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A Scheduling Model for Balancing the Workload at Supermarket X Using Integer Programming

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Abstract - *Employee scheduling is an important operational problem in the retail industry, as it affects both workforce efficiency and workload balance. This study aims to develop an employee scheduling model for Supermarket X using an integer programming approach based on simulated data. The model considers two work shifts, 42 employees, and an eight-day scheduling period, with decision variables representing work assignments and days off. Several operational constraints are included, such as minimum staffing requirements, one-shift-per-day restrictions, and limitations on the number of employees off on the same day. The model is solved using LINGO software. The results show that each employee is assigned seven working days and one rotating day off, while all constraints are satisfied. These results indicate that integer programming is an effective method for generating balanced and feasible employee schedules in retail operations.*

Keywords: *Balancing Workload; Scheduling; Integer Programming Model.*

1. INTRODUCTION

In many various kinds of businesses, scheduling is a crucial decision-making process. It deals with allocating tasks to resources and scheduling their processing while adhering to specified restrictions in a way that maximises one or more goals [1]. Employee scheduling has become a major challenge for operational management in the competitive retail industry, particularly due to overlapping work shifts and variations in daily workloads. According to [2], the intense competition in this industry demands cost efficiency and optimal service quality, where ineffective scheduling can lead to imbalanced workloads, reduced operational efficiency, employee dissatisfaction, and higher turnover rates. This issue is increasingly critical because the success of retail businesses depends on the ability to manage human resources fairly and efficiently [3].

In service industries such as retail, scheduling plays a crucial role in business operations management. Effective scheduling leads to increased productivity and efficiency, labor cost savings, and higher employee satisfaction. Conversely, poor scheduling can cause employee burnout due to uneven workloads, staff shortages during peak hours, or excessive overtime, which ultimately reduces the quality of customer service [4].

Some studies about the scheduling problems have demonstrated the effectiveness of integer programming methods in solving various scheduling problems, for example Irsyad et al. [5] applied integer linear programming to employee scheduling to minimize wage costs and produce a more efficient schedule compared to manual methods. Some researchers investigated the scheduling in the hospital such as nurse scheduling using integer linear programming [6][7][8], mathematical programming [9], goal programming [10][11][12], integrated Lexicographic goal programming and dynamic satisfaction function model [13], self-scheduling [14], qualitative descriptive design [15], while [16] discussed the risks posed by nurses' working hours in Intensive Care Unit.

Employee or personnel scheduling is the process of constructing work timetables for the staff, assigning qualified workers to meet employee demand for the task, and satisfying employees' working condition and individual preferences [17]. The integer linear programming had been used for personnel scheduling in had been investigated by some researchers including Ang et al. using integer linear programming [18], guided simulated annealing and integer linear programming [19], mixed-integer programming [20]. In this study we will discuss the integer programming model to optimize the employee scheduling at Supermarket X, Bandar Lampung.

2. RESEARCH METHODOLOGY

2. 1 Mathematical modelling

Mathematical modeling is a process that uses mathematical terms to simulate real-world problems in an effort to find solutions. A mathematical model can be defined as a simplification or abstraction of a real-world problem or situation into a mathematical form; in other words, it transforms a real-world problem into a mathematical problem [21]. Mathematical problems can be solved using known methods to find their solutions. Subsequently, the solutions are interpreted and explained in real-world terms. According to [22], the steps involved in mathematical modeling are as follows:

i. Problem identification, which involves identifying the variables present in the problem; the identified variables are given shorter names, consisting of single letters, to simplify the model's presentation and facilitate the calculation process;
ii. Making necessary assumptions to simplify the phenomenon so that it can be analysed mathematically;
iii. Model formulation, which involves translating the problem into mathematical form using equations or functions
iv. Model verification, which involves ensuring that the model created aligns with reality; and
v. Solution and analysis, which involves drawing mathematical conclusions from the obtained solution and interpreting them as solutions or estimates in the real world.

2. 2 Integer programming

Integer Programming is a mathematical technique widely used to solve scheduling problems. This method allows problems to be formulated into an optimization model consisting of an objective function and a set of constraints that must be satisfied. Solutions generated using IP (integer programming) are optimal and mathematically sound. The integer programming method is particularly well-suited for employee scheduling because it can address real-world constraints such as the number of employees per shift, the prohibition against working two shifts in a single day, and the fair distribution of working hours. This method is a general optimization framework that can be applied to various purposes, such as production planning, scheduling, and graph optimization [23].

Effective scheduling not only boosts productivity but also enhances employee job satisfaction. Various strategies have been proposed, ranging from simple manual approaches to more complex ones, such as the use of information technology. Factors such as employee preferences, workload, and labor regulations must be taken into account in effective scheduling [24]. According to [25], there are three types of scheduling optimization problems, namely:

i. Days-off scheduling involves determining workers' workdays and days off within a specific time period;
ii. Shift scheduling focuses on workers' work and rest intervals; and
iii. Tour scheduling is a combination of patterns formed by days-off scheduling and shift scheduling.

This study uses simulated data from Supermarket X, a retail store with 42 employees working in two shifts: the morning shift from 7:00 AM to 4:00 PM and the afternoon shift from 1:00 PM to 10:00 PM. For

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Supermarket X employees, the manual scheduling currently in place has the potential to create an imbalance in workload, which can directly impact productivity and employee retention. The complexity of scheduling at Supermarket X is compounded by the differing workloads between the morning and afternoon shifts, as well as daily fluctuations in customer volume. The manual scheduling method currently in use often fails to optimally address all aspects, resulting in schedules that are inefficient and unfair to employees.

2. 3 LINGO

LINGO is an all-inclusive software tool for creating, resolving, and evaluating optimisation models, encompassing integer, quadratic, nonlinear, and linear programming. There are several steps in LINGO for determining the optimal value according to [26] as follow:

i. determining a mathematical model based on real data;
ii. determining the program formulation for LINGO;
iii. inputting the model into LINGO;
iv. running the model and analysing the results, specifically using the "solve" command to find the optimal solution; and
v. validating the model, specifically ensuring that the obtained solution satisfies all constraints and is realistic within the context of the problem being solved.

3. RESULTS AND DISCUSSION

3.1 The Data

The data used in this study consists of simulation data designed to illustrate the shift scheduling conditions for employees at Supermarket X over an 8-day work cycle that repeats monthly. This model is adapted from nurse scheduling, in which each employee works for several consecutive days and then takes a day off on a rotating basis. This study uses simulated data on employees at Supermarket X. A total of 42 employees were included in this simulation, comprising several departments: cashiers, sales associates, warehouse staff, and cleaning service staff. The number of employees in each department was adjusted to meet the supermarket's daily operational needs. The sales staff department has the largest number of employees, about 20 people, because it has a wide scope of work, such as serving customers and arranging merchandise. Meanwhile, the cashier, warehouse, and cleaning service departments have fewer employees in proportion to their workload. Table 1 shows the details of the number of employees in each department.

Table 1. List of positions and number of employees.

No	Type of work	The number of employees (people)
1	Cashier	8
2	Sales	20
3	Warehouse	6
4	Cleaning Service	8

3.2 Work Shifts

Supermarket X operates on a two-shift system: a morning shift and an afternoon shift. The morning shift runs from 7:00 AM to 4:00 PM, while the afternoon shift runs from 1:00 PM to 10:00 PM. Each employee is scheduled to work only one shift per day, so there is no overlap in working hours between shifts. This two-shift system was chosen to align with the supermarket's operating hours, which run from morning through the evening, and to ensure that staffing needs in every department are consistently met throughout operating hours. Additionally, implementing these two shifts allows workloads to be distributed evenly, preventing employee burnout and enabling them to provide better service to customers. To maintain optimal supermarket operations, a minimum of 3 cashiers, 8 sales associates, 2 warehouse staff, and 3 cleaning staff are required daily. There are two shifts daily, the first shift is from 07.00 AM to 04.00 PM and the second shift is from 01.00 PM to 10.00 PM. There are 3 hours' time overlapping between the first and second shift for shift handoffs and related matters.

3.3 Work Schedule

Each employee in this study was scheduled to work for seven consecutive days on one of two shifts, with one day off on the eighth day. Among the employees, days off were assigned on a rotating basis to balance workloads and rest periods. In this system, workdays are designated as the first, second, through eighth periods, without reference to specific days of the week. Scheduling continues into the next period with the same pattern after the previous period ends, but each employee's day off is shifted by one day from the previous period. For example, if employee i has a day off on the first day of the first period, he will have a day off on the second day of the second period, and so on until returning to the first day after eight periods have ended. This shift pattern for days off serves two purposes: (a) ensuring that employees have an equal workload; and (b) ensuring that the minimum daily staffing requirements are met. Additionally, this system allows the work schedule to be applied repeatedly over a longer period without the need for rescheduling.

3.4 Model Formulation

The model formulation was derived from the information available in the employee scheduling research data used. Based on that information the decision variables are defined as Equation (1) and Equation (2) as follows:

$$x_{i,j,k} = \begin{cases} 1, if\ the\ i^{th}\ employee\ works\ the\ j^{th}\ shift\ on\ the\ k^{th}\ day, \\ 0,\ otherwise \end{cases} \quad (1)$$

$$y_{i,k} = \begin{cases} 1, if\ the\ i^{th}\ employee\ is\ off\ on\ the\ k^{th}\ day, \\ 0,\ otherwise \end{cases} \quad (2)$$

i. i is the index for the employees, i = 1, 2, 3, …, 42;
ii. For cashier, i = 1, 2, 3, …,8;
iii. For sales, i = 9, 10, 11, …, 28;
iv. For warehouse, i = 29, 30, 31, 32, 33, 34;
v. For cleaning service, i = 35, 36, …, 42;
vi. j is the index for work shift, j = 1, 2; and
vii. k is the index for work day, k = 1, 2, 5…, 8.

Using these decision variables, the shift requirements, work schedule requirement, and meet the maintaining optimal supermarket operations requirements, the model is constructed as shown on Equation (3) to Equation (12) as follow:

$$\text{Obj: } Min\ \sum_{i=1}^{42}\sum_{j=1}^{2}\sum_{k=1}^{8} x_{i,j,k} \quad (3)$$

Subject to:

(a) Minimum staffing requirements per shift per day

i. Minimum 3 cashier per shift per day:

$$\sum_{i=1}^{8}\sum_{j=1}^{2} x_{i,j,k} \geq 3\ , \forall\ k = 1, 2, 3, \dots, 8 \quad (4)$$

ii. There must be at least 8 sales per shift per day:

$$\sum_{i=9}^{28}\sum_{j=1}^{2} x_{i,j,k} \geq 8\ , \forall\ k = 1, 2, 3, \dots, 8 \quad (5)$$

iii. The must be at least two warehouse people:

$$\sum_{i=29}^{34}\sum_{j=1}^{2} x_{i,j,k} \geq 2\ , \forall\ k = 1, 2, 3, \dots, 8 \quad (6)$$

iv. Minimum 3 cleaning service:

$$\sum_{i=35}^{32} \sum_{j=1}^{2} x_{i,j,k} \;\; \geq 2 \;, \forall\; k = 1, 2, 3, \dots, 8 \tag{7}$$

(b) Day off distribution

i. No employee may work more than one shift per day:

$$\sum_{j=1}^{2} x_{i,j,k} \leq 1 \;, \forall i = 1, 2, \dots, 42 \;;\; \forall k = 1, 2, \dots 8 \tag{8}$$

ii. Employees are only off work if they are not scheduled for any shift

$$\sum_{j=1}^{2} x_{i,j,k} + y_{i,k} = 1 \;, \forall i = 1, 2, \dots, 42 \;;\; \forall k = 1, 2, \dots 8 \tag{9}$$

iii. Every employee gets one day off:

$$\sum_{k=1}^{8} y_{i,k} = 1, \;\; \forall\; i = 1, 2, \dots, 42 \tag{10}$$

iv. A maximum of six people may take the day off on the same day:

$$\sum_{i=1}^{42} y_{i,k} \leq 6 \;;\; \forall k = 1, 2, \dots, 8 \tag{11}$$

v. Rotating holidays (based on employee index):

$$y_{i,((i-1) mod\;\; 8)+1} = 1 \;, \forall\; i = 1, 2, \dots, 42 \tag{12}$$

Figure 1 shows the screenshot of part of the model in LINGO. After inputting model in LINGO, we get the following main results which is shown on Figure 2, and the part of the of the detail results on Figure 3.

```
MODEL:
SETS:
karyawan/1..42/:totalkerja;
shift/1..2/:;
hari/1..8/:;
IJK(karyawan, shift, hari):Xijk;
Y(karyawan, hari):Yik;

ENDSETS

!-----------------------------------------------
!Fungsi tujuan: meminimalkan ketidakseimbangan beban kerja
!-----------------------------------------------

!Tujuan: minimalisasi selisih jumlah kerja dari target 7 hari;
        min=@sum(IJK(i,j,k):Xijk(i,j,k));
!Hitung total hari kerja setiap karyawan;
        @for(karyawan(i):
                totalkerja(i)=@sum(shift(j):@sum(hari(k):Xijk(i,j,k))));

!-----------------------------------------------
!Kendala kebutuhan minimal tenaga kerja tiap hari dan shift
!-----------------------------------------------

!Kasir (1-8): minimal 3 orang per shift per hari;
        @for(hari(k):
                @for(shift(j):
                                @sum(karyawan(i)|i#LE#8:Xijk(i,j,k))>=3));
!Pramuniaga (9-28): minimal 8 orang per shift per hari;
        @for(hari(k):
                @for(shift(j):
                        @sum(karyawan(i)|i#GE#9#AND#i#LE#28:Xijk(i,j,k))>=8));
!Gudang (29-34): minimal 2 orang per shift per hari;
        @for(hari(k):

                @for(shift(j):
                                @sum(karyawan(i)|i#GE#29#AND#i#LE#34:Xijk(i,j,k))>=2));
!Cleaning Service (35-42): minimal 3 orang per shift per hari;
        @for(hari(k):
                @for(shift(j):
                                @sum(karyawan(i)|i#GE#35#AND#i#LE#42:Xijk(i,j,k))>=3));

!-----------------------------------------------
!Kendala distribusi dan hari libur
!-----------------------------------------------

!Setiap karyawan tidak boleh kerja lebih dari 1 shift per hari;
        @for(karyawan(i):
                @for(hari(k):
                                @sum(shift(j):Xijk(i,j,k))<=1));
!Karyawan hanya bisa libur kalau tidak bekerja di semua shift;
        @for(karyawan(i):
                @for(hari(k):
```

Figure 1. Screenshot part of the model in LINGO.

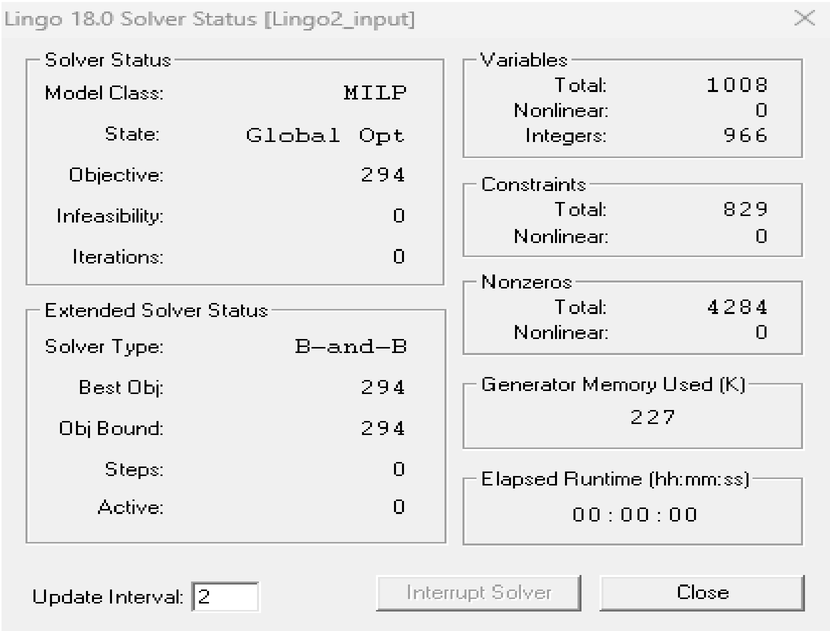

Figure 2. Output from LINGO.

```
TOTALKERJA( 39)        7.000000        0.000000
TOTALKERJA( 40)        7.000000        0.000000
TOTALKERJA( 41)        7.000000        0.000000
TOTALKERJA( 42)        7.000000        0.000000
 XIJK( 1, 1, 1)        0.000000        1.000000
 XIJK( 1, 1, 2)        1.000000        1.000000
 XIJK( 1, 1, 3)        1.000000        1.000000
 XIJK( 1, 1, 4)        1.000000        1.000000
 XIJK( 1, 1, 5)        1.000000        1.000000
 XIJK( 1, 1, 6)        1.000000        1.000000
 XIJK( 1, 1, 7)        1.000000        1.000000
 XIJK( 1, 1, 8)        1.000000        1.000000
 XIJK( 1, 2, 1)        0.000000        1.000000
 XIJK( 1, 2, 2)        0.000000        1.000000
 XIJK( 1, 2, 3)        0.000000        1.000000
 XIJK( 1, 2, 4)        0.000000        1.000000
 XIJK( 1, 2, 5)        0.000000        1.000000
 XIJK( 1, 2, 6)        0.000000        1.000000
 XIJK( 1, 2, 7)        0.000000        1.000000
 XIJK( 1, 2, 8)        0.000000        1.000000
 XIJK( 2, 1, 1)        1.000000        1.000000
 XIJK( 2, 1, 2)        0.000000        1.000000
 XIJK( 2, 1, 3)        0.000000        1.000000
```

Figure 3. Part of the output from LINGO.

Figure 2 shows that the LINGO 18.0 programming process consists of 1,008 decision variables, 829 constraints, and 4,284 variables with non-zero values. The results of the model solution indicate that the system can meet scheduling requirements while adhering to all designed constraints. The LINGO output obtained was then further processed using Microsoft Excel. The purpose of this processing was to present the scheduling results in a more structured format, thereby facilitating the analysis process. Additionally, this process is used to verify whether the schedules assigned to each employee align with the designed model. Furthermore, this process ensures that workload distribution is fair and does not violate the previously defined constraints. Table 2 shows the output of LINGO and processed using Microsoft Excel. Note that columns numbered 1,1 through 2,8 represent the grouping on j (shift 1 and shift 2) and k (day 1 through 8). Meanwhile, rows numbered 1 through 42 indicate the employees 1 to 42.

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Table 2. LINGO 18.0 output processed using Microsoft Excel regarding the activity schedule.

i \ *j,k*	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8
1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
3	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1
4	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1
5	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
6	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0
7	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0
8	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
11	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1
12	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
13	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
14	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0
15	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0
16	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
17	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
18	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
19	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0
20	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
21	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
22	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0
23	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	1
24	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
25	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
26	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
27	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1
28	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1
29	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
30	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0
31	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	1
32	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
33	0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1
34	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
35	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0
36	0	0	1	0	0	0	0	0	1	1	0	0	1	1	1	1
37	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1
38	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1
39	1	1	0	0	0	0	0	1	0	0	1	1	1	1	0	0
40	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
41	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
42	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0

The scheduling results meet the predefined requirements and constraints, as shown in Table 2, based on the output generated from modeling and programming using LINGO 18.0. Each employee is scheduled to work at least once during each shift over an eight-day work period. The minimum workforce requirement per shift per day is met. Additionally, the distribution of days off meets the expected criteria. The following is an interpretation of the results read by Microsoft Excel and displayed in Table 2.

(1) Employee 1 is scheduled to work seven times during an eight-day work period, with the following shift and day-off schedule:

   a. Employee 1 works Shift 1 from Day 2 through Day 8,

   b. Employee 1 has the first day off.

(2) Employee 2 is scheduled to work seven times during an eight-day work period, with the following shift assignments:

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a. Employee 2 works on Shift 1 on Day 1 and Shift 2 from Day 3 through Day 8,

b. Employee 2 has the day off on Day 2.

(3) Employee 3 is scheduled to work seven times during an eight-day work period, with the following shift assignments:

a. Employee 3 works on shift 2 on days 1 through 2 and days 4 through 8,

b. Employee 3 has the day off on the third day.

(4) Employee 4 is scheduled to work seven times during an eight-day work period, with the following shift schedule:

a. Employee 4 works on shifts 2 on days 1 through 3 and days 5 through 8,

b. Employee 4 has the day off on the fourth day.

(5) Employee 5 is scheduled to work seven times during an eight-day work period, with the following shift assignments:

a. Employee 5 works on Shift 1 from days 6 through 8 and on Shift 2 from days 1 through 4,

b. Employee 5 has the day off on the fifth day.

… and so on, until

(41) Employee 41 is scheduled to work seven times during an eight-day work period, with the following shift assignments:

a. Employee 41 works Shift 1 on days 2 through 8,

b. Employee 41 has the day off on the first day.

(42) Employee 42 is scheduled to work seven times during an eight-day work period, with the following shift assignments:

a. Employee 42 works on Shift 1 on Day 1 and Days 3 through 8,

b. Employee 42 has the day off on the second day.

Table 3 shows the distribution of employees' days off during the work period, with each row representing an employee and each column representing a day of the week. The shaded cells indicate the days off for that employee.

Table 3. LINGO 18.0 output processed using Microsoft Excel regarding employee day off.

i \ *k*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	**1**	0	0	0	0	0	0	0
2	0	**1**	0	0	0	0	0	0
3	0	0	**1**	0	0	0	0	0
4	0	0	0	**1**	0	0	0	0
5	0	0	0	0	**1**	0	0	0
6	0	0	0	0	0	**1**	0	0
7	0	0	0	0	0	0	**1**	0
8	0	0	0	0	0	0	0	**1**
9	**1**	0	0	0	0	0	0	0
10	0	**1**	0	0	0	0	0	0
11	0	0	**1**	0	0	0	0	0
12	0	0	0	**1**	0	0	0	0
13	0	0	0	0	**1**	0	0	0
14	0	0	0	0	0	**1**	0	0
15	0	0	0	0	0	0	**1**	0
16	0	0	0	0	0	0	0	**1**

i \ *k*	1	2	3	4	5	6	7	8
17	**1**	0	0	0	0	0	0	0
18	0	**1**	0	0	0	0	0	0
19	0	0	**1**	0	0	0	0	0
20	0	0	0	**1**	0	0	0	0
21	0	0	0	0	**1**	0	0	0
22	0	0	0	0	0	**1**	0	0
23	0	0	0	0	0	0	**1**	0
24	0	0	0	0	0	0	0	**1**
25	**1**	0	0	0	0	0	0	0
26	0	**1**	0	0	0	0	0	0
27	0	0	**1**	0	0	0	0	0
28	0	0	0	**1**	0	0	0	0
29	0	0	0	0	**1**	0	0	0
30	0	0	0	0	0	**1**	0	0
31	0	0	0	0	0	0	**1**	0
32	0	0	0	0	0	0	0	**1**
33	**1**	0	0	0	0	0	0	0
34	0	**1**	0	0	0	0	0	0
35	0	0	**1**	0	0	0	0	0
36	0	0	0	**1**	0	0	0	0
37	0	0	0	0	**1**	0	0	0
38	0	0	0	0	0	**1**	0	0
39	0	0	0	0	0	0	**1**	0
40	0	0	0	0	0	0	0	**1**
41	**1**	0	0	0	0	0	0	0
42	0	**1**	0	0	0	0	0	0

4. CONCLUSION

Research on an integer programming-based scheduling model at Supermarket X shows that it successfully produced an optimal schedule balancing employee workload. The model, using decision variables $x_{i,j,k}$ and $y_{i,k}$, accounts for two shifts, 42 employees, and an eight-day period. Optimization results assign each employee seven workdays and one day off in rotation, ensuring equal workloads. The schedule also meets all operational constraints, including staffing minimums, day-off distribution, prohibition of multiple shifts per day, and limits on simultaneous absences. While validated in simulation, the model demonstrates strong potential for real-world application. Using LINGO 18.0, optimal solutions were identified and verified in Microsoft Excel to ensure compliance with scheduling rules. The study confirms that integer programming effectively addresses scheduling challenges, achieving fair workload distribution and labor efficiency in retail settings such as Supermarket X.

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