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Systems Simulation
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Panera Cashier Simulation Analysis

1. The Problem Definition and Purpose of the Simulation

The Stow Panera wants to know the optimal number of cashiers to have scheduled during the busiest time of the day, lunch. The measures they want to use to make this decision is based upon the customer experience, percentage time utilization of cashiers, and the profit made during lunch.

The customer experience will be measured based on the time the customer spends waiting to place their order and the number of customers in line waiting. The desire for both measures is to have the lowest possible time and number of customers in line. The lower the numbers, the better the experience will be for the customer. The goal for the customer experience is to find the lowest possible value for both measures while weighing the other measures of this project.

Utilizing the cashiers is another measure that will be used. Panera wants to make sure the cashiers are not having too much time standing at the register but also does not want them to be so busy that they cannot keep up with the arrival of customers. The ideal utilization time is between 50-75% of the time. The cashiers will not just be taking customer orders they will also be preparing food such as smoothies, bagels, and pastries.

Lastly, as a business, the goal is always to maximize profit. Panera wants to achieve the highest profit it can achieve without hurting the customer experience. If customers are not satisfied with the service, then most likely that will ultimately determine if a customer will return or not to that business.

2. Data Collection and Assumptions

2.1 Data Collection

The data I collected was during normal lunch hours on a weekend day from 11:15 am to 1:15 pm and on two weekdays from 11:30 am to 1:00 pm. The data I collected was on the wait time of the customer, the amount of time it took for a customer to place the order, the party size, and the total time the customer was in process from the time they entered to the time the order was completed. To further clarify how I defined party size, a party size represents the number of people in a group but represents one order. For example, if a group of 5 people came into Panera but only placed one order, the party size is 5 but only represents one order.

2.2 Assumptions

In this section, I will state the assumptions that I used when completing this project. I will begin with the profit margin number that I used within the project. I used 45% as the gross profit margin and my source for this number was from CSI Market's website which the website address can be found in my reference section. This seemed like a reasonable number as most businesses desire to have a profit margin of around 50% to make their business viable.

The last assumption I made was on the min, max, and average order amount per person. Based on the menu I assumed that the lowest amount for the order would be the cost of a beverage which $2.00. The

highest amount would be a “You Pick Two” order with a beverage which would total about $20. The average order per person that I choose was $10.

3. Simulation System

3.1 Random Distributions

After I finished collecting the data, I used a program called “Input Analyzer” to determine the appropriate random distribution to use for customer arrival times, order times, and the party size. Jeremie Gallien, a professor at MIT, gives a great overview of each distribution that I used in this project.

Below is a chart of the random distribution given to each variable in the simulation system:

FIG 1. WEEKEND RANDOM DISTRIBUTIONS

Variable	*Formula*	*Distribution Type*
Customer Arrival Times	-0.001+LOGN(2.7,9.4)	Lognormal
Party Size	POIS(1.54)	Poisson
Order Cost	TRIA(2,10,20)	Triangular
Order Time	LOGN(2.07,1.35)	Lognormal

FIG 2. WEEKDAY RANDOM DISTRIBUTIONS

Variable	*Formula*	*Distribution Type*
Customer Arrival Times	-0.001+GAMM(3.25,0.556)	Gamma
Party Size	POIS(1.28)	Poisson
Order Cost	TRIA(2,10,20)	Triangular
Order Time	LOGN(1.91,1.48)	Lognormal

3.2 The Model of the Cashier Ordering System

The system begins with the party enters the store. The party is randomly assigned a value that represents the number of customers in the party. The party is also assigned an order cost value representing the total cost of the order depending on the number of people in the party. After possibly waiting for a cashier to become available to take their order, the party then places their order, and then after ordering the customer leaves the system.

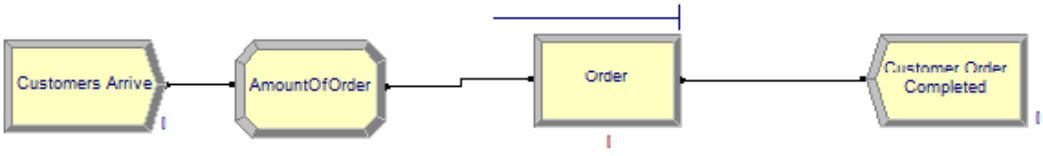

Fig. 3: The ordering system model.

3.3 The Simulation Run Setup

The simulation performed 150 replications of 2 hours for the weekend model and 1.5 hours for the weekday model.

4. Analysis of Simulation System

4.1 Validity of Results

Figures 4 and 5 below, show a comparison of the results of the system with the actual results from the days that I collected the data. I compared some of the results from the system with 2 cashiers on weekends and 1 cashier on weekdays since that was what I observed occurred during my data collection.

Fig 4: Weekend Data Comparison

	Ave Customer Wait Time	*Max Wait Time*	*Total number of Customers*
Actual Results	1.6 minutes	5.4 minutes	65
Simulated Results	1.4 minutes	5.8 minutes	75

Fig 5: Weekday Data Comparison

	Ave Customer Wait Time	*Max Wait Time*	*Total number of Customers*
Acutal Results	4.45 minutes	12.3 minutes	41
Simulated Results	8.4 minutes	19.6 minutes	41

The differences on the weekday while significant are not too concerning. There is greater variability in the dataset during the weekday compared to the weekend. The variability will be difficult to model due to the relatively small dataset that the simulation was based upon. However, what the model does pick up on is the significant amount of wait time the customer is experiencing versus the weekend customer. I believe the simulation accurately picks up on the trends between the weekend and weekday. Overall, by comparing the actual results with the simulated results, I believe that the system models the scenario well for the relatively small sample size that it was provided.

4.2 Analysis of the Simulation Results

4.2.1 Weekend Analysis

The Customer Experience

The customer will experience on average 78% less wait time as the number of more cashiers is added and have, on average, 85% shorter lines. However, the range of party's orders completed ranges from 42 to 51 with 1 to 4 cashiers. The most significant change occurred from 1 to 2 cashiers for every measurement.

FIG 6. WEEKEND SIMULATION RESULTS

Number of Cashiers	*Ave Customer Wait Time (min)*	*Maximum Customer Wait Time (min)*	*Ave Line of Customers*	*Max Line of Customers*
1	9.6	22.8	6	15
2	1.4	5.8	2	8
3	0.3	2.2	1	6
4	0.1	1.1	1	6

Cashier Utilization

Cashier utilization went down each time a cashier was added into the simulation. Intuitively this makes sense, the customers experience less wait time, but the cashiers experience more wait time because they do not serve as many customers. Again, the most significant decrease in utilization occurred from 1 to 2 cashiers. However, two cashiers are being utilized almost 50% of the time which is still reasonable for this scenario.

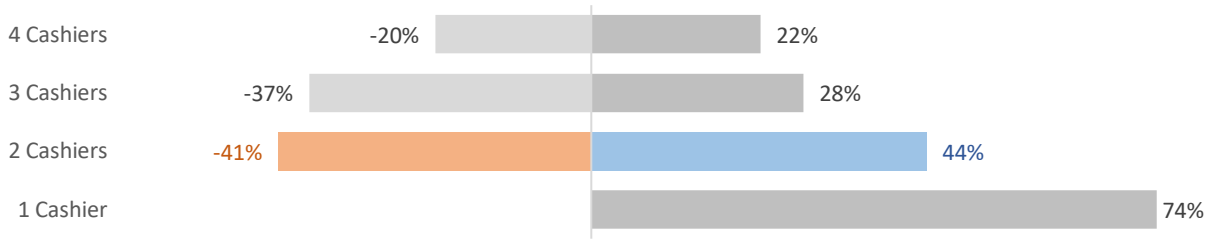

FIG 7. Cashier Utilization

Profit

Percent of profit change varied from 17% to -2% as cashiers were added. Surprisingly, there was a decrease in profit from adding 2 to 3 cashiers. The highest profit total was $370 with having 4 cashiers.

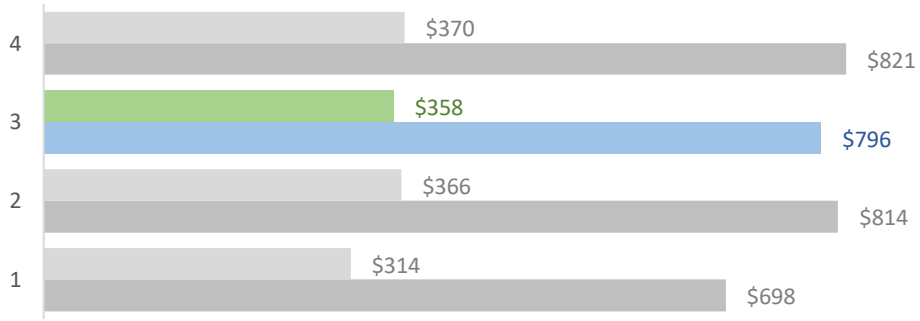

FIG 8. Total Profit and Revenue

4.2.2 Weekday Analysis

The Customer Experience

The customer will experience on average 85% less wait time as the number of cashiers is added and have, on average, 85% shorter lines. However, the range of party orders completed is very similar to the weekend with a range from 41 to 50 with 1 to 4 cashiers.

FIG 9. WEEKDAY SIMULATION RESULTS

Number of Cashiers	*Ave Customer Wait Time (min)*	*Maximum Customer Wait Time (min)*	*Ave Line of Customers*	*Max Line of Customers*
1	8.4	19.6	5	13
2	0.9	4.8	1	5
3	0.2	1.9	0	3

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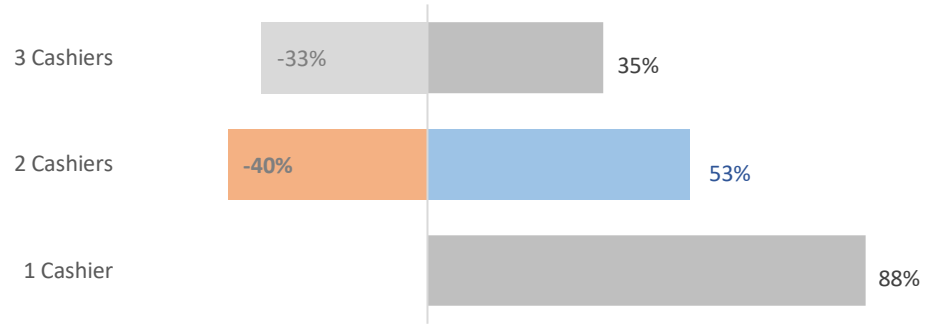

FIG 10. Cashier Utilization

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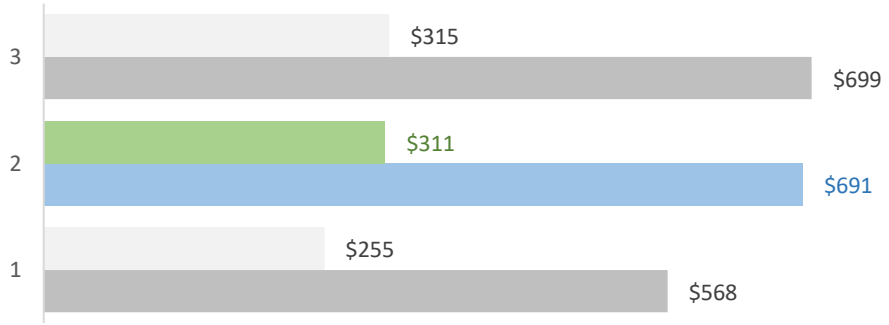

FIG 11. Total Profit **and** Revenue

5. Recommendations

Based on my analysis, 2 cashiers for both the weekend and weekday would be optimal. The average wait time decreases by over 78% for both types of days and so does the number of customers waiting in line. Also, increasing to 3 or 4 cashiers does not improve the number of party's orders completed or significantly increase the profit. Also, 2 cashiers are utilized at a much greater percentage so that they are not standing around for too long. For all those reasons, 2 cashiers will be the right balance of customer experience, profit generation, and utilization of the cashiers.

Note: For more details see the appendix for complete analysis tables.

References

CSI Market Website: https://csimarket.com/stocks/singleProfitabilityRatios.php?code=PNRA&gro

Gallien, J. (2003, October 25). *Common Probability Distributions for Simulation Modeling*. MIT Sloan School of Management. https://dspace.mit.edu/bitstream/handle/1721.1/74618/2-854-fall-2004/contents/lecture-notes/distrimodeling.pdf.

APPENDIX

Part 1. WEEKEND ANALYSIS

Total Revenue	Total Profit	Profit % Change	Number of Cashiers	Cashier Utilization	Cashier Utilization Change
$ 698	$ 314	0%	**1 Cashier**	74%	0%
$ 814	$ 366	17%	**2 Cashiers**	44%	-41%
$ 796	$ 358	-2%	**3 Cashiers**	28%	-37%
$ 821	$ 370	3%	**4 Cashiers**	22%	-20%

Ave Customer Wait Time	Ave Wait Time % Change	Maximum Customer Wait Time	Maximum Wait Time % Change	Ave. Customers in Process	Maximum Customers in Process	Ave Number of Customers Waiting	Maximum Number of Customers Waiting	Total Customers Served	Total Parties Served
9.6	0%	22.8	0%	6	15	5	14	65	42
1.4	-85%	5.8	-74%	2	8	1	6	75	50
0.3	-81%	2.2	-62%	1	6	0	3	73	48
0.1	-69%	1.1	-49%	1	6	0	2	76	51

Part 2. WEEKDAY ANALYSIS

Number of Cashiers	Total Revenue	Total Profit	Profit % Change	Number of Cashiers	Cashier Utilization	Cashier Utilization Change
1	$ 568	$ 255	0%	1 Cashier	88%	0%
2	$ 691	$ 311	22%	2 Cashiers	53%	-40%
3	$ 699	$ 315	1%	3 Cashiers	35%	-33%

Number of Cashiers	Average Customer Wait Time	Ave Wait Time % Change	Maximum Customer Wait Time	Maximum Wait Time % Change	Ave. Customers in Process	Maximum Customers in Process	Ave Number of Customers Waiting	Maximum Number of Customers Waiting	Total Customers Served	Total Groups Served
1	8.4	0%	19.6	0%	6	14	5	13	53	41
2	0.9	-89%	4.8	-76%	2	7	1	5	65	49
3	0.2	-80%	1.9	-61%	1	6	0	3	66	50