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The Study of Linear Programming Approach for Optimal Scheduling of Work in A Corporation With different Models

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Abstract

In the present research paper, two types of models are discussed for linear programming problems. Models are determining the work of the employee in day-to-day life. The first is Staff Scheduling for Bhopal-Dewas Corridor Toll Plaza and second is worker scheduling for Aqua sure Aquagurad Water Purifiers drinking water Company(Rukmani Beverages Pvt. Ltd.).

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Keywords: Mathematical optimization, Linear programming, Integer programming, Scheduling, staff scheduling.

1. Introduction

Staff scheduling is a special case of a linear programming problem, which is used to reduce the number of employees, labour costs and expenses incurred in any business or industry. For example, in all the critical small and large enterprises, scheduling of employees in many big toll plazas, many telephone companies, large hospitals, etc. are required. The present work discusses only two types of the problems first for Staff Scheduling for Bhopal-Dewas Corridor Toll Plaza and second for Aqua sure Aquagurad Water Purifiers Drinking Water Company. These models aim to arrange the scheduling of staff and utilize their efficiency. Many others researcher as Rama.S, Srividya S, Deepa Bellatti[1], Lorraine Trilling, Alain Guinet, Dominique Le Magny[2], Mohsen Bayati, ErfanKharazmi, Mehdi Javananbakht, Aboozar Sadeghi, MasudArefnejad, SajadVahedi, FiroozEsmaeilzadeh[3], worked in this field. We [4] also worked in this field.

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2. MODEL 1: Staff Scheduling for Bhopal-Dewas Corridor Toll Plaza

3. 3.1 Problem Definition and solutions: The Bhopal- Dewas Corridor Toll Plaza has Open 24 hours with the Staff Scheduling requests, staff demand for each 24-hour time frame:

Hours	Need Workers (Collectors)
12 a.m. to 6 a.m.	20
6 to 10 a.m.	30
10 to 12 p.m.	24
12 p.m. to 4 p.m.	22
4 to 6 p.m.	16
6 to 10 p.m.	25
10 to 12 a.m. (midnight)	23

Each worker (collector) works four working hours, is of one hour off, and then works another four working hours. A collector can start at each working hour. Considering the purpose is to reduce the number of workers (Toll Plaza collectors) hired how different collectors should begin work every hour.

3.2. Problem Formulation and Solution

Determine the decision variables:

S_1 = No. of Toll Plaza collectors to begin work at 12 a.m. midnight,

S_2 = No. of Toll Plaza collectors to begin work at 1 a.m.,

S_3 = No. of Toll Plaza collectors to begin work at 2 a.m.,

S_4 = No. of Toll Plaza collectors to begin work at 3 a.m.,

S_5 = No. of Toll Plaza collectors to begin work at 4 a.m.,

S_6 = No. of Toll Plaza collectors to begin work at 5 a.m.,

S_7 = No. of Toll Plaza collectors to begin work at 6 a.m.,

S_8 = No. of Toll Plaza collectors to begin work at 7 a.m.,

S_9 = No. of Toll Plaza collectors to begin work at 8 a.m.,

S_{10} = No. of Toll Plaza collectors to begin work at 9 a.m.,

S_{11} = No. of Toll Plaza collectors to begin work at 10 a.m.,

S_{12} = No. of Toll Plaza collectors to begin work at 11 a.m.,

S_{13} = No. of Toll Plaza collectors to begin work at 12 p.m.,

S_{14} = No. of Toll Plaza collectors to begin work at 1 p.m.,

S_{15} = No. of Toll Plaza collectors to begin work at 2 p.m.,

S_{16} = No. of Toll Plaza collectors to begin work at 3 p.m.,

S_{17} = No. of Toll Plaza collectors to begin work at 4 p.m.,

S_{18} = No. of Toll Plaza collectors to begin work at 5 p.m.,

S_{19} = No. of Toll Plaza collectors to begin work at 6 p.m.,

S_{20} = No. of Toll Plaza collectors to begin work at 7 p.m.,

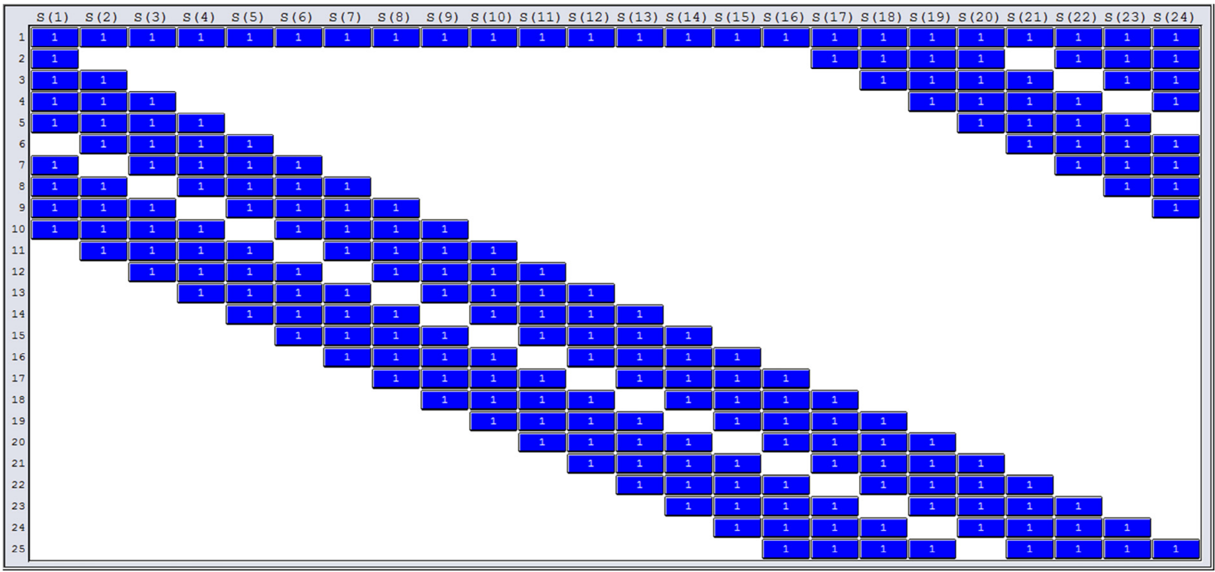
S_{21} = No. of Toll Plaza collectors to begin work at 8 p.m.,

S_{22} = No. of Toll Plaza collectors to begin work at 9 p.m.,

S_{23} = No. of Toll Plaza collectors to begin work at 10 p.m.,

S_{24} = No. of Toll Plaza collectors to begin work at 11 p.m.

An obstacle will be mandatory for every working hours of the day, which expresses the number of Toll Plaza collectors of that time, what is the required number for that hour. It aims to minimize the number of Toll Plaza collectors chosen for the 24 hours. All formally:



	S(1)	S(2)	S(3)	S(4)	S(5)	S(6)	S(7)	S(8)	S(9)	S(10)	S(11)	S(12)	S(13)	S(14)	S(15)	S(16)	S(17)	S(18)	S(19)	S(20)	S(21)	S(22)	S(23)	S(24)
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1																1	1	1	1		1	1	1
3	1	1																1	1	1	1		1	1
4	1	1	1																1	1	1	1		1
5	1	1	1	1																1	1	1	1	
6		1	1	1	1																1	1	1	1
7	1		1	1	1	1																1	1	1
8	1	1		1	1	1	1																1	1
9	1	1	1		1	1	1	1																1
10	1	1	1	1		1	1	1	1															
11		1	1	1	1		1	1	1	1														
12			1	1	1	1		1	1	1	1													
13				1	1	1	1		1	1	1	1												
14					1	1	1	1		1	1	1	1											
15						1	1	1	1		1	1	1	1										
16							1	1	1	1		1	1	1	1									
17								1	1	1	1		1	1	1	1								
18									1	1	1	1		1	1	1	1							
19										1	1	1	1		1	1	1	1						
20											1	1	1	1		1	1	1	1					
21												1	1	1	1		1	1	1	1				
22													1	1	1	1		1	1	1	1			
23														1	1	1	1		1	1	1	1		
24															1	1	1	1		1	1	1	1	
25																1	1	1	1		1	1	1	1

$$\text{Minimize } = S_1 + S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8 + S_9 + S_{10} + S_{11} + S_{12} + S_{13} + S_{14} + S_{15} + S_{16} + S_{17} + S_{18} + S_{19} + S_{20} + S_{21} + S_{22} + S_{23} + S_{24};$$

Subject to :

$$S_1 + S_{17} + S_{18} + S_{19} + S_{20} + S_{22} + S_{23} + S_{24} \geq 20;$$

$$S_1 + S_2 + S_{18} + S_{19} + S_{20} + S_{21} + S_{23} + S_{24} \geq 20;$$

$$S_1 + S_2 + S_3 + S_{19} + S_{20} + S_{21} + S_{22} + S_{24} \geq 20;$$

$$S_1 + S_2 + S_3 + S_4 + S_{20} + S_{21} + S_{22} + S_{23} \geq 20;$$

$$S_2 + S_3 + S_4 + S_5 + S_{21} + S_{22} + S_{23} + S_{24} \geq 20;$$

$$S_1 + S_3 + S_4 + S_5 + S_6 + S_{22} + S_{23} + S_{24} \geq 20;$$

$$S_1 + S_2 + S_4 + S_5 + S_6 + S_7 + S_{23} + S_{24} \geq 30;$$

$$S_1 + S_2 + S_3 + S_5 + S_6 + S_7 + S_8 + S_{24} \geq 30;$$
$$S_1 + S_2 + S_3 + S_4 + S_6 + S_7 + S_8 + S_9 \geq 30;$$
$$S_2 + S_3 + S_4 + S_5 + S_7 + S_8 + S_9 + S_{10} \geq 30;$$
$$S_3 + S_4 + S_5 + S_6 + S_8 + S_9 + S_{10} + S_{11} \geq 24;$$
$$S_4 + S_5 + S_6 + S_7 + S_9 + S_{10} + S_{11} + S_{12} \geq 24;$$
$$S_5 + S_6 + S_7 + S_8 + S_{10} + S_{11} + S_{12} + S_{13} \geq 22;$$
$$S_6 + S_7 + S_8 + S_9 + S_{11} + S_{12} + S_{13} + S_{14} \geq 22;$$
$$S_7 + S_8 + S_9 + S_{10} + S_{12} + S_{13} + S_{14} + S_{15} \geq 22;$$
$$S_8 + S_9 + S_{10} + S_{11} + S_{13} + S_{14} + S_{15} + S_{16} \geq 22;$$
$$S_9 + S_{10} + S_{11} + S_{12} + S_{14} + S_{15} + S_{16} + S_{17} \geq 16;$$
$$S_{10} + S_{11} + S_{12} + S_{13} + S_{15} + S_{16} + S_{17} + S_{18} \geq 16;$$
$$S_{11} + S_{12} + S_{13} + S_{14} + S_{16} + S_{17} + S_{18} + S_{19} \geq 25;$$
$$S_{12} + S_{13} + S_{14} + S_{15} + S_{17} + S_{18} + S_{19} + S_{20} \geq 25;$$
$$S_{13} + S_{14} + S_{15} + S_{16} + S_{18} + S_{19} + S_{20} + S_{21} \geq 25;$$
$$S_{14} + S_{15} + S_{16} + S_{17} + S_{19} + S_{20} + S_{21} + S_{22} \geq 25;$$
$$S_{15} + S_{16} + S_{17} + S_{18} + S_{20} + S_{21} + S_{22} + S_{23} \geq 23;$$
$$S_{16} + S_{17} + S_{18} + S_{19} + S_{21} + S_{22} + S_{23} + S_{24} \geq 23;$$
$$S_1 \geq 0; S_2 \geq 0; S_3 \geq 0; S_4 \geq 0; S_5 \geq 0; S_6 \geq 0; S_7 \geq 0;$$
$$S_8 \geq 0; S_9 \geq 0; S_{10} \geq 0; S_{11} \geq 0; S_{12} \geq 0; S_{13} \geq 0; S_{14} \geq 0;$$
$$S_{15} \geq 0; S_{16} \geq 0; S_{17} \geq 0; S_{18} \geq 0; S_{19} \geq 0; S_{20} \geq 0; S_{21} \geq 0;$$
$$S_{22} \geq 0; S_{23} \geq 0; S_{24} \geq 0;$$

3.3. Programming:

There are two different sets, in which one of them for the 24-hours in the day & then another for the nine-hour shift scheduling.

The index for the S variable:
MODEL:! 24-hour Staff scheduling shift;
SETS:!Every shift is Four hours on, One hour off, Four hours on;
HOUR/1...24/: S, NEED;
END SET
DATA:
NEED=20, 20, 20, 20, 20, 20, 30, 30, 30, 30, 24, 24, 22, 22, 22, 22, 16, 16, 25, 25, 25, 25, 23, 23;
END DATE
MIN = @SUM (HOUR (I): S (I));

@FOR (HOUR (I):! Representation number of Persons on duty in the hour I am those who started nine or sometimes earlier, but not five;

@SUM(HOUR(J)|(J#LE#9)#AND#(J#NE#5) : S(@WRAP((I - J + 1),24))) ≥ NEED(I));

END

Result and discussion model 1:

When applying Linear programming problem, then we are getting an objective value Such that = 72, among the following nonzero variables:
$S_2 = 5.5, S_5 = 3, S_8 = 3, S_{15} = 7.75, S_{18}=4, S_{22}= 0.50, S_3 = 5.25, S_6 = 3, S_{11} = 4.75,$
$S_{16} =3.50$, S19=6.25, $S_{23}=3.25, S_4 = 5, S_7 = 8.25, S_{14} = 3, S_{17} = 3.50, S_{20}=0.50, S_{24}= 2$.

The appropriate solution is not useful directly because some of the quantities are partial. To authorize the integral borders, after using the @GIN function (the general integer variable domain function, @GIN).

@FOR (HOUR (I):@GIN(X(I)));

When applying the @GIN function, then we are getting an objective value Such that = 72, among the following nonzero variables:

$S_2 = 6, S_5 = 6, S_8 = 1, S_{14} = 3, S_{17}=5, S_{20}= 3, S_3 = 5, S_6 = 6, S_9 = 5,$
$S_{15} =3, S_{18}=1, S_{23}=5, S_4 = 1, S_7 = 6, S_{13} = 4, S_{16} = 6, S_{19}=6.$

4. MODEL 2: Aqua sure Aquagurad Water Purifiers Drinking Water Company (Rukmani Beverages Pvt. Ltd.):

$$MIN\ Z = \sum_{i=1}^{3} \sum_{j=1}^{4} X_{ij}\ ,$$

X_{ij} = Number of Worker on Category i and Working on Shift type j.

i = 1 to 3 and j = 1 to 4.

4.1 Problem Definition and solutions:

In our study in an Aqua soft Drinking water Company, there are three categories of worker are required in an Aqua soft Drinking water Company first Making bottles, other Filling water in bottles, third Packing and working time in an hour divided into four different Shifts.Minimize the number of Workers required to hire for the Company.

1. First shift 8:00 am to 2:00 pm
2. Second shift 2:00 pm to 8:00 pm
3. Third shift 8:00 pm to 2:00 am
4. Fourth shift 2:00 am to 8:00 am.

Each Worker has to Work in two consecutive shifts per day. Details of Worker demand in a Company as follows:

Categories shift	X_1 Making bottles	X_2 Filling water in bottles	X_3 Packing
First shift	10	8	10
Second shift	12	10	14
Third shift	8	9	12
Fourth shift	10	8	13

Solving the shifting problem table possibility Shift of Workers:

	X_1				X_2				X_3			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
First shift	*	*	-	-	*	*	-	-	*	*	-	-
Second shift	*	-	-	*	*	-	-	*	*	-	-	*
Third shift	-	*	*	-	-	*	*	-	-	*	*	-
Fourth shift	-	-	*	*	-	-	*	*	-	-	*	*

Objective function:

$$MIN\ Z = \sum_{i=1}^{3} \sum_{j=1}^{4} X_{ij} ,$$

X_{ij} = Number of Worker on Category i and Working on Shift type j.

i = 1 to 3 and j = 1 to 4.

Constraints:

First Making bottles:

$$X_{11} + X_{12} \geq 10,$$
$$X_{11} + X_{14} \geq 12,$$
$$X_{12} + X_{13} \geq 8,$$
$$X_{13} + X_{14} \geq 10,$$

Second Filling water in bottles:

$$X_{21} + X_{22} \geq 8,$$
$$X_{21} + X_{24} \geq 10,$$
$$X_{22} + X_{23} \geq 9,$$
$$X_{23} + X_{24} \geq 10,$$

Third Packing:

$$X_{31} + X_{32} \geq 10,$$
$$X_{31} + X_{34} \geq 14,$$
$$X_{32} + X_{33} \geq 12,$$
$$X_{33} + X_{34} \geq 13,$$

$$X_{11} \geq 0, X_{12} \geq 0, X_{13} \geq 0, X_{14} \geq 0, X_{21} \geq 0, X_{22} \geq 0, X_{23} \geq 0, X_{24} \geq 0,$$
$$X_{31} \geq 0, X_{32} \geq 0, X_{33} \geq 0, X_{34} \geq 0.$$

Result and discussion model 2:

Solved the above model by using LINGO 18.0 software and the results obtained as given below:
Objective Value: 65
Solution Table:

Categories Shift	X_1	X_2	X_3
Shift type one	2	10	1
Shift type two	8	1	12
Shift type three	0	8	0
Shift type four	10	0	13

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