Durham Diner Operations Analysis for Efficiency

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Contents

Introduction

In this report, we present a probabilistic analysis to maximize customer satisfaction and profit for "Durham Diner" and ensure long-term success for the business. We model the behavior of arriving customers and track key metrics that will determine our efficiency and success by influencing important business decisions such as number of dining tables to purchase, chefs to hire, and operational hours of the establishment. This project has significance to all shareholders and investors into Durham Diner, and will impact the efficiency and chances for long-term success of the business. The National Restaurant Association estimates a 20% success rate for all restaurants, with over 60% of restaurants failing within the first year of operation. This means that in order to keep the restaurant afloat long enough to establish itself in the Durham community, we must allocate resources efficiently to not waste seed money, and in the process, ensure maximally positive customer experiences. Modeling potential scenarios and using probabilistic analysis to make calculated business decisions will ensure we've taken the proper steps as responsible managers to mitigate risk of failure for Durham Diner.

Objectives

- Maximize profit
- Optimize customer satisfaction by minimizing wait times and maximizing table turnover efficiency
- Determine optimal staffing levels and table configurations based on the simulations
- Identify peak operating hours and adjust business hours accordingly

Model Assumptions:

- Customer arrivals follow a Poisson distribution.
- Service times are modeled using an exponential distribution.
- 45-minute maximum wait time before customer departure.
- Durham Diner does not allow reservations or take-out, and all customers follow the same purchase process (queue, then service)
- Downtime is calculated as time when no customers are waiting or being served, which represents inefficient allocation of resources

Customers arrive following a **Poisson process** with rate λ. The inter-arrival times T_i are distributed as:

$$f_{T_i}(t) = \lambda e^{-\lambda t}, \quad t \geq 0$$

Each customer requires a **service time** S_i, which is distributed as:

$$f_{S_i}(s) = \mu e^{-\mu s}, \quad s \geq 0$$

Limitations:

- Durham Diner's simulation assumes consistent distributions and poisson processes across days, despite behavioral differences (i.e. people go out more on weekends or during certain seasons)
- "Profit" does not actually represent profit as there are numerous costs that go into calculating that figure, including food, overhead, etc. For the purpose of this simulation, it represents revenue minus the cost of chefs.
- Subjectivity in customer experience: customers may not be "satisfied" just because they were served quickly—food quality, ambience, and service quality are also factors that our model cannot quite capture

Model Justification

In each scenario, we use a Poisson process for arrivals, which is justified by the randomized and independent nature of customer arrivals. Similarly, the exponential distribution for service times is supported by the need to model variability in customer orders and preparation times.

Scenario 1: Single Table and Chef

Setup

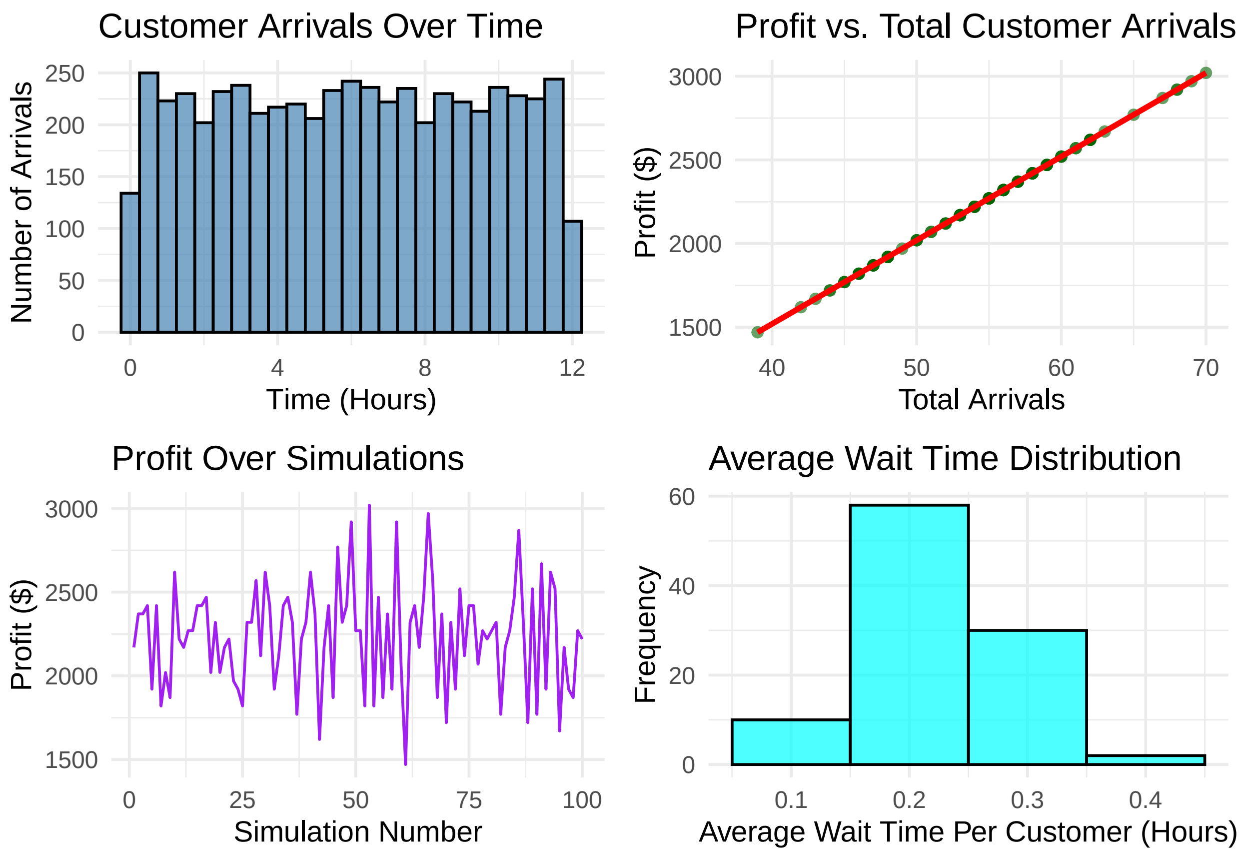
Scenario 1 simulates our diner operating with a single table and single chef; this represents the most basic operational configuration for understanding restaurant dynamics with minimal resources. We assume an arrival rate of 5 customers per hour and a service rate of 6 customers per hour. The simulation runs for 12 hours, to simulate our 10 AM to 10 PM operational hours. We perform 100 simulations to account for variability and generate more robust metrics for analysis.

Summary Statistics

Table 1: Scenario 1 Summary Statistics

Revenue Mean	Profit Mean	Customers Served	Avg Wait Time	Avg Service Time	Avg Downtime
2719	2239	54.38	0.22	0.167	0.17

Visualization of Scenario 1 Metrics



Analysis

We generated an average revenue of $2719 per day and an average profit of $2239 per day, indicating a relatively healthy revenue stream even under minimal resources. On average, our restaurant can support 54-55 customers per day, with an average wait time of 13 minutes (0.22 hour), which is generally acceptable for a restaurant setting, but can be improved to further increase customer satisfaction. The restaurant experiences about 10 minutes of downtime on average per day, where no customers are being served, which suggests we should take efforts to optimize staffing and table configuration. Customer arrivals follow a uniform distribution with slight spikes around typical meal times, which suggests our restaurant should be prepared to handle a consistent flow of customers. The scatter plot indicates a positive correlation between total customer arrivals and profit, which highlights the importance of maximizing customer throughput within the given resource constraints to maximize profit. The line of profit over simulation does show some variability, which suggests the need to plan for and manage inherent variability in our daily operations. Finally, our histogram of customer wait times shows a peak around 12-18 minutes, which is in line with our summary statistics, but it also includes a longer tail, which suggests that some customers experience longer wait times. Overall, the Scenario 1 results show a viable baseline performance for the restaurant, but there are areas for potential improvement, such as reducing wait times and minimizing downtime.

Scenario 2: 5 Tables and Variable Chef Count

Setup

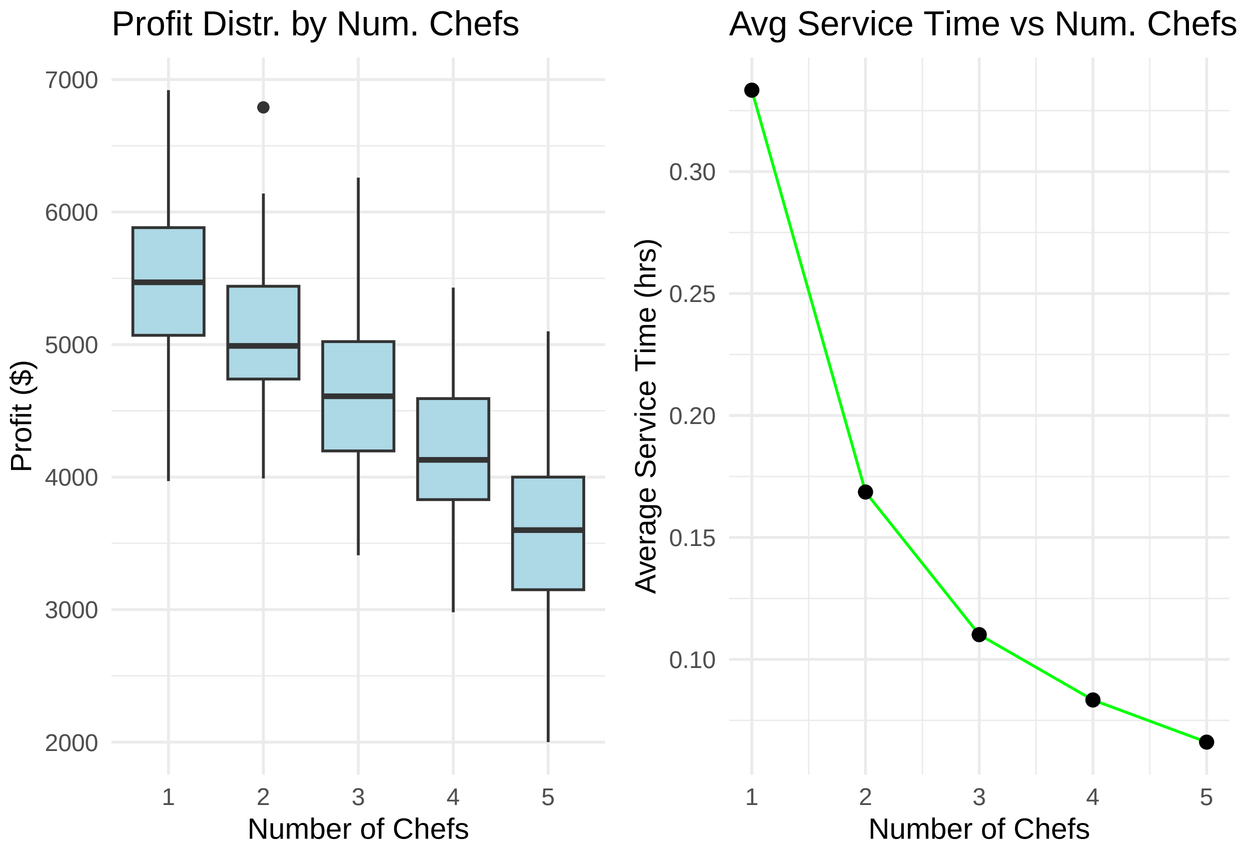
Scenario 2 explores the impact of varying chef count while maintaining a constant number of tables. We assume an arrival rate of 10 customers per hour and a constant of 5 tables. The service rate is proportional to the number of chefs, L, with a rate of 3 customers per hour per chef. The simulation runs for 12 hours and we perform 100 simulations to account for variability, similarly to scenario 1.

Summary Statistics

Table 2: Scenario 2 Summary Statistics

Chef	Revenue Mean	Profit Mean	Customers Served	Avg Wait Time	Avg Service Time	Avg Downtime
1	5927.5	5447.5	118.55	0.050	0.333	0.04
2	6041.5	5081.5	120.83	0.002	0.169	0.15
3	6084.5	4644.5	121.69	0.000	0.110	0.23
4	6101.0	4181.0	122.02	0.000	0.083	0.52
5	5992.0	3592.0	119.84	0.000	0.066	0.46

Visualizations for Scenario 2 Metrics

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## Optimal number of chefs for maximum average profit: 1
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Analysis

Our maximum average profit of $5447.50 is achieved with only 1 chef. Adding more chefs decreases average profit, but customer service metrics improve, which suggests the need for a balance between profitability and customer satisfaction. The wait time and service time both significantly decrease as a result of adding more chefs, which suggests that this is an effective way to manage restaurant efficiency and customer throughput. The downtime increases as a result of adding more chefs, since there are more employees to manage customers, and it is also optimized with a single chef.

Scenario 3: 2 Chefs and Variable Table Count

Setup

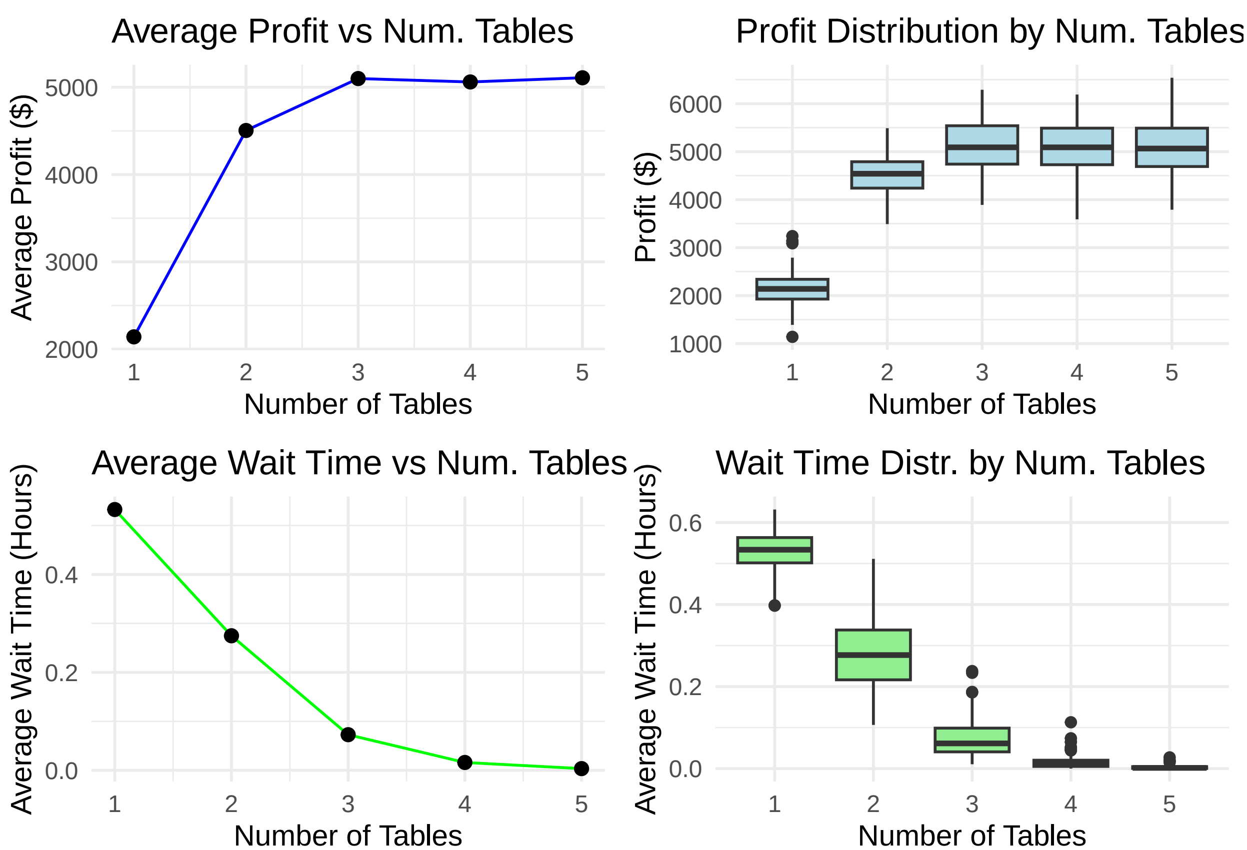
In our third scenario, we investigate the optimal table count for restaurant performance, assuming a constant number of chefs. We assume an arrival rate of 10 customers per hour and a service rate of 5 customers per hour, and maintain a constant of 2 chefs. The table count is varied from 1-5 to find the optimal value, and the simulation is run 100 times as previously. This could represent a plausible situation for Durham Diner where we have qualified chefs we definitely want to hire, but now need to determine the optimal number of tables to purchase such that we can efficiently accomodate as many customers as possible.

Summary Statistics

Table 3: Scenario 3 Summary Statistics

Table	Revenue Mean	Profit Mean	Customers Served	Avg Wait Time	Avg Service Time	Avg Downtime
1	3100.5	2140.5	62.01	0.533	0.204	0.00
2	5465.0	4505.0	109.30	0.275	0.200	0.05
3	6060.0	5100.0	121.20	0.073	0.199	0.10
4	6021.0	5061.0	120.42	0.016	0.198	0.13
5	6069.0	5109.0	121.38	0.003	0.200	0.11

Visualizations for Scenario 3 Metrics

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## Optimal number of tables for maximum average profit: 5
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Analysis

As you can see in the above graphs, there is a negative exponential correlation between wait times and the number of tables and a positive exponential correlation between profit and the number of tables. Logically, this makes sense as having more tables allows the restaurant to accommodate more customers at a time. **We've also determined that with 2 chefs, the optimal number of tables to purchase would be 5** and in experimental simulations where we've tested up to 10 tables, the results still point to an optimal number of tables being 5. As you can see, the wait time approaches 0 as table count increases, with a steep decline at 5 while profit levels out. Although we did not account for a "table cost", it would be an interesting metric for future consideration to determine the optimal number of tables by table cost, profit, and wait time.

Conclusion

Based on the simulation results and analyses, Durham Diner can achieve a balanced approach to profitability and customer satisfaction by carefully selecting the right combination of tables and chefs. The initial baseline scenario with a single table and one chef demonstrated a stable but limited revenue, with moderate wait times and manageable downtime. As we introduced more chefs without increasing tables, we saw a reduction in wait times, but the added labor costs eroded profits, indicating that simply adding staff is not a cost-effective strategy. Conversely, when we held chef count constant and increased tables, we found that profit levels rose and wait times dropped significantly, suggesting that expanding seating capacity is more critical to driving both revenue and customer satisfaction than hiring more chefs beyond a certain point.

In particular, our results indicate that with two chefs, five tables appears to be an optimal configuration that provides near-zero wait times while maintaining high profitability. Adding more tables could further reduce wait times, but the gains in profit stabilize at around five tables. Since each additional chef adds substantial costs that are not offset by comparable increases in revenue, it is more beneficial to invest in additional seating rather than expanding the kitchen staff. We recommend that Durham Diner start with two experienced chefs, acquire five tables, and adjust operations as needed. Future considerations could include factoring in table acquisition costs, refining the arrival and service time models to reflect seasonal and time-of-day demand variations, and incorporating other qualitative factors such as ambience and service quality to achieve the best overall outcome.