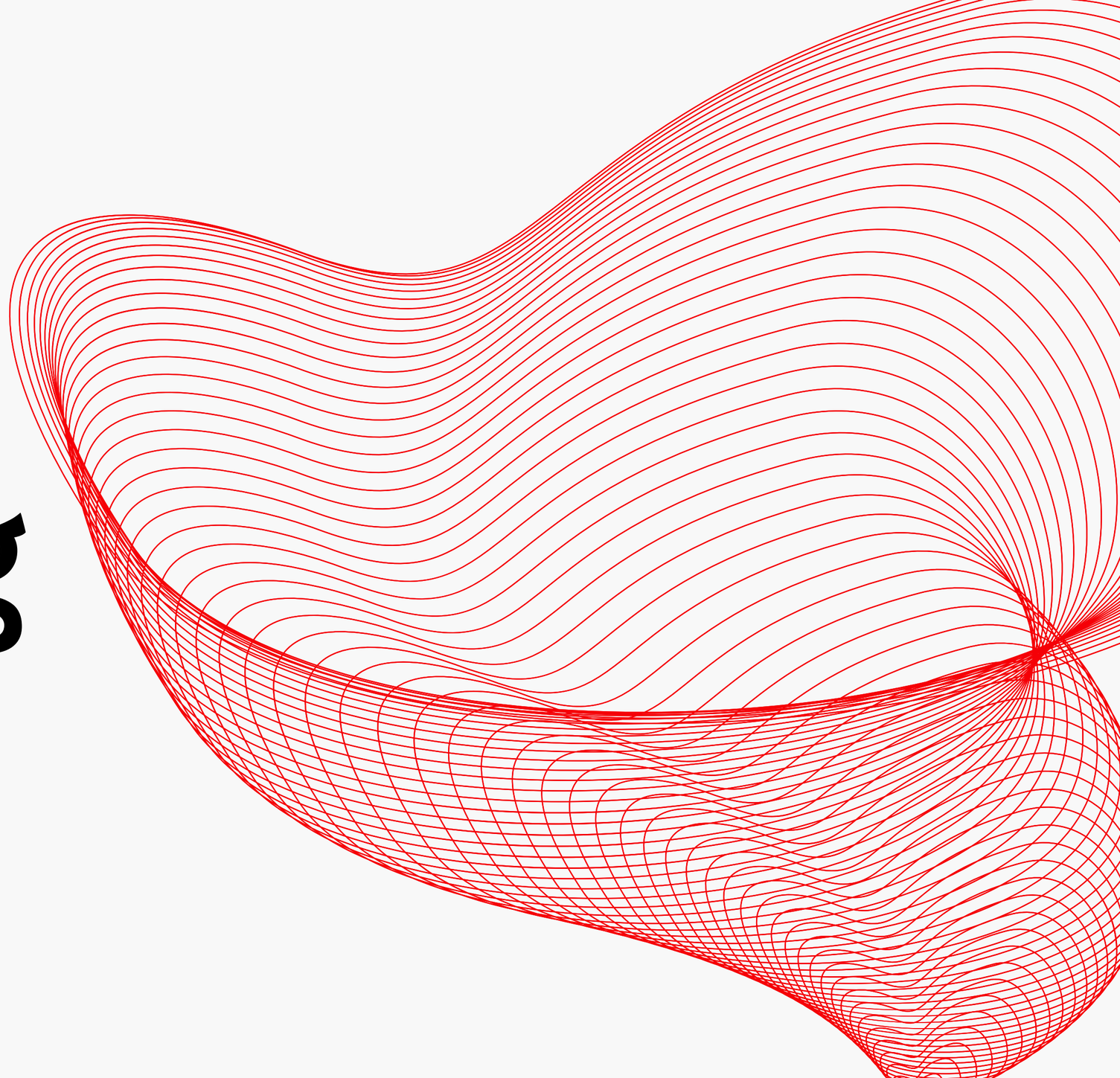
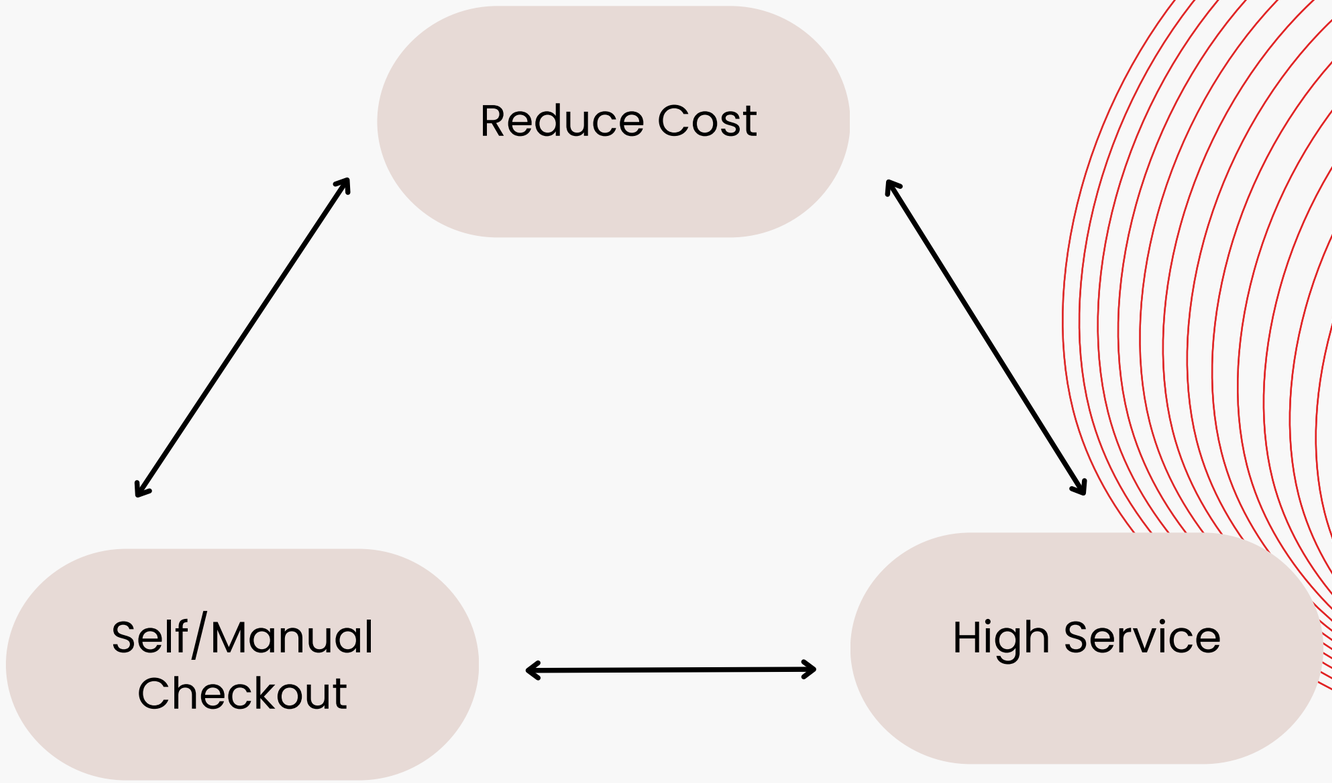
coles

Employee Scheduling Problem



Introduction



Goals

- Reducing labour costs
- Maintain Efficient Service
- Maintain Customer Satisfaction
- Reduce wait times

Literature Review

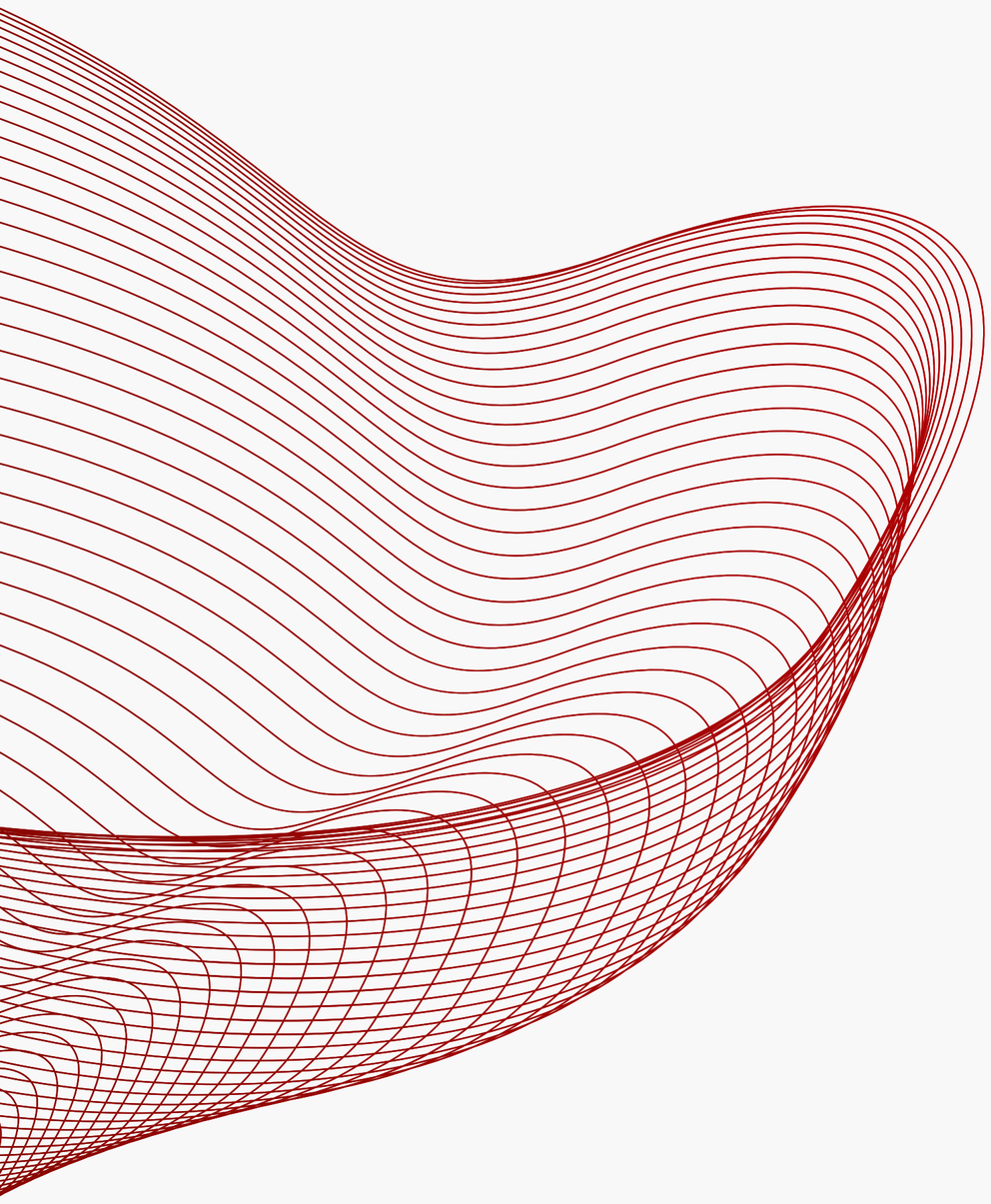
Pros

- Looked into different mathematical models for employee scheduling
- Insights on constraints
- Minimising customer wait times
- Decreasing Labour Costs
- Improved efficiency

Cons

- Lack similarity to real-life scenarios in Australia
- Employee dissatisfaction
- Employee turnover
- Sick leave
- Impacts of self-checkout machines

Cole's Collingwood Store Optimization Problem



Step I:

Using a binary integer model to optimise the employment schedule to minimise labour costs by considering self-checkout machines, penalties for not meeting shift demand, and worker request ratio while restricting the employee's continued working days and shift fairness while meeting the customer flow request.

Store Basic Information & Assumption

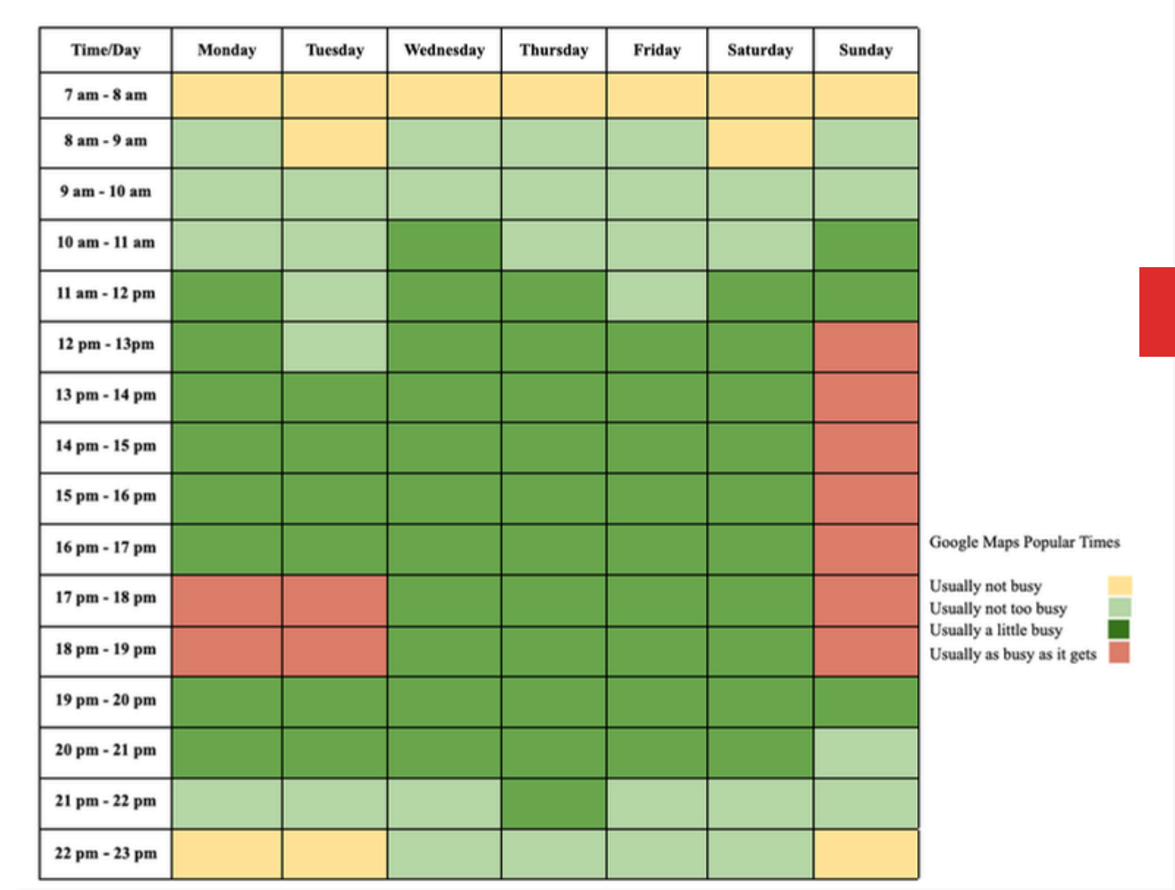
- 7 a.m. to 11 p.m., Monday through Sunday.

- 4 shifts per day
  - Shift 1: 7 to 11 am
  - Shift 2: 11 to 15 pm
  - shift 3 from 15 to 19 pm
  - shift 4 from 19 to 23 pm,

- The average weekly population visitation per Coles store in Victoria: 16014

- Operation time
  - "usually not busy,"
  - "usually not too busy"
  - "usually as busy as it gets"
  - "usually as busy as it gets"

Store Basic Information & Assumption



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
7 am - 11 am	2	1	2	2	2	1	3
11 am - 15 pm	3	3	3	3	3	3	4
15 pm - 19 pm	4	4	3	3	3	3	4
19 pm - 23 pm	3	3	3	3	3	2	3

- Minimum number of staff at cashier checkouts
  - 0 (Yellow)
  - 1 (Light Green)
  - 2 (Dark Green)
  - 3 (Red)
- Number of staff Monitor self-checkout machine： 1
- **10 employees in total**
- Three typical employee types in the store
  - Full- Time
  - Part-Time
  - Casual

Step 2: Define the Decision Variables

$$X_{ijkl} = \begin{cases} 1, & Staff\ i\ is\ allocated\ to\ the\ Working\ Section\ j\ on\ the\ Day\ k\ during\ Shift\ l \\ 0, & Otherwise \end{cases}$$

Where,

i: Employee Type

- $i = 1, 2, 3 \rightarrow$ Full-time employee
- $i = 4, 5, 6, 7 \rightarrow$ Part-time employee
- $i = 8, 9, 10 \rightarrow$ Casual employee

j: Working Section

- $j = 1 \rightarrow$ Employee monitoring self-checkout machines
- $j = 2 \rightarrow$ Employee at manual check-out cashiers

k: Day in the Week

- $k = 1 \rightarrow$ Monday
- $k = 2 \rightarrow$ Tuesday
- $k = 3 \rightarrow$ Wednesday
- $k = 4 \rightarrow$ Thursday
- $k = 5 \rightarrow$ Friday
- $k = 6 \rightarrow$ Saturday
- $k = 7 \rightarrow$ Sunday

l: Shifts in a Day

- $l = 1 \rightarrow$ 7 am - 11 am
- $l = 2 \rightarrow$ 11 am - 15 pm
- $l = 3 \rightarrow$ 15 pm - 19 pm
- $l = 4 \rightarrow$ 19 pm - 23 pm

$$P_{1kl} = \begin{cases} 1, & Number\ of\ staff\ allocated\ to\ Day\ k\ Shift\ l\ does\ not\ meet\ the\ target \\ 0, & Otherwise \end{cases}$$

$$P_{2kl} \begin{cases} 1, & If\ the\ ratio\ \dfrac{Full-time\ Employee}{Part-time + Casual\ Employee}\ in\ Day\ k\ < 1:3 \\ 0, & Otherwise \end{cases}$$

Step 3: Identify the Objective Function

Time / Weekday	Pay Rate	Monday - Friday		Saturday (135% for casual, 125% for others)	Sunday (195%)
7: 00 - 18: 00 (100%)	1	Full Time ($ / hour)	22.68	28.35	44.226
		Part-Time ($ / hour)	20.55	25.6875	40.0725
		Casual ($ / hour)	24.4	30.5	47.58
After-Hour Wage					
18: 00 - 23: 00 (125%)	1.25	Full Time ($ / hour)	28.35		44.226
		Part Time ($ / hour)	25.6875		40.0725
		Casual ($ / hour)	30.5		47.58

Step 3: Identify the Objective

Function

Employee Type		Wk Work Section	Monday				Tuesday				Wednesday				Thursday				Friday				Saturday				Sunday			
			Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4	Shift 1	Shift 2	Shift 3	Shift 4
Full-Time Staff	1	Self-Checkout	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
		Manual	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
	2	Self-Checkout	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
		Manual	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
	3	Self-Checkout	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
		Manual	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	90.72	90.72	96.39	113.4	113.4	113.4	113.4	113.4	176.904	176.904	176.904	176.904
Part-Time Staff	4	Self-Checkout	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
		Manual	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
	5	Self-Checkout	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
		Manual	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
	6	Self-Checkout	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
		Manual	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
	7	Self-Checkout	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
		Manual	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	82.2	82.2	87.34	102.75	102.75	102.75	102.75	102.75	160.29	160.29	160.29	160.29
Casual Staff	8	Self-Checkout	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
		Manual	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
	9	Self-Checkout	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
		Manual	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
	10	Self-Checkout	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
		Manual	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	97.6	97.6	103.7	122	122	122	122	122	190.32	190.32	190.32	190.32
Demand Penalty			999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
Ratio Penalty			999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999

Objective Function & Decision Variables

$$Minimise\ the\ Total\ Cost\ or\ Z = \sum_{i=1}^{10}\sum_{j=1}^{2}\sum_{k=1}^{7}\sum_{l=1}^{4} \cdot X_{ijkl} S_{ijkl} + D_{kl} \sum_{k=1}^{7}\sum_{l=1}^{4} \cdot P_{1kl} + R_{kl} \sum_{k=1}^{7}\sum_{l=1}^{4} \cdot P_{2k}$$

Where,

S_{ijkl} = The Salary of Staff i assigned to Working Section j on Day k during the Shift l

D_{kl} = The penalty cost for not enough of staff on Day k during the shift l (i.e., \$999 per shift)

R_{kl} = The penalty cost for not satisfying the 1:3 ratio of full-time to part-time (casual) allocation on Day k (i.e., \$999 per shift)

Step 4:
Identify the Constraints

Constraint 1 : Working Hours of Full-time Employee

A full-time staff must work at least 38 hours per week and no more than 40 hours per week.

$$38 \leq \sum_{j=1}^{2} \sum_{k=1}^{7} \sum_{l=1}^{4} X_{ijkl} \cdot 4 \leq 40, \text{ For } i \in 1, 2, 3;$$

Constraint 2 : Working Hours of Part-time Employee

A part-time staff may work a minimum of four hours per week and no more than 38 hours per week.

$$4 \leq \sum_{j=1}^{2} \sum_{k=1}^{7} \sum_{l=1}^{4} X_{ijkl} \cdot 4 \leq 38, \text{ For } i \in 4, 5, 6, 7;$$

Constraint 3 : Working Hours of Casual Employee

A casual staff can work up to 38 hours per week with no restrictions on the minimum number of hours they can work.

$$0 \leq \sum_{j=1}^{2} \sum_{k=1}^{7} \sum_{l=1}^{4} X_{ijkl} \cdot 4 \leq 38, \text{ For } i \in 8, 9, 10;$$

Constraint 4 : Consecutive Working Days within One Week

All employees cannot work more than 5 consecutive days per week.

$$X_{ik1} + X_{ik2} + X_{ik3} + X_{ik4} - (M \times Y_{ik}) \leq 0$$

$$Y_{ik} - (X_{ik1} + X_{ik2} + X_{ik3} + X_{ik4}) \leq 0$$

For Staff $i \in 1, 2, \ldots, 10$; Day $k \in 1, 2, 3, 4, 5, 6, 7$;

$$\sum_{k=1}^{6} Y_{ik} \leq 5$$

$$\sum_{k=2}^{7} Y_{ik} \leq 5$$

For Staff $i \in 1, 2, \ldots, 10$;

M is set as an arbitrarily large number set as 9999.

Y_{ik} is set as a binary variable indicating whether this employee is working on this day.

Constraint 5 : Service Quality Requirements

At least one full-time employee should be allocated during each shift.

$$\sum_{i=1}^{3}\sum_{j=1}^{2} X_{ijkl} \geq 1$$

For $k \in 1, 2, 3, 4, 5, 6, 7$, $l \in 1, 2, 3, 4$;

Constraint 6 : Service Quality Requirements

There must be at least 2 employees in each shift, regardless of whether they are working in self-checkout areas or manual check-out cashiers.

$$\sum_{i=1}^{10} \sum_{j=1}^{2} X_{ijkl} \geq 2$$

For $k \in 1, 2, 3, 4, 5, 6, 7$, $l \in 1, 2, 3, 4$;

Constraint 7 : Minimum Number of Employees in each Role

For four peak shift time periods (Shift 3 on Monday, Shift 3 on Tuesday, Shift 2 and 3 on Sunday), there must be at least one employee at self-checkout and one employee at manual cashier check-out areas.

$$\sum_{i=1}^{10} X_{i1kl} \geq 1$$

$$\sum_{i=1}^{10} X_{i2kl} \geq 1$$

For $k \in 1$, $l \in 3$; For $k \in 2$, $l \in 3$; For $k \in 7$, $l \in 2,3$;

Constraint 8 : Customer Demand Penalty Cost

The penalty cost if the number of staff on Day k during the shift l is fewer than the minimum requirement of employees (i.e. $999 per shift).

$$P_{1kl} = \begin{cases} 1, & Number\ of\ staff\ allocated\ to\ Day\ k\ Shift\ l\ does\ not\ meet\ the\ target \\ 0, & Otherwise \end{cases}$$

Formula		LHS	Inequality	RHS
=SUM(D33:D52)+D53*D25	Monday	2	>=	2
=SUM(E33:E52)+E53*E25		3	>=	3
=SUM(F33:F52)+F53*F25		4	>=	4
=SUM(G33:G52)+G53*G25		3	>=	3
=SUM(H33:H52)+H53*H25	Tuesday	2	>=	1
=SUM(I33:I52)+I53*I25		3	>=	3
=SUM(J33:J52)+J53*J25		4	>=	4
=SUM(K33:K52)+K53*K25		3	>=	3
=SUM(L33:L52)+J53*J25	Wednesday	2	>=	2
=SUM(M33:M52)+M53*M25		3	>=	3
=SUM(N33:N52)+N53*N25		3	>=	3
=SUM(O33:O52)+O53*O25		3	>=	3
=SUM(P33:P52)+P53*P25	Thursday	2	>=	2
=SUM(Q33:Q52)+Q53*Q25		3	>=	3
=SUM(R33:R52)+R53*R25		3	>=	3
=SUM(S33:S52)+S53*S25		3	>=	3
=SUM(T33:T52)+T53*T25	Friday	2	>=	2
=SUM(U33:U52)+U53*U25		3	>=	3
=SUM(V33:V52)+V53*V25		3	>=	3
=SUM(W33:W52)+W53*W25		3	>=	3
=SUM(X33:X52)+X53*X25	Saturday	2	>=	1
=SUM(Y33:Y52)+Y53*Y25		3	>=	3
=SUM(Z33:Z52)+Z53*Z25		4	>=	3
=SUM(AA33:AA52)+AA53*AA25		2	>=	2
=SUM(AB33:AB52)+AB53*AB25	Sunday	3	>=	3
=SUM(AC33:AC52)+AC53*AC25		4	>=	4
=SUM(AD33:AD52)+AD53*AD25		4	>=	4
=SUM(AE33:AE52)+AE53*AE25		3	>=	3

Constraint 9 : Employee Ratio Penalty Cost

There is a $999 penalty if the ratio of full-time to part-time plus casual is lower than 1: 3, because the unbalanced employee ratio will affect the service quality.

$$P_{2kl}\begin{cases}1, & If\ the\ ratio\ \dfrac{Full-time\ Employee}{Part-time+Casual\ Employee}\ in\ Day\ k\ < 1:3\\ 0, & Otherwise\end{cases}$$

Formula	LHS	Inequality	RHS
=3*SUM(D33:G38)-SUM(D39:G52)+D54*D26	4	>=	0
=3*SUM(H33:K38)-SUM(H39:K52)+H54*H26	4	>=	0
=3*SUM(L33:O38)-SUM(L39:O52)+L54*L26	5	>=	0
=3*SUM(P33:S38)-SUM(P39:S52)+P54*P26	13	>=	0
=3*SUM(T33:W38)-SUM(T39:W52)+T54*T26	5	>=	0
=3*SUM(X33:AA38)-SUM(X39:AA52)+X54*X26	5	>=	0
=3*SUM(AB33:AE38)-SUM(AB39:AE52)+AB54*AB26	2	>=	0

Constraint 10 : Non-Negativity

The variables in this model should not have negative values.

$$X_{ijkl} \geq 0, \qquad For\ all\ i, j, k, l$$

$$Y_{ik} \geq 0\ , \qquad For\ all\ i, k$$

Constraint II : Binary Integrity

All of the variables in this model are binary variables that their values are either 0 or 1.

$$X_{ijkl} = 0 \text{ or } 1, \qquad For\ all\ i, j, k, l$$

$$Y_{ik} = 0 \text{ or } 1, \qquad For\ all\ i, k$$

$$P_{1kl} = 0 \text{ or } 1, \qquad For\ all\ k, l$$

$$P_{2kl} = 0 \text{ or } 1, \qquad For\ all\ k, l$$

Discussions & Conclusion

Strength & Limitation

Strength

- Considers self-checkout department
- Maintenance of quality service
- Ensuring Efficient Operation in Scheduling

Limitation

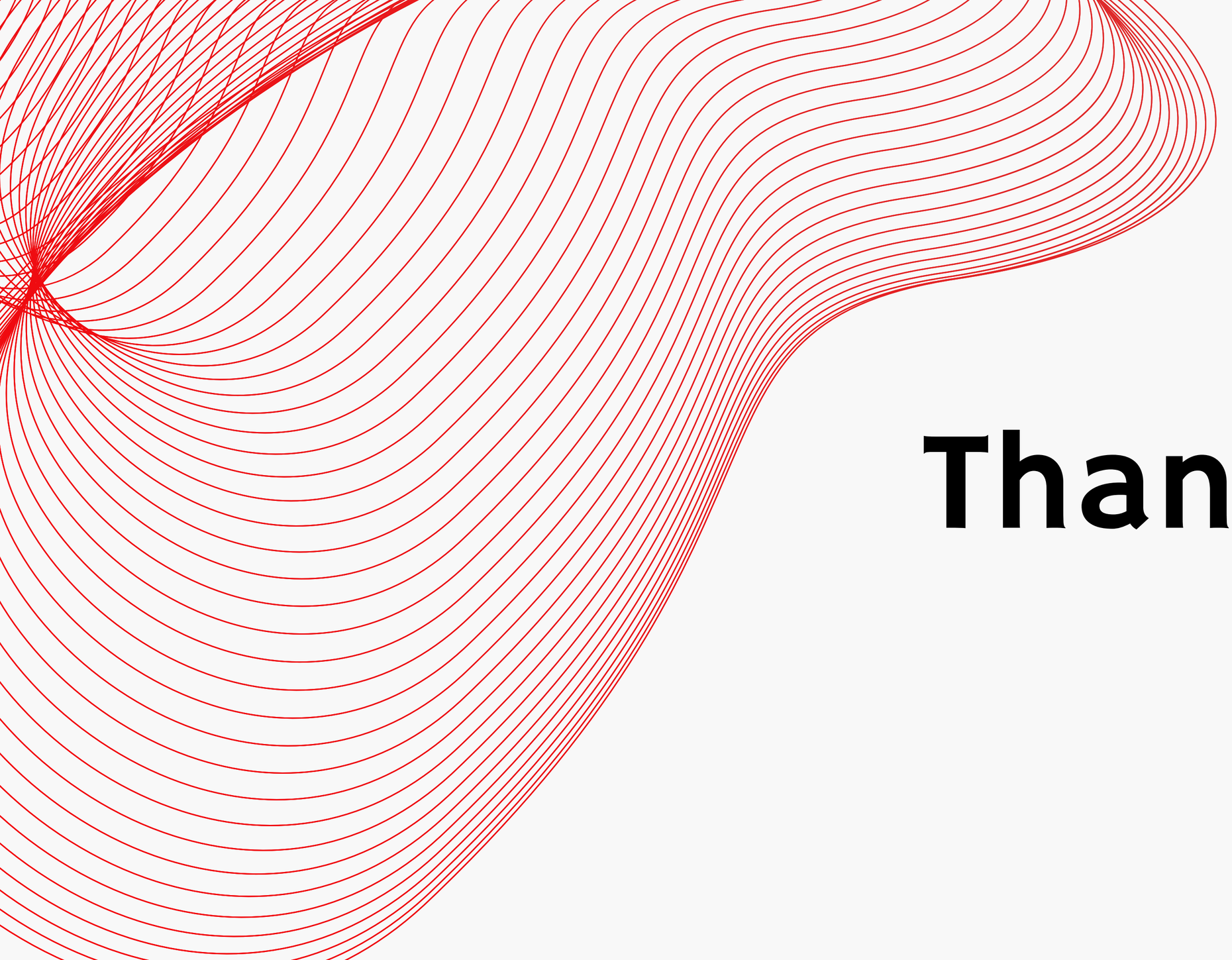
- Does not consider the public holiday
- Staff preferences failed to consider
- Failed to consider break time for Part-time / Casual employees
- Simultaneous Assignment of Employees to Multiple Positions

Recommendations

- Increase constraints and consider more comprehensive decision variables
  - -Break Time & Employee Preferences
- More accurate data
  - -Collect accurate daily customer traffic data
- Recruiting more Employees to Deal with Increasing Customer Demand
  - -The recovery of the economy
- Multi-skilled staff development
  - -Further reduction of staff costs

Conclusions

- A binary integer programming model with 9 constraints and 2 assumptions
- Minimize staffing costs
- Informative methodologies and considerations



Thank You