Optimizing Staff Scheduling at Iowa City Papa Johns

Grace Trane, Carrie Cox, Arun Ganapathy,
Michael Neuhaus

Presentation Agenda

- Problem Description
- Papa John's Data
- Optimization Formulation
- Computational Results
- Challenges
- Discussion

Problem Description

- Currently scheduling staff manually
- High variability in demand based on time of day, day of the week, season of the year
- Optimize number of part-time and full-time employees to meet customer demand

Problem Description – Shifts & Sales

Table 1. Original Shifts

Shift	Hours
Lunch	10:00 am - 2:59 pm
Afternoon	3:00 pm - 4:59 pm
Day	5:00 pm - 8:59 pm
Evening	9:00 pm - 11:59 pm
Late Night	12:00 am - 1:59am
After	2:00 am --

Table 1. Net Sales from a week in Fall 2018

Day	Net Sales	% of Total Weekly Sales
Monday	$2,705.80	6.68%
Tuesday	$3,270.30	8.07%
Wednesday	$3,193.83	7.88%
Thursday	$3,973.62	9.81%
Friday	$7,097.74	17.51%
Saturday	$16,509.44	40.74%
Sunday	$3,774.80	9.31%

Problem Description - Deliverables

We want to provide Iowa City Papa John's management with a tool that they can use to schedule the most optimal number of workers and have them start at the optimal time.

To solve the issue of scheduling an inefficient number of workers that cannot meet demand and ultimately leading to a negative customer and employee experience.

We will solve this issue through creating an Integer Linear Program that uses data from Papa John's for demand and has constraints relating to shift length, labor hours, and store hours.

Data – Shift setup

- Sales periods represent general patterns of business
- Shifts are meant to cover sales periods
- Demand is not always evenly distributed through each period

Table 1. Original Shifts

Sales Period	Time
Lunch	10:00 am - 1:59 pm
Afternoon	2:00 pm - 4:59 pm
Dinner	5:00 pm - 8:59 pm
Evening	9:00 pm - 11:59 pm
Late Night	12:00 am - 1:59 am
After	--

Data - New Shifts

Redefined shifts by breaking down sales periods into 2-hour increments

Table 4. Updated Shifts for Modeling

Shift Name	Shift Time
Lunch AM	10:00 am - 11:59 am
Lunch PM	12:00 pm - 1:59 pm
Afternoon AM	2:00 pm - 3:59 pm
Afternoon PM	4:00 pm - 5:59 pm
Day	6:00 pm - 7:59 pm
Evening AM	8:00 pm - 9:59 pm
Evening PM	10:00 pm - 11:59 pm
Late Night	12:00 am - 1:59 am
After	2:00 am --

Data - Modeling Demand

Management's Rule of Thumb:

- 1 insider per 15 products per hour
- 1 driver per 4 deliveries per hour

Table 3. Driver and Inside Workers Raw Counts

Monday								
	Del	C/O	DV	IN	Prd	Del	C/O
Before	0	0	0.00	1.29	0	2	0
10:00 am - 10:59 am	3	0	1.44	2.00	6	3	0
11:00 am - 11:59 am	1	2	2.00	2.00	6	3	2
12:00 pm - 12:59 pm	5	2	2.00	2.00	10	1	3
01:00 pm - 01:59 pm	10	2	3.33	1.61	25	1	0
02:00 pm - 02:59 pm	4	4	4.00	1.00	14	2	1
03:00 pm - 03:59 pm	7	3	3.29	1.97	18	0	2
04:00 pm - 04:59 pm	7	4	3.24	2.95	24	5	1
05:00 pm - 05:59 pm	10	8	3.86	4.15	29	7	5
06:00 pm - 06:59 pm	13	4	4.86	5.00	38	8	2
07:00 pm - 07:59 pm	8	11	5.00	5.00	30	3	6
08:00 pm - 08:59 pm	6	9	5.00	4.93	20	6	4
09:00 pm - 09:59 pm	7	5	3.33	3.01	15	5	1
10:00 pm - 10:59 pm	3	6	2.35	2.09	16	7	3
11:00 pm - 11:59 pm	2	4	2.00	2.00	9	11	2
12:00 am - 12:59 am	3	1	2.00	2.00	6	13	2
01:00 am - 01:59 am	0	0	1.63	1.66	0	0	0
After	0	0	0.00	0.00	0	0	0
Totals :	89	65	49.33	44.66	266	77	34

Data - Modeling Demand

- All numbers rounded up (ceiling function)
- Insiders & drivers combined into single metric
- Demand can exceed availability

DEMAND OF EMPLOYEES *(Table 5)*

Shift No	Shift Name	Shift Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Lunch AM	10:00 am - 11:59 am	2	8	9	9	12	7	4
2	Lunch PM	12:00 pm - 1:59 pm	7	1	4	3	2	8	6
3	Afternoon AM	2:00 pm - 3:59 pm	5	1	4	3	4	12	7
4	Afternoon PM	4:00 pm - 5:59 pm	8	9	12	11	11	39	12
5	Day	6:00 pm - 7:59 pm	10	7	12	13	20	36	13
6	Evening AM	8:00 pm - 9:59 pm	6	5	5	7	16	51	12
7	Evening PM	10:00 pm - 11:59 pm	3	7	5	6	19	44	15
8	Late Night	12:00 am - 1:59 am	2	5	1	7	27	57	0
9	After	2:00 am - 3:59 am	0	0	0	1	13	19	0

Data – Employee Requirements

- Hard constraints for the model
- Tied to store's workforce

Table 6. Minimum and Maximum Employee Requirements

Shift No	Shift Name	Shift Time	Minimum	Maximum
1	Lunch AM	10:00 am - 11:59 am	3	6
2	Lunch PM	12:00 pm - 1:59 pm	3	6
3	Afternoon AM	2:00 pm - 3:59 pm	3	6
4	Afternoon PM	4:00 pm - 5:59 pm	3	15
5	Day	6:00 pm - 7:59 pm	3	27
6	Evening AM	8:00 pm - 9:59 pm	3	27
7	Evening PM	10:00 pm - 11:59 pm	3	20
8	Late Night	12:00 am - 1:59 am	3	8
9	After	2:00 am - 3:59 am	3	8

Data – Model Input

FINALIZED MAX REQUIREMENTS OF EMPLOYEES *(Table 7)*

Shift No	Shift Name	Shift Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Lunch AM	10:00 am - 11:59 am	**3**	**6**	**6**	**6**	**6**	**6**	4
2	Lunch PM	12:00 pm - 1:59 pm	**6**	3	4	3	**3**	**6**	6
3	Afternoon AM	2:00 pm - 3:59 pm	5	**3**	4	3	4	**6**	**6**
4	Afternoon PM	4:00 pm - 5:59 pm	8	9	12	11	11	**15**	12
5	Day	6:00 pm - 7:59 pm	10	7	12	13	20	**27**	13
6	Evening AM	8:00 pm - 9:59 pm	6	5	5	7	16	**27**	12
7	Evening PM	10:00 pm - 11:59 pm	3	7	5	6	19	**20**	15
8	Late Night	12:00 am - 1:59 am	**3**	**5**	**3**	7	**8**	**8**	**3**
9	After	2:00 am - 3:59 am				**3**	**8**	**8**	

Optimization Formulation

- Further technique and application detailed in Jupyter Notebook

Results

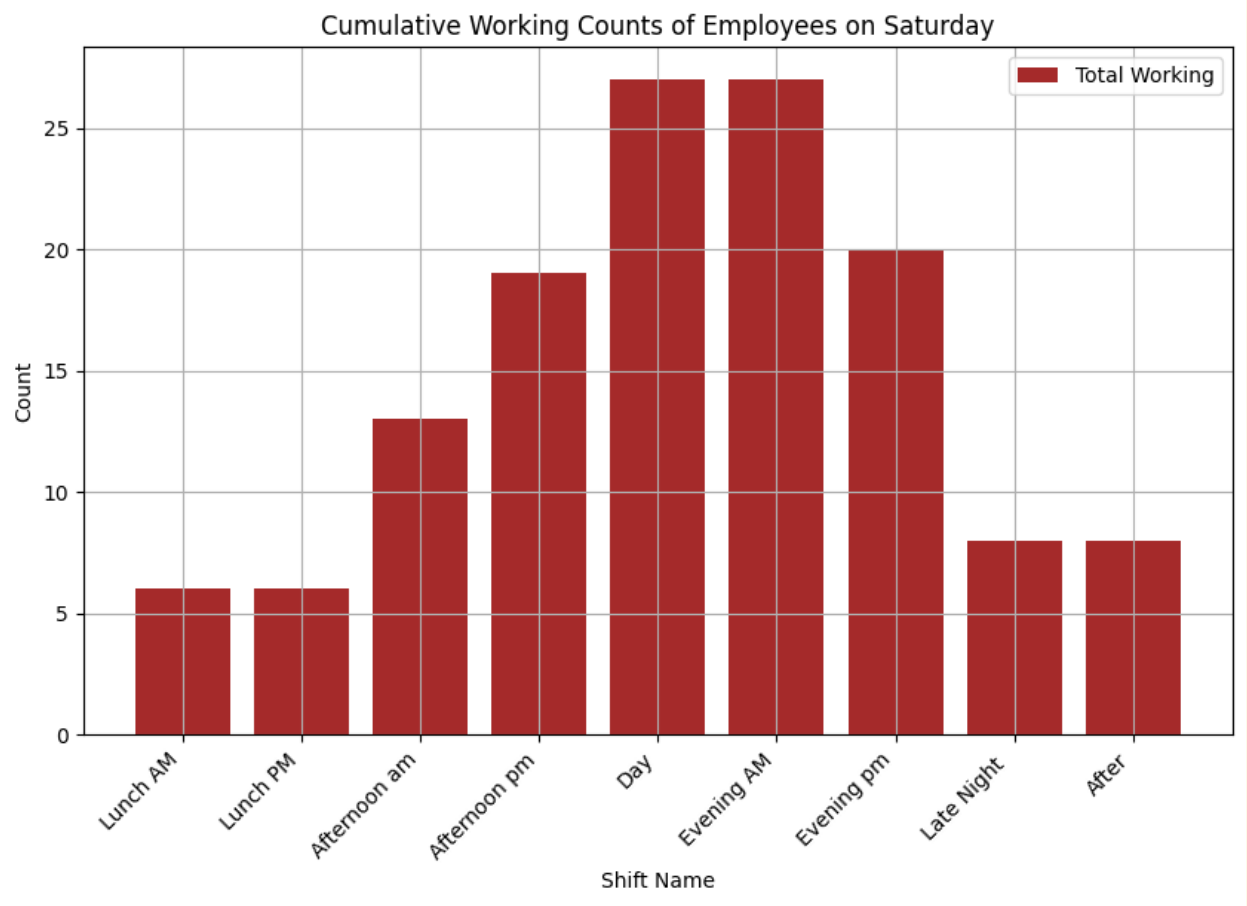

Figure 1. Optimization results – Cumulative Worker Counts

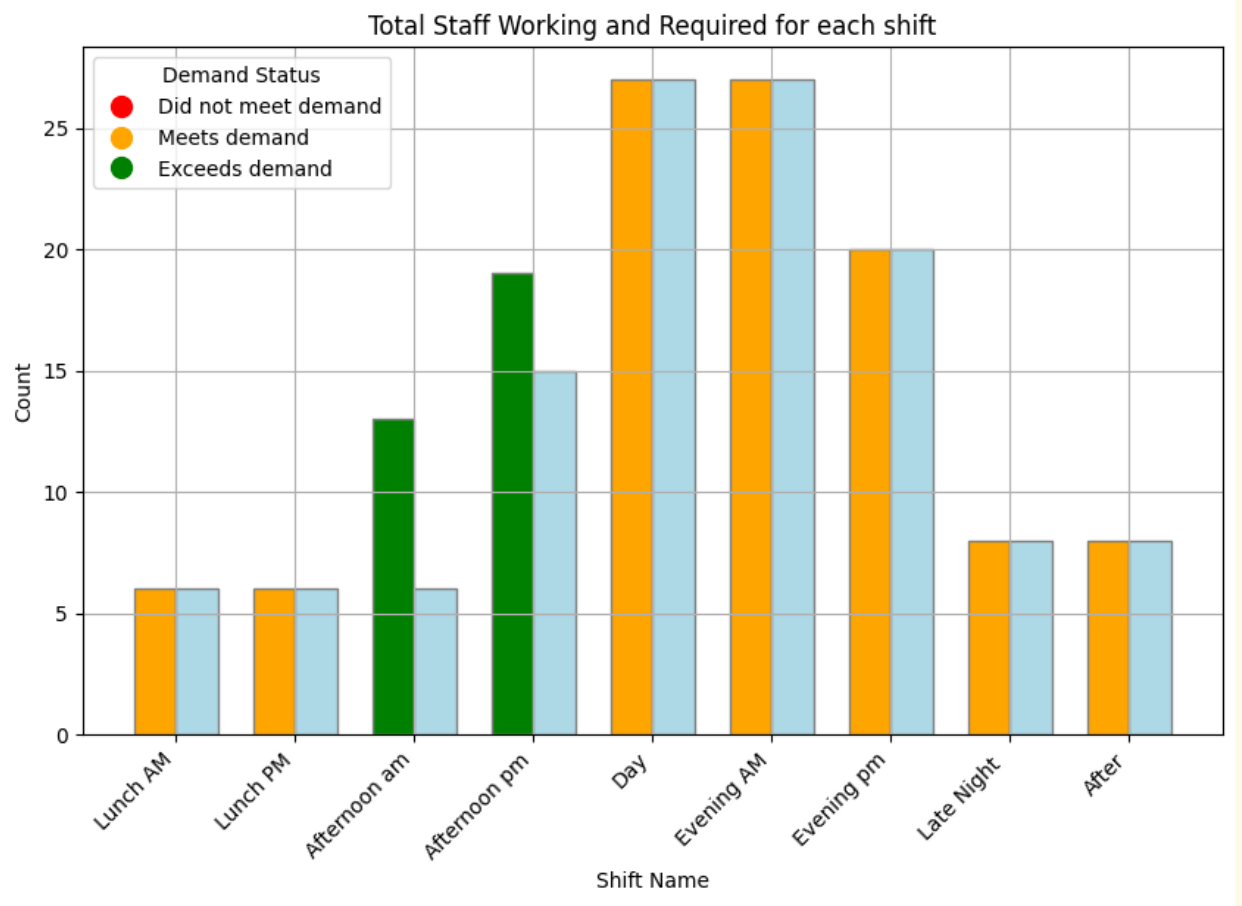

Figure 2. Cumulative demand requirements

Results

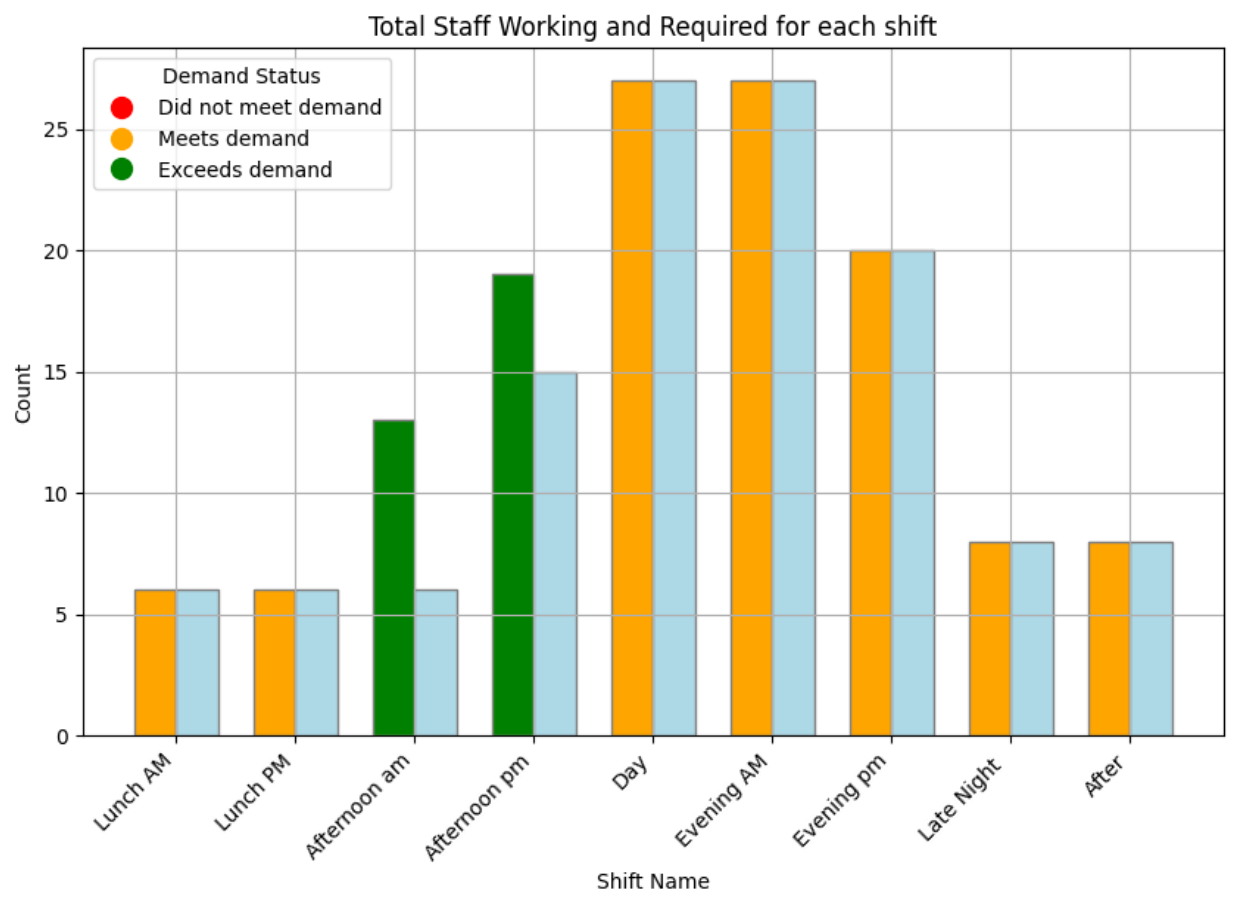

Figure 2. Cumulative demand requirements

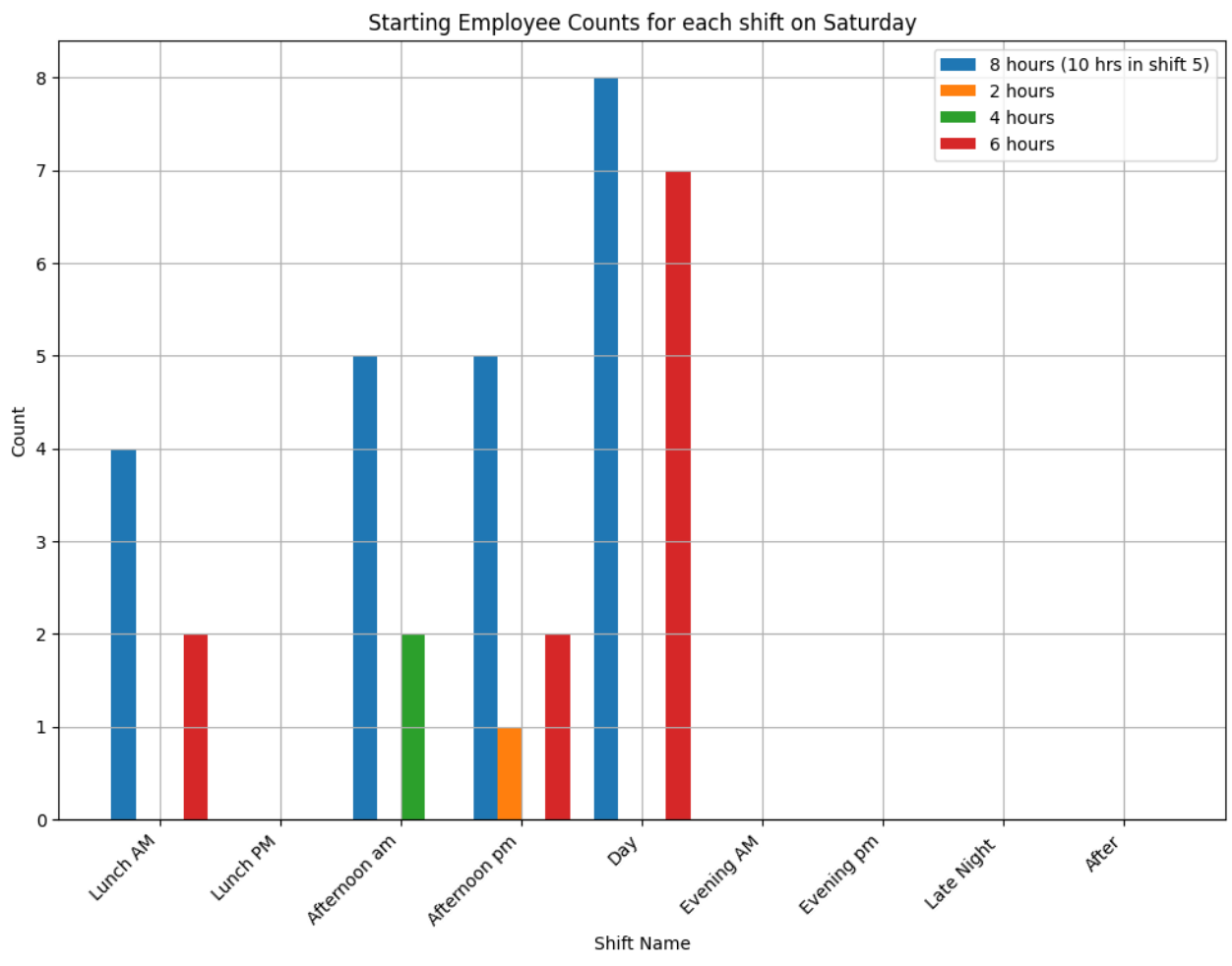

Figure 3. Results separated by shift type

Results

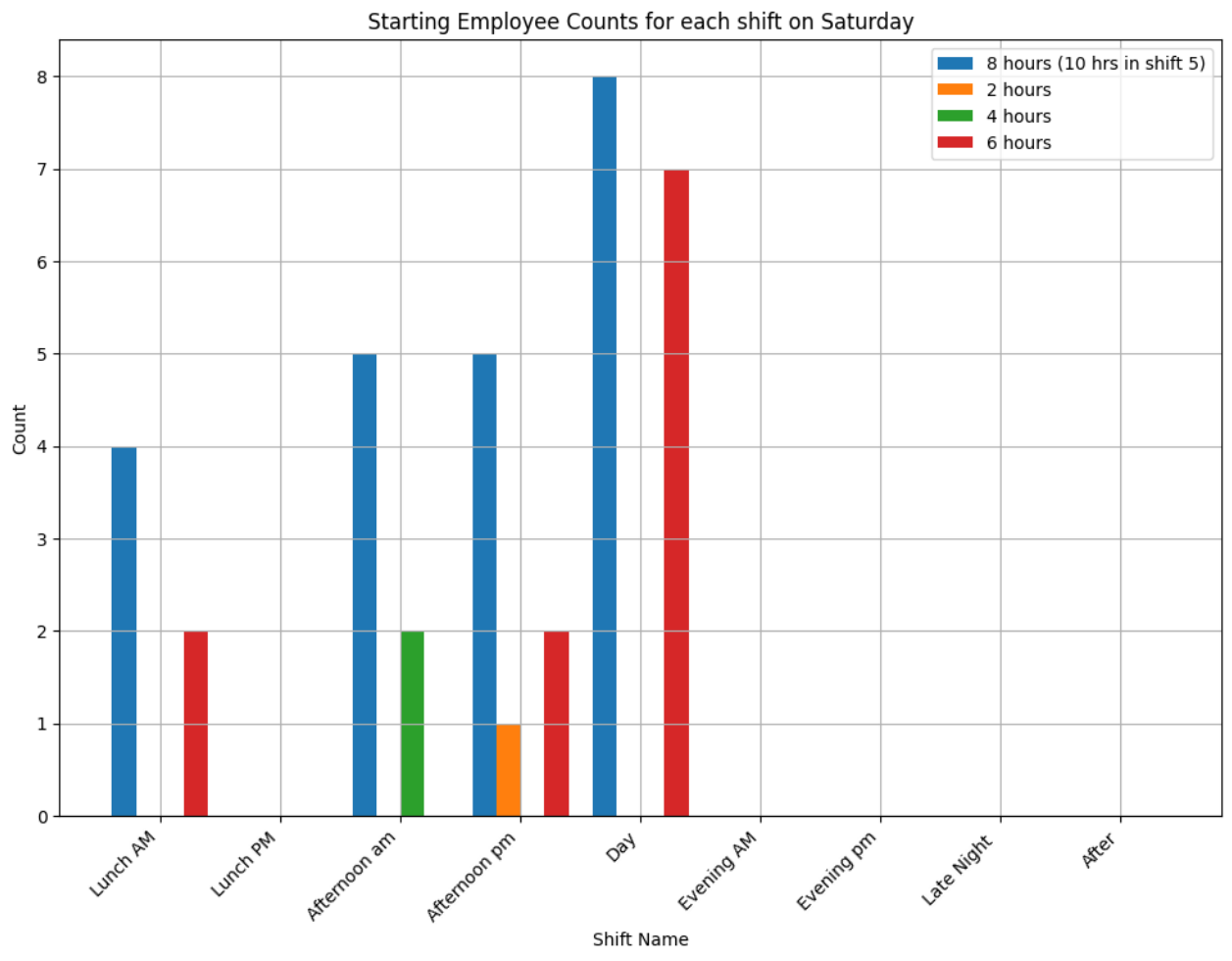

Figure 3. Results separated by shift type

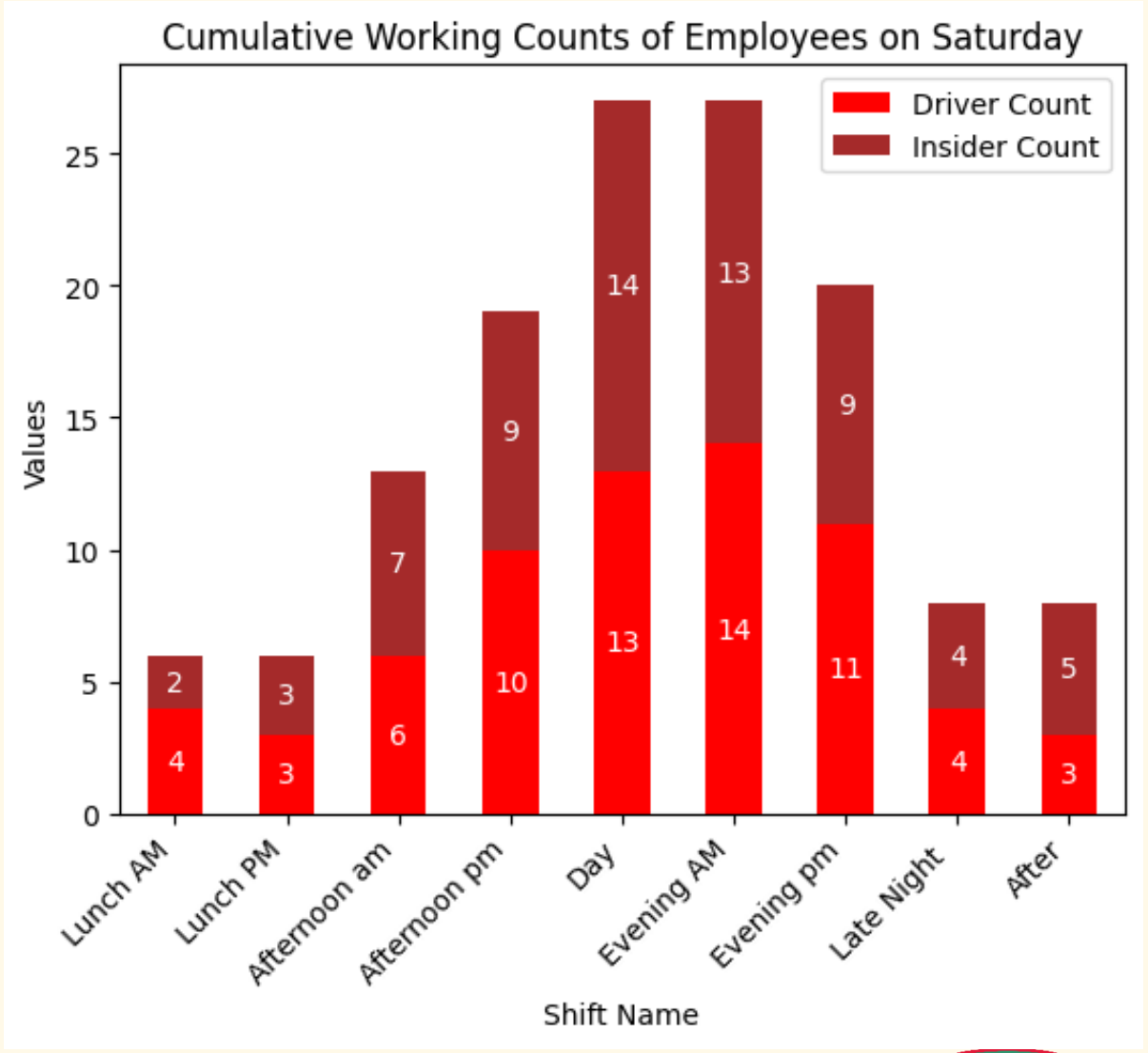

Figure 4. Ratio of Drivers and Inside Employees

Challenges

Practical

- Employees don’t start shifts after dinner time (Shift 5: 'Day')
- Management won’t schedule employees for only 2 hours

Technical

- One specific week, not simulated data
- Shift names & lengths were changed from original data
- Did not solve for the individual worker to ensure 39.9 hrs for near full-time employees

Discussion

Moving forward, Papa John's management could dynamically change the demand inputs in Excel based on forecasts of sales

Opportunity to modify our model to have increased flexibility for which shift types management would like to prioritize

Overall, Iowa City Papa John's can increase operational efficiency and improve customer and employee experience

Thank you!

Q & A

Credits: This presentation template was created by Slidesgo, including icons from Flaticon, & images by Freepik