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A MIXED INTEGER LINEAR PROGRAMMING MODEL FOR CREW SCHEDULING AT FAST FOOD RESTAURANT

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Abstract: *This paper addressed crew scheduling problem at a fast-food restaurant. In the current practice, manager experiencing difficulties when he or she must consider quite a few restrictions when making schedule. Often, they must reschedule several times throughout the week. Even though there are several guidelines or rules in developing the schedule, unfortunately it is done manually. Hence, there is a need for management to have a mechanism that can automate the scheduling process with an optimum number of crews. This paper modified a mixed integer linear programming model which considered new constraints. First, the model does not allow female crew to work night shift and second, allowing male crew to go to Friday prayers. This model also managed to minimize the total excess and shortage number of crew in the current workforce. Ultimately, managed to find the optimal working schedule for the restaurant crews. The optimal solution was obtain using MATLAB R2017b. The tool has proven to be time effective due to its short computing time. To this end, the three-shift working schedule with the conditions is recommended to the company as it is expected to be able to overcome the conflicts in the scheduling problem and produce the best monthly cost saving.*

Keywords: Optimization, Scheduling, Fast-food restaurant, Linear Programming.

1. Introduction

Scheduling is an allocation of resources over time to perform a collection of an assignments (Baker, 2014). It is an important task for every organization. Leader or manager can face the mounting pressure when scheduling processes are not effective. It tends to hurt worker morale when they do not have the rights in scheduling process that serves their skills, experiences, and needs. Developing, publishing, and editing employee schedules requires the schedulers to deal with piles of timetable schedules and employee requests. The process often takes days and even weeks to accomplished. In general, there are several aspects to consider for having optimum working schedules, which are shift work, break, and performance.

This paper discusses on work scheduling of a fast-food restaurant. It is crucial to have a systematic working schedule for the restaurant to perform better. Currently, the crew schedule is done manually which can be time consuming. Any alteration of schedule must be done at an instant to avoid problems. There is a need for management to have a mechanism that can automate the scheduling process with an optimum number of crews. Though, the management does not intend to reduce the number of crew. Instead, they want to know the number of excess and shortage of crews in each period to avoid crew redundancy in certain hours due to overlapping shift. Hence, this research intends to assist the restaurant by constructing the working schedule by means of a mathematical model which can produce the most optimum schedule with least number of worker excess and shortage.

2. Literature Review

Scheduling is defined as the allocation, subject to constraints, of resources to objects being placed in space-time, in such a way as to minimize the total cost of some set of the resources (Wren, 1996). Research on task allocation and scheduling problem began in the mid-20th century, and still evolving, especially with the current situation on pandemic Covid-19. It involved many aspects of scheduling, be it from psychological aspect of staff (Suswati, 2020), theory of scheduling (Herroelen, 2005) and development of staff scheduling using mathematical model.

Not only on staff scheduling, there is also research on project scheduling (Hartmann & Briskorn, 2022; Kosztyán & Szalkai, 2020), machine scheduling (Bold & Goerigk, 2022; S. Wang & Cui, 2021; Yue et al., 2020), bus scheduling (Banerjee & Smilowitz, 2019; Bie et al., 2021; C. Wang et al., 2020; Noor et al., 2019) and many more. In addition to that, research also expanding related to solution approaches, depending on the complexity of the problem. Solving an NP-hard scheduling problem can be done using either heuristics or metaheuristic (Werner et al., 2020) approaches instead of exact method.

Staff scheduling of police officer and medical workers especially nurse rostering are among favourable areas of research. Garbarino et al., (2019) evaluated the quality of sleep through the Pittsburgh Sleep Quality Index (PSQI) in police forces where result shows a low average quality sleep. Noor et al. (2020) developed a mathematical program to address a few scheduling problems encountered by the police officer at a local university. Yan et al. (2020) overcome a lack of systematic planning by utilizing a mathematical programming method to construct individual and integrated patrolling system. Todovic et al. (2015)on the other hand utilizing a goal programming model for automatically determining the optimal allocation of police officers according to the division and organization of labor. Meanwhile studies from Abdelghany et al. (2021), Abuhamdah et al. (2021), Asta et al. (2016), Burke et al. (2004), Burke and Curtois (2014), Ceschia et al. (2019), Jaradat et al. (2019), Kingston (2021), Mischek and Musliu (2019) as well as Sarkar et al. (2019) are all related to medical workers. Scheduling involving nurse is called nurse rostering. These types of scheduling are usually consisting of few numbers of shifts. There is other job area that also require shift such as power station worker (Shuib & Kamarudin, 2019).

However, to our knowledge research in staff scheduling among restaurant's crew are still lacking. They are the backbone of our food industry. Most of the time, they worked on their feet with minimum wages. Studies from (Zouhar & Havlová, 2012), (Love & Hoey, 1990) as well as (Choi et al., 2009) are about fast-food restaurant chain of a case of crew optimization. Zouhar and Havlová (2012) used mixed integer linear programming model (MILP) in their studies. Choi et al. (2009) on the other hand, used integer programming (IP) to minimize the labour cost over the scheduling in a week. Love and Hoey (1990) discussed the operation in the fast-food restaurant, where several conditions and constraints were considered. Each of these studies, have different models sets, decision variables and assumptions. As for this paper, we are considering a different set of constraints to suit the restaurant needs. As customers, we always demand for good quality services from them, be it the quality of food, service times and price. Hence it is fair, if we could contribute in terms of developing a better work schedule that helps our restaurant crew to serve better in the future.

3. Method

Data on the number of crews, a week shift schedule, numbers of crews a day, scheduling ruling, working standard and crew's wages were obtained through interview session with the restaurant manager and few crews. There are 2 types of crews, full time, and part time. Both have different working rule. Full time crews work 48 hours per week, while part time crews work for at least 24 hours a week. Currently, the restaurant is running on 3 shifts, morning which start from 0800 to 1600. For afternoon shift, crews start working from 1100 to 2000 and night shift starts at 1500 and ends at 0000. Both afternoon and night shift have 1 hour break, that can be taken at any time during the shift. Noticed that the length of each shift is fixed at eight hours. At present, there are 25 full time crews and 3 part time crew. Eight of them are female. Table 2 shows the number of crews in the restaurant according to their attributes, while Table 3 shows the wages rate for both type of crews.

Table 2: Number of Crews

Types of crews	Male (Muslim)	Male (Non-Muslim)	Female	Number of crews
Full-time	9	8	8	25
Part-time	1	2	0	3

Table 3: Payment Rate

Type of crew	Duration of work	Payment rate per hour	Total wages per month
Full-timer	Six days per week	RM 5.20	RM 998.40
Part-timer	At least three days per week	RM 5.20	At least RM 499.20

In this study, a mathematical programming model is modified based on the reference model by Zouhar and Havlová (2012). The proposed model in this research aimed to minimize the number of excess and shortage crews. Bear in mind that, the manager has no intention to limit any of the crews. The whole process is basically to schedule in such a way that all crews are schedule correctly to avoid redundancy.

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The model modification is done to cater restrictions in which female crew are not allowed to work during night shift and Muslim male crews will be given time off during Friday afternoon to perform Friday prayer. At the same time, the conditions and rules given by the organization in the working schedule must be satisfied. The constraints are modified to accommodate the security and social needs of the workers.

The model sets refer to the set of data that will be used in the process of developing the mathematical model. The set *e* indicates the set of all employers, which might consist of fulltime and part time crew, set *d* indicates the set of working days, from Monday to Sunday. The set *s* indicates set of shifts. The parameter c^{under} represent the unit cost for under coverage (staff shortage), c^{over} represent unit cost for overage (staff excess) and c^{shift} represent unit cost for each shift. le_s represent length of shifts. re_{dt} represent the number of staff required at time *t*, on day *d*. The model decision variable that best represents the solution to the model is the binary variable, denoted as x_{eds}. The decision variable value 1 indicate the employee *e* is available for shift *s*, on day *d*. Otherwise the value will be 0. For decision variables of δ_{dt}^{-} and δ_{dt}^{+} give the number of crew excess and shortage in time, *t*. The following notations are used in the developments.

x_{eds} = Crew *e* works in shift *s*, on day *d*.
δ_{dt}^{-} = The number of crew shortage on day *d* at time *t*.
δ_{dt}^{+} = The number of crew excess on day *d* at time *t*.

The full modified model is stated as:

Minimize cost,

$$Z=\sum_{d,t}\delta_{dt}^{-}+\sum_{d,t}\delta_{dt}^{+} \tag{3.1}$$

Subject to:

$$re_{dt}-\sum_{s,e}co_{st}x_{eds}=\delta_{dt}^{-}-\delta_{dt}^{+} \quad \forall\, d, t, \tag{3.2}$$

$$\sum_{s}x_{eds}\le s_{pday} \quad \forall\, e, d, \tag{3.3}$$

$$\sum_{s,d}x_{eds}\le s^{\max} \quad \forall\, e, \tag{3.4}$$

$$\sum_{s,d}le_s x_{eds}\le H_{ft}^{\max} \quad \forall\, e, \tag{3.5}$$

$$\sum_{s,d}le_s x_{eds}=H_{ft}^{\max} \quad \forall\, e \in E_{full}, \tag{3.6}$$

$$\sum_{s,d}le_s x_{eds}\ge H_{pt}^{\max} \quad \forall\, e \in E_{part}. \tag{3.7}$$

The objective function (3.1) of this research is to minimize the number of excess and shortage crew in each period. Constraint (3.2) calculates the number of crew required and minus with the crew works in shift *s*, on day *d*, which leads to get the number of shortage and overage staff in each period. Constraint (3.3) and Constraint (3.4) enforce that on each day, a crew’s time on duty must be made up by consecutive time periods and a crew can be assigned to at most six shifts per week respectively. Constraint (3.5), Constraint (3.6) and Constraint (3.7) stated that no crew can be assigned to more than 48 hours per week in total. In addition, full-time crews must be given exactly 48 hours per week and part-time crews at least 24 hours per week.

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4. Results and Discussion

This study focused on reducing the number of excess and shortage crew in each period. The difference between number of crews on duty and crews' demand will determine whether the restaurant has shortage or excess crew. Three different shift schedules were compared to verify the effectiveness of the modified model.

I: Current three-shift schedule

At present, a total of 161 shifts have been made available for 28 crews. Table 4 shows the current work schedule. For the morning shift and night shift, 11 crews are assigned to be on duty while for afternoon shift only 1 crew is on duty. In the last right column shows the total number of working shifts for each crew per week. The binary number 1 represents if crew works in a particular period and 0, otherwise. The orange boxes represent the off day for each crew. There are exactly five crews who are not assigned to work in each day. Crew 1 to Crew 25 must work exactly 6 shifts per week, which equal to 48 hours per week. For part-time crews, Crew 26 and Crew 28 are assigned to work 3 shifts per week and for Employee 27 is 5 shifts per week. The number of shifts assigned to each crew satisfied the condition given by the restaurant. As mentioned before, the rate of wages for full-time and part-time crews is the same. The crews will be paid based on the total number of working hours per month. The total wages spend per week by the organization for three-shift schedule are calculated as 161 x 8 hours x RM 5.20 = RM 6697.50 per week.

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Table 4: The Current Three-shift Schedule

CREW	Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Sunday			Total shift
	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	
1	0	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	6
2	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	6
3	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	6
4	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	1	1	0	0	6
5	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	6
6	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	6
7	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	6
8	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	6
9	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	6
10	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	6
11	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	6
12	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	6
13	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	6
14	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	6
15	0	0	1	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	6
16	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	6
17	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	6
18	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	1	6
19	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	6
20	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	6
21	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	6
22	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	1	6
23	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	6
24	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	6
25	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	1	6
26	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	3
27	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	5
28	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	3
Total Crew	11	1	11	11	1	11	11	1	11	1	1	11	11	1	11	11	1	11	11	1	11	161

M-morning shift, A-Afternoon shift, N-Night shift, 1-on shift, 0-off shift,

II: Proposed three-shift schedule using modified model

Table 5 represent the schedule for all 28 crews with the restrictions based on availability as proposed in the modified model. The binary number "1" represent if crew works in a particular period and "0", otherwise. The green boxes represent the off day for each crew. The yellow boxes represent the female crews in which they are not assigned to work in the night shift for all day. In addition, orange boxes on Friday represent the male Muslim crews as they are not allowed to work during the morning and afternoon shift. The last row shows that the total number of crews assigned to work on the particular shift. The result obtained most likely similar to the current three-shift schedule. Hence the total wages spend by organization per week is RM 6697.50.

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However, the off day assigned to each employee is different. By formulating the model using MILP formulation, it is proven that the systematic schedule with certain restrictions can be formed in least amount of time.

Table 5: The Three-Shift Schedule Using Modified Model

CREW	Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Sunday			Total shift
	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	
1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
2	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
3	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
4	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
5	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
6	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
7	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	6
8	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	6
9	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	6
10	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	6
11	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	6
12	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	6
13	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	6
14	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	6
15	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	6
16	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	6
17	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	6
18	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	6
19	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	6
20	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	6
21	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	6
22	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	6
23	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	6
24	1	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	6
25	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	1	6
26	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	4
27	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
28	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Total Crew	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	161

M-morning shift, A-Afternoon shift, N-Night shift, 1-on shift, 0-off shift

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Table 6: Work Schedule for All Crew in Two-Shift

CREW	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Total shift
	M	N	M	N	M	N	M	N	M	N	M	N	M	N	
1	1	0	1	0	0	0	1	0	1	0	1	0	1	0	6
2	0	0	1	0	1	0	1	0	1	0	1	0	1	0	6
3	0	0	1	0	1	0	1	0	1	0	1	0	1	0	6
4	0	0	1	0	1	0	1	0	1	0	1	0	1	0	6
5	1	0	0	0	1	0	1	0	1	0	1	0	1	0	6
6	1	0	0	0	1	0	1	0	1	0	1	0	1	0	6
7	1	0	0	0	1	0	1	0	1	0	1	0	1	0	6
8	1	0	0	0	1	0	1	0	1	0	1	0	1	0	6
9	0	1	1	0	1	0	0	1	0	1	0	0	0	1	6
10	0	1	1	0	1	0	0	1	0	1	0	0	0	1	6
11	0	1	0	1	1	0	0	1	0	0	0	1	0	1	6
12	1	0	1	0	1	0	0	1	0	0	0	1	0	1	6
13	1	0	1	0	0	0	0	1	0	1	0	1	0	1	6
14	1	0	1	0	0	1	0	1	0	0	0	1	0	1	6
15	1	0	1	0	0	0	1	0	0	1	1	0	0	1	6
16	0	1	1	0	0	1	0	0	0	1	1	0	0	1	6
17	1	0	1	0	1	0	0	0	0	1	1	0	0	1	6
18	0	1	0	1	0	1	1	0	0	1	0	1	0	0	6
19	1	0	0	1	0	1	1	0	0	1	0	1	0	0	6
20	0	1	0	1	0	1	0	1	0	0	0	1	0	1	6
21	0	1	0	1	0	1	0	1	0	1	0	1	0	0	6
22	0	0	0	1	0	1	0	1	1	0	0	1	1	0	6
23	1	0	0	1	0	1	0	1	1	0	0	0	1	0	6
24	0	1	0	1	0	1	0	1	1	0	0	1	0	0	6
25	0	1	0	1	0	0	0	1	1	0	0	1	1	0	6
26	0	1	0	1	0	1	0	0	0	1	0	1	0	1	6
27	0	1	0	1	0	1	1	0	0	1	0	0	0	1	6
28	0	1	0	1	0	1	0	0	0	1	1	0	1	0	6
Total Crew	12	12	12	12	12	12	12	12	12	12	12	12	12	12	168

M-morning shift, A-Afternoon shift, N-Night shift, 1-on shift, 0-off shift

III: Proposed two-shift schedule using modified model

The two-shift schedule seeks to investigate if the working schedule can be further improved in terms of minimizing the number of excess and shortage crew in each day. The first shift starts at 0800 and ends at 1600, while the second shift starts at 1500 and ends at 0000. Table 6 shows the working schedule for all 28 crews in two-shift.

Comparison:

Table 7 shows the total wages between schedules. Provided that other operational costs are considered the same, total wages on these 3 schedules are varies. Clearly, modified two-shift resulted in slightly higher cost due to extra number of crews. But both three-shifts for current and proposed model resulted in the same wages, that is RM6697.50. It may seem that proposing new approach does not make any changes, but 2 restrictions have been incorporated in the modified model. Which makes suggested scheduling is better than the current approach. Table 8 shows the number of shortages and excess crew for all 3 schedules. Both current and proposed three-shift have excess of 11 crews while modified two-shift has 12 extra crew. However, as mentioned earlier, the management does not have intention to retrench any of their crews.

Table 7: Comparison of Wages between Schedules

Schedule	Total wages per week
Current three-shift	RM 6697.50
Modified Three-shift	RM 6697.50
Modified Two-shift	RM 6988.80

Table 8: Comparison Number of Shortage and Excess Crew

Schedule	Maximum Shortage crew	Maximum Excess Crew
Current Three-shift	0	11
Modified Three-shift	0	11
Modified Two-shift	0	12

5. Conclusion

This study was intended to minimize the number of excess and shortage of crew in each period. The modified mathematical model has successfully help reduced the annual cost and optimize the employee's schedule. From a company's point of view, the use of the automatic scheduling model proposed in this study can represent a powerful tool for increasing both effectiveness and the efficiency of the staff scheduling process, leading to higher profitability and productivity. However, the implementation of such a solution into practice is not always easy, it deeply depends on the involvement of the company in the whole development process. By performing crew scheduling using the model formulation, the proposed automatic-scheduling system creates a balance and a better duty roster, which can integrate the two novelties in this study. In addition, the automatic-schedule system satisfied all the requirements as stated in the policy of the fast-food restaurant company and the same time it minimizes the operational cost. It is therefore recommended that a three-shift schedule integrated with novelties is adopted by the company's management.

Although this study can be deemed successful, there are also room for improvement that can be considered. For instance, adding time break for employees as one of the constraints might change the working days. Besides that, using metaheuristic method instead of exact method could also produce better solution in a shorter computing time.

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References

Abdelghany, M., Eitawii, A. B., Yahia, Z., & Nakata, K. (2021). A Hybrid Variable Neighbourhood Search and Dynamic Programming Approach for The Nurse Rostering Problem. Journal of Industrial and Management Optimization, 17(4).

Abuhamdah, A., Boulila, W., Jaradat, G. M., Quteishat, A. M., Alsmadi, M. K., & Almarashdeh, I. A. (2021). A novel population-based local search for nurse rostering problem. International Journal of Electrical and Computer Engineering, 11(1).

Asta, S., Özcan, E., & Curtois, T. (2016). A tensor based hyper-heuristic for nurse rostering. Knowledge-Based Systems, 98.

Banerjee, D., & Smilowitz, K. (2019). Incorporating equity into the school bus scheduling problem. Transportation Research Part E: Logistics and Transportation Review, 131.

Bie, Y., Hao, M., & Guo, M. (2021). Optimal electric bus scheduling based on the combination of all-stop and short-turning strategies. Sustainability (Switzerland), 13(4).

Bold, M., & Goerigk, M. (2022). Investigating the recoverable robust single machine scheduling problem under interval uncertainty. Discrete Applied Mathematics, 313.

Burke, E. K., & Curtois, T. (2014). New approaches to nurse rostering benchmark instances. European Journal of Operational Research, 237(1).

Burke, E. K., de Causmaecker, P., Berghe, G. vanden, & van Landeghem, H. (2004). The state of the art of nurse rostering. Journal of Scheduling, *7*(6).

Ceschia, S., Dang, N., de Causmaecker, P., Haspeslagh, S., & Schaerf, A. (2019). The Second International Nurse Rostering Competition. Annals of Operations Research, 274(1–2).

Choi, K., Hwang, J., & Park, M. (2009). Scheduling restaurant workers to minimize labor cost and meet service standards. Cornell Hospitality Quarterly, 50(2), 155–167.

Garbarino, S., Guglielmi, O., Puntoni, M., Bragazzi, N. L., & Magnavita, N. (2019). Sleep quality among police officers: Implications and insights from a systematic review and meta-analysis of the literature. International Journal of Environmental Research and Public Health, 16(5), 1–15.

Hartmann, S., & Briskorn, D. (2022). An updated survey of variants and extensions of the resource-constrained project scheduling problem. In European Journal of Operational Research, 297(1).

Herroelen, W. (2005). Project scheduling - Theory and practice. In Production and Operations Management, 14(4).

Jaradat, G. M., Al-Badareen, A., Ayob, M., Al-Smadi, M., Al-Marashdeh, I., Ash-Shuqran, M., & Al-Odat, E. (2019). Hybrid Elitist-Ant System for Nurse-Rostering Problem. Journal of King Saud University - Computer and Information Sciences, 31(3).

Kingston, J. H. (2021). Modelling history in nurse rostering. Annals of Operations Research, 302(2).

Kosztyán, Z. T., & Szalkai, I. (2020). Multimode resource-constrained project scheduling in flexible projects. Journal of Global Optimization, 76(1).

Love, R. R., & Hoey, J. M. (1990). Management Science Improves Fast-Food Operations. INFORMS Journal on Applied Analytics, 20(2), 21–29.

Mischek, F., & Musliu, N. (2019). Integer programming model extensions for a multi-stage nurse rostering problem. Annals of Operations Research, 275(1).

Noor, N. M., Alwadood, Z., Murad, N. A., Maisarah, N., & Termizi, M. (2019). Optimization of Private Bus Scheduling in UiTM Shah Alam Using Integer Linear Programming. Journal of Advanced Research in Computing and Applications Journal Homepage, 15, 26–34.

Noor, N. M., Alwadood, Z., Sabri, N. S., & Syafiqah, N. (2020). Scheduling of Police Officer in a Local University Using Integer Programming. International Journal of Technology Management and Information System, *2*(3), 1–8.

Sarkar, P., Chaki, N., & Chaki, R. (2019). A study of Resource Optimization for Nurse Scheduling Problem. 2019 4th International Conference on Computer Science and Engineering (UBMK), 757–761.

Shuib, A., & Kamarudin, F. I. (2019). Solving shift scheduling problem with days-off preference for power station workers using binary integer goal programming model. Annals of Operations Research, 272(1–2), 355–372.

Suswati, E. (2020). Cite this article as: Suswati, Endang. 2020. Job Stress Influence on Turnover Intention: Performance of Employees as Mediation in Casual Dining Restaurant. Journal of Applied Management (JAM), 18(2), 391–399.

Todovic, D., Makajic-Nikolic, D., Kostic-Stankovic, M., & Martic, M. (2015). Police officer scheduling using goal programming. Policing, 38(2), 295–313.

Wang, C., Shi, H., & Zuo, X. (2020). A multi-objective genetic algorithm-based approach for dynamical bus vehicles scheduling under traffic congestion. Swarm and Evolutionary Computation, 54.

Wang, S., & Cui, W. (2021). Approximation algorithms for the min-max regret identical parallel machine scheduling problem with outsourcing and uncertain processing time. International Journal of Production Research, 59(15).

Werner, F., Burtseva, L., & Sotskov, Y. N. (2020). Special issue on exact and heuristic scheduling algorithms. In Algorithms, 13(1).

Wren, A. (1996). Scheduling, timetabling, and rostering — A special relationship? In E. Burke & P. Ross (Eds.), Practice and Theory of Automated Timetabling. Springer Berlin Heidelberg, 46–75.

Yan, S., Wang, C. Y., & Chuang, Y. W. (2020). Optimal scheduling for police patrol duties. Journal of the *C*hinese Institute of Engineers, Transactions of the Chinese Institute of Engineers, Series A, 43(1), 1–12.

Yue, F., Song, S., Jia, P., Wu, G., & Zhao, H. (2020). Robust single machine scheduling problem with uncertain job due dates for industrial mass production. Journal of Systems Engineering and Electronics, 31(2).

Zouhar, J., & Havlová, I. (2012). Are fast food chains really that efficient? A case study on crew optimization. Proceedings of 30th International Conference Mathematical Methods in Economics, 1033–1038.