jj in J) (S[i][jj][k]));
    forall(j in J)
       S[2][j][1]==0;
    forall(j in J)
       S[4][j][3]==0;
    forall(j in J)
       S[5][j][2]==0;
        };

tuple someTuple{
int a;
int b;
int c;
int value;
};
{someTuple} someSet = {<i,j,k,S[i][j][k]> | i in I, j in J, k in K};
```

CPlex output:

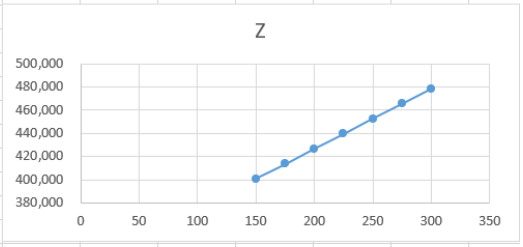


Sensitive Analysis:

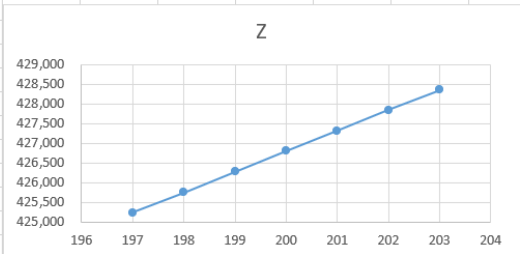
Upper Bound	Z
34	441,100
35	431,400
36	426,800
37	425,200
38	423,600
39	423,600
40	423,600



زینه ناحیه 3 به مدرسه 3	Z
150	400,850
175	413,825
200	426,800
225	439,750
250	452,700
275	465,650
300	478,600



زینه ناحیه 3 به مدرسه 3	Z
197	425,243
198	425,762
199	426,281
200	426,800
201	427,318
202	427,836
203	428,354



Shadow price:

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
I4	XA	0	-11.25	20	11.25	1.00E+30
J4	XB	10	0	50	1.00E+30	3.333333333
K4	XC	0	-2.5	35	2.5	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
O5	Milling	50	0	60	1E+30	10
P5	Rounding	65	0	100	1E+30	35
Q5	Drilling	40	12.5	40	8	40

RESULT:

Area	Grade	School	Capacity
1	7	1	0
1	7	2	144
1	7	3	0
1	8	1	0
1	8	2	171
1	8	3	0
1	9	1	0
1	9	2	135
1	9	3	0
2	7	1	0
2	7	2	222
2	7	3	0
2	8	1	0
2	8	2	168
2	8	3	0
2	9	1	0
2	9	2	210
2	9	3	0
3	7	1	0
3	7	2	0
3	7	3	165
3	8	1	0
3	8	2	0
3	8	3	176
3	9	1	12
3	9	2	20
3	9	3	177
4	7	1	98
4	7	2	0
4	7	3	0
4	8	1	140
4	8	2	0
4	8	3	0
4	9	1	112
4	9	2	0
4	9	3	0
5	7	1	195
5	7	2	0
5	7	3	0
5	8	1	170
5	8	2	0
5	8	3	0
5	9	1	135
5	9	2	0
5	9	3	0
6	7	1	0
6	7	2	0
6	7	3	153
6	8	1	0
6	8	2	0
6	8	3	126
6	9	1	0
6	9	2	0
6	9	3	171