Developing Staff Schedules under the Constraint of Constant Total Staff Quantity in a Gas Station

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Abstract

The present employee scheduling of the sample 24 hours gas station has only 2 main shifts for conforms the cash remittance cycle which is controlled by head office. The two working schedules are between 5 a.m. to 5 pm. and 5 p.m. to 5 a.m. that don't match the customer arrival time which overcrowds in 7-10 a.m. and 4-7 p.m.

This research aims to solve the labor scheduling under the constraint of constant total staff quantity to minimize the labor cost and increase the service level because the executive doesn't want to recruit or discharge any staff. The methodology consists of studying the gas station work procedure, collecting service time in each activity and customer arrival time in each hour. The Integer programming models were developed under the constraint of constant total staff quantity and minimum required staff in each hour. These models have 504 variables because the working shifts can start every hour, and the rest periods and overtime are assigned in every tour. The gas station simulation model were created and run 1,000 replications to compare the customer waiting time and staff utilization between the former and new staff schedules.

The study discovered that the new schedules reduce 23.48% of labor cost, 54.19% of customer waiting time and increase staff utilization 17.89%.

Keywords: Employee scheduling; Integer programming; Gas station

Introduction

After Thai government approved to increase minimum daily wage in all provinces on 2013, significantly increases expenses for labor-intensive industries such as textiles, garments and services. The gas station business is affected from this issue because offer the full services. The executive of a sample gas station wish to reduce labor cost and increase service level.

The case study is a 24/7 gas station and have 9 staff. The executive want to improve staff scheduling to match the customer arrival and remain the total staff without recruit or discharge any staff. The current staff schedule has only 2 shifts a day for matching the cash remittance cycle that controlled by head office. The first shift starts at 5 a.m. and out at 5 p.m. and the second shift is between 5 p.m. and 5 a.m. All shifts have 11 working hours (8 normal working hours and 3 overtime working hours) and 1 braking hour. All shifts require 1 cashier and every staff has 1 day off in every 2 weeks.

The company have to follow Thailand Labor Protection Act. There are some sections that relevance this paper, for example

- Normal Working Time must not exceeding 48 hours a week.
- A rest of not less than one hour a day after working five hours.
- A weekly holiday must not be less than one day per week.
- Overtime pay at a rate not less than 1.5 times of the hourly wage rate on working day and 3 times on holiday.
- Holiday pay not less than 2 times for employee doesn't receive wage on holiday.

This paper aims to solve the manpower problem with integer programming models were developed under the constraint of constant total staff quantity and minimum required staff in each hour and test the effects of new schedule models with simulation model..

Model development

The first step of this paper is hourly wage calculation for benchmark between the as is model and to be model. The current hourly wage calculation is shown below

- 1 normal working hour = 1 hourly wage (h.w.)
- 1 overtime working hour = 1.5 h.w.
- 1 holiday working hour = 2 h.w.
- 1 holiday overtime working hour = 3 h.w.
    - 8 normal + 3 overtime working hour = 12.5 h.w.
    - 8 holiday + 3 overtime working hour = 25 h.w

From this calculation method, the current working schedule is 788 hourly wage/week as shown on the figure 1

	Week 1							Week 2						
Staff	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su
1	off	12.5	12.5	12.5	12.5	12.5	12.5	25	12.5	12.5	12.5	12.5	12.5	12.5
2	25	12.5	12.5	12.5	12.5	12.5	12.5	Off	12.5	12.5	12.5	12.5	12.5	12.5
3	12.5	off	12.5	12.5	12.5	12.5	12.5	12.5	25	12.5	12.5	12.5	12.5	12.5
4	12.5	25	12.5	12.5	12.5	12.5	12.5	12.5	off	12.5	12.5	12.5	12.5	12.5
5	12.5	12.5	off	12.5	12.5	12.5	12.5	12.5	12.5	25	12.5	12.5	12.5	12.5
6	12.5	12.5	25	12.5	12.5	12.5	12.5	12.5	12.5	off	12.5	12.5	12.5	12.5
7	12.5	12.5	12.5	off	12.5	12.5	12.5	12.5	12.5	12.5	25	12.5	12.5	12.5
8	12.5	12.5	12.5	25	12.5	12.5	12.5	12.5	12.5	12.5	off	12.5	12.5	12.5
9	12.5	12.5	12.5	12.5	off	12.5	12.5	12.5	12.5	12.5	12.5	25	12.5	12.5

Figure 1: The current hourly wage

Second, the customer arrival rate in each hour is observed. The 30 days customer arrival number observation finds the peak hours that between 7-10 a.m. and 4-7 p.m., as shown on figure 2.

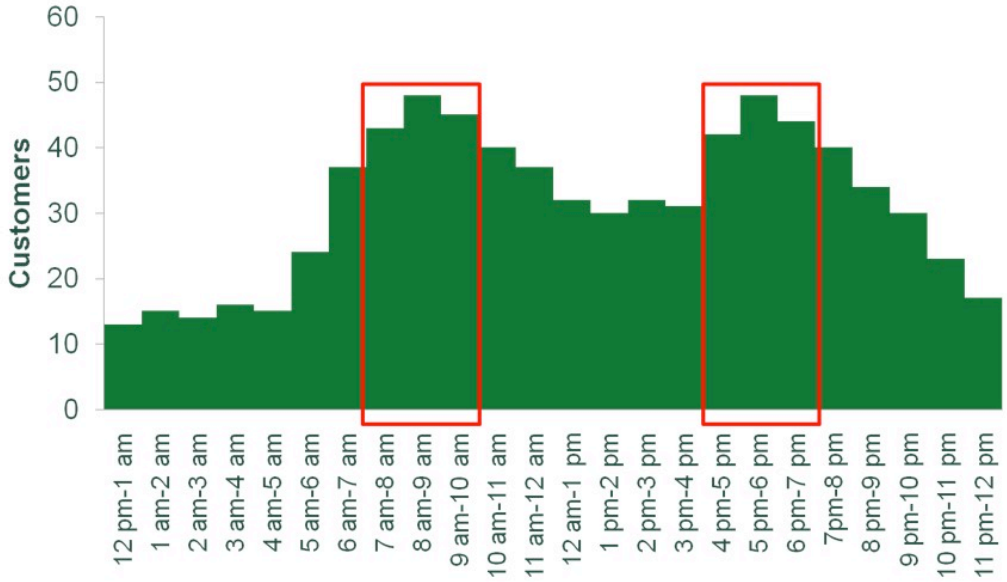

Figure 2: Average 30 days customer arrival rate

Third, the minimum staff in each hour are set by management. The executive requires minimum 3 staff and 4 staff in peak hours during 7-10 a.m. and 4-7 p.m. to match customer arrival rate. The minimum daily staff in current working schedule is solved with integer programing. The solution for minimum staff in 1 day is 11 staff that isn't match the current total 9 staff. So, the new schedule rule is set with this new conditions

- Tour can start every hour
  - 12 pm - 9 am ... 11 pm – 8 am
  - 1 day has 24 main tours
- 7 working hour patterns

    - Every tour can work overtime 0 to 6 hours
- 3 breaking hour patterns
    - Every tour can break 1 hour after working 3 or 4 or 5 hours

From above condition, the possible working tour in one day is 504 tours.

Next, the new integer programing is developed to solve the minimum hourly wage in a week and every staff have 1 day off in a week. The equation is shown below.

The objective function:

$$Min\ Z = \sum_{b=1}^{3}\sum_{h=1}^{7}\sum_{t=1}^{24}\sum_{d=1}^{7}\sum_{s=1}^{9} x_{sdthb}$$

Subject to

x = Number of hourly wage
b = 1,2,3 : Set of braking hour patterns
h = 1,…7 : Set of working hour patterns
t = 1,…24 : Set of starting hour
d = 1,…7 : Set of working day
s = 1,…9 : Set of staff

Under the constraints

- Staff works 6 day in a week

$$\sum x_{1dthb} = \sum x_{2dthb} = \sum x_{3dthb} = \sum x_{4dthb} = \sum x_{5dthb} = \sum x_{6dthb} = \sum x_{7dthb} = \sum x_{7dthb} = \sum x_{7dthb} = 1$$

  Subject to

$$x_{1dthb} = 1$$

- Minimum staff in each hour

$$\sum x_{1dthb} \begin{cases} \geq 3 ; t = 1, \dots 7, 10, \dots 16, 20, \dots 24 \\ \geq 4 ; t = 8, 9, 10, 17, 18, 19 \end{cases}$$

  Subject to

$$x_{sdthb} = 1$$

- 1 cashier works between 5 a.m.-5 p.m.

$$\sum x_{sd6,4b} \geq 1$$

  Subject to

$$x_{sdtht} = 1$$

- 1 cashier works between 5 p.m.-5a.m.

$$\sum x_{sd18,4b} \geq 1$$

Subject to

$$x_{sdtht} = 1$$

From new integer programing model, the minimum hourly wage in a week is 603 h.w. and has 3 schedule patterns as shown on figure 3. The hourly wage for 7 staff in a day is 89, 8 staff is 85 and 9 staff is 81.

Day /Pattern	D1	D2	D3	D4	D5	D6	D7	H.W.
P1	7	7	7	7	8	9	9	603
P2	7	7	7	8	8	8	9	603
P3	7	7	8	8	8	8	8	603

Figure 3: Minimum staff in new schedule

Last, the gas station working process and service time in each process are observed. The process and working distribution time are shown as figure 4.

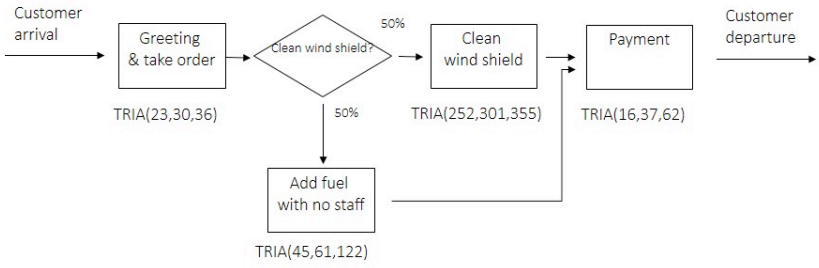

Figure 4: Gas station working process

The gas station working process simulation models are created to compare the current schedule model and new schedule model. The simulation models are run 1,000 replications for minimize half width and accuracy. The result of models show that customer total time, customer waiting time and labor cost of new schedule is lower than current model as shown in figure 5

Model	Customer Waiting Time (Minute)	Customer Total Time (Minute)	Labor Cost (h.w.)	Staff utilization
Current	3.21	7.50	788	49.71%
New	1.47	5.76	603	58.6%
Chg.%	-54.2%	-23.2%	-23.5%	17.9%

Figure 5: Staff scheduling models comparison

Summary, conclusions, and implementation issues

This research aims to reduce labor cost in a 24 hours gas station. Increasing working tours can reduce labor cost because the schedule can set to match the customer arrival rate. But too many tour is difficult to scheduling with manual method. Moreover, staff who work more than 8 hours may work ineffectively so supervisor should to arrange breaking time properly. The staff who start and end their job between 11 p.m.-5 a.m. may affect their commuting. The executive should realize this issue. If the station installs security devices, the staff schedule can reduces staff between 11 p.m.-5 a.m. from 3 to 2 staff.

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