The School of Mathematics

Chaiiology Café Simulation

Group No. 19

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Introduction

This project simulates a local café, Chaiiology, which offers hot food, desserts, drinks for both eat-in and takeaway, investigating the waiting times and its resulting impact on the business. Thus, provide suggestions to improve the customer service and boost profits.

Chaiiology, Cardiff

We observed the waiting times issue was serious on Saturdays, the busiest day of the week, which was also highlighted by the café owner during the interview. Here, the waiting time encompassed time to stand in the queue to place the order, waiting for a free table if none are vacant (dine-in orders), and food and drink preparations.

We achieved this by investigating several aspects of the café, such as staff allocation, the number of different staff (server, kitchen, etc.), table size, even considering the takeaway aspect. We used Simul8 to simulate several café operations using the real-time data collected from the café. The simulation model reduces the average waiting time, enhancing the customer service thus increasing the profits of Chaiiology in the long run.

Having collated the results from these experiments and the simulation model, we derive and provide solutions to the Chaiiology as the optimal change to implement that minimises waiting times for the least possible expense, increase customer satisfaction and boosting business.

Research Objectives

- **Simulation Model Creation:** Develop a simulation model using Simul8 to replicate a standard Saturday at Chaiiology. This model will encompass various factors like table layout, staff shifts, peak hours, and the takeaway dynamics of the business.
- **Investigate Long Waiting Times:** Analyse and understand the causes and consequences of prolonged waiting times within the café. This includes assessing its impact on the business's operations and overall performance.
- **Simulation Analysis:** Utilize the simulation results to gain insights into the reasons behind the long waiting times. This analysis will help in identifying potential bottlenecks or inefficiencies in the current system.
- **Implement Optimizations:** Based on the findings from the simulation analysis, implement experiments and modifications within the café's operational framework. The objective is to suggest and introduce changes aimed at reducing waiting times, improving customer experience, accommodating more patrons, and subsequently boosting revenue and profits.

Data Collection Method

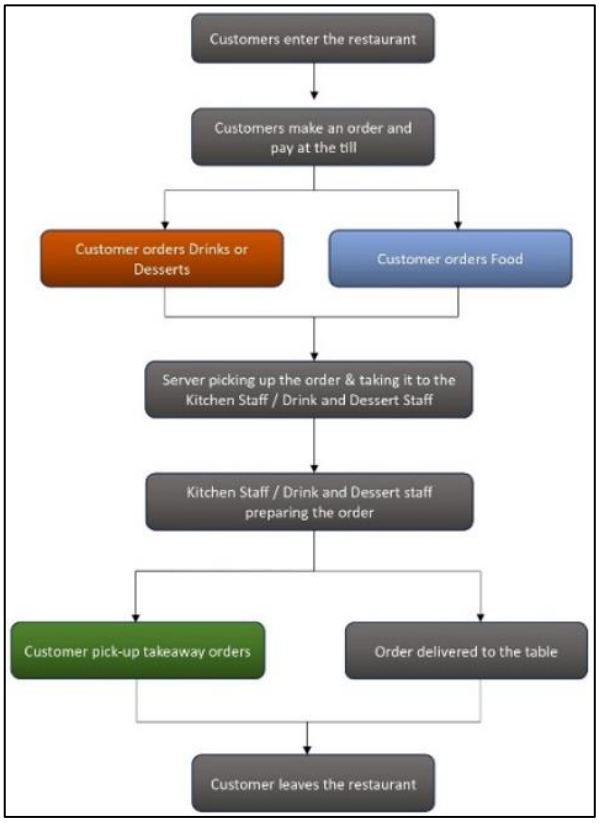
During our meeting with the Chaiiology owner on November 9, 2023, he provided comprehensive insights into the café's operations, resource allocation, staff schedules, and highlighted Saturday as the busiest day.

Additionally, he emphasized the challenges faced, particularly the issue of extended waiting times, underscoring its significant impact on customer service and the overall business. Based on the insights gleaned from our discussion, we devised a plan to conduct real-time observations and data collection during the cafe's operational hours on Saturday, the 18th of November 2023.

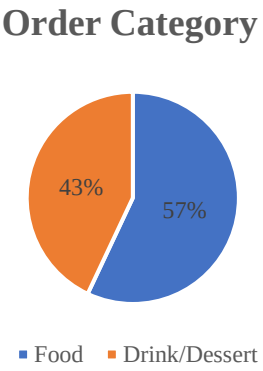
The cafe typically operates for 14 hours daily, commencing service at 9:00 am and concluding orders at 11:00 pm. To streamline our observation process, we organized ourselves into two distinct groups. Each group monitored and collected data for a seven-hour period, with each member assigned to observe the activities on a round-robin basis as customers arrived.

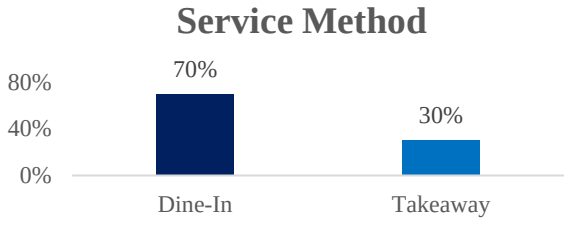
We meticulously recorded the following dataset for this project:

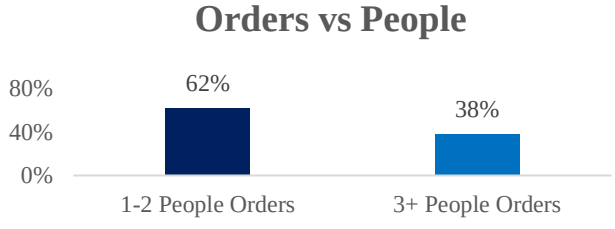
a. Inter-arrival times between customers.
b. Service method: Dine-in or Takeaway.
c. Order categories: Food / Desserts & Drinks.
d. Quantity of orders placed.
e. Preparation time for Food, Desserts, and Drinks.
f. Server count.
g. Kitchen Staff count.
h. Dessert Staff count.
i. No of Tables and Size.
j. Duration of customers' stay at tables for dine-in orders.



Process Flow Diagram







Data Limitations

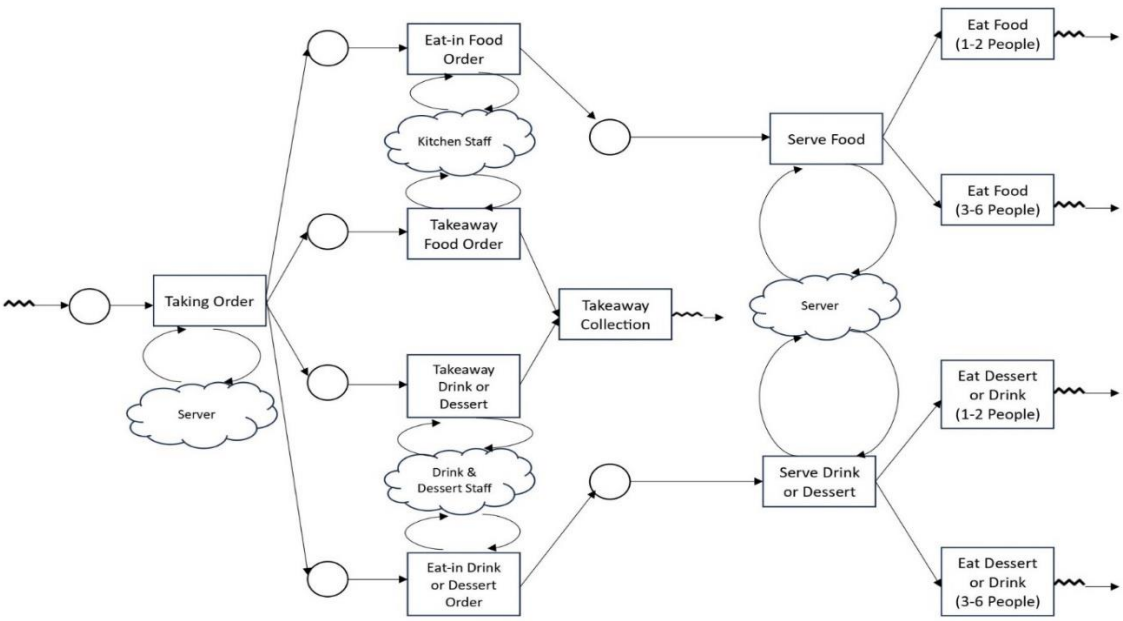
- We only manage to collect data for a singular Saturday, meaning we have a relatively low sample size, and so are unsure whether this is a particularly quiet/busy Saturday for the café.
- Staff shifts are taken as irrelevant, explained later.
- Orders are assumed to be either completely food or dessert/drink orders, and all 1 item rather than specifying every single item on the menu.

Data Usage within Simul8 Model

- **Inputs:** Time for activities, percentages for routing, inter arrival times
- **Outputs:** Staff Utilisation, Average Waiting times

Activity Flow Diagram

- **Entities:** Customers
- **Resources:** Server, Kitchen Staff, Drink/Dessert staff, 6 person Tables, 2 Person Tables
- **Duration:** 9 AM-11PM
- **Queues:** Queue to order, queue for food preparation (dine-in and takeaway), queue for drink/dessert preparation (dine-in and takeaway), queue for table availability (2 person and 6 person tables)
- **Activities:** Ordering, food preparation (dine-in and takeaway), dessert/drink Preparation (dine-in and takeaway), takeaway collection, food serving and consumption.
- **Events:** Customer arrival, takeaway customer departure, eat-in customer departure

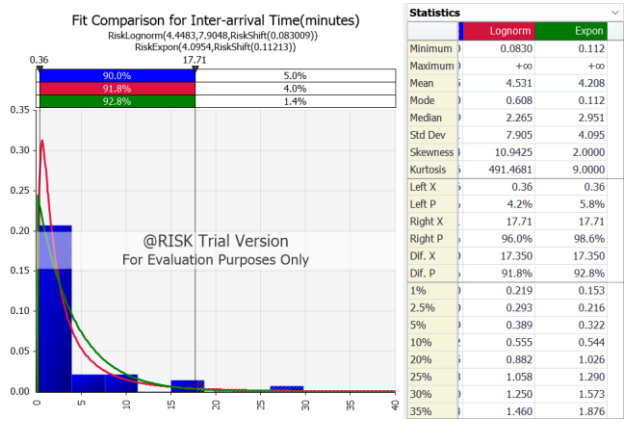


Activity Flow Diagram

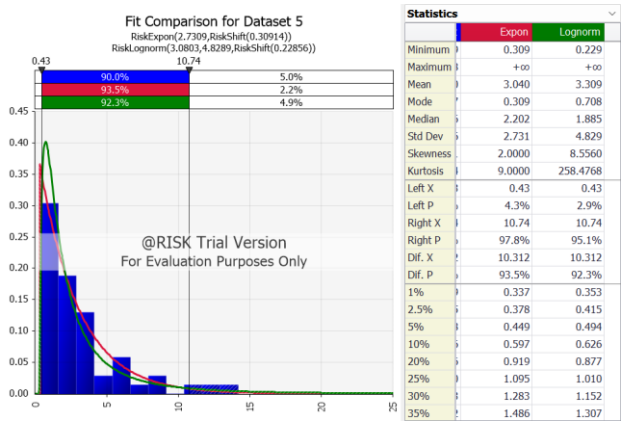
Aspects of the Simulation

Distributions/Variables for Model

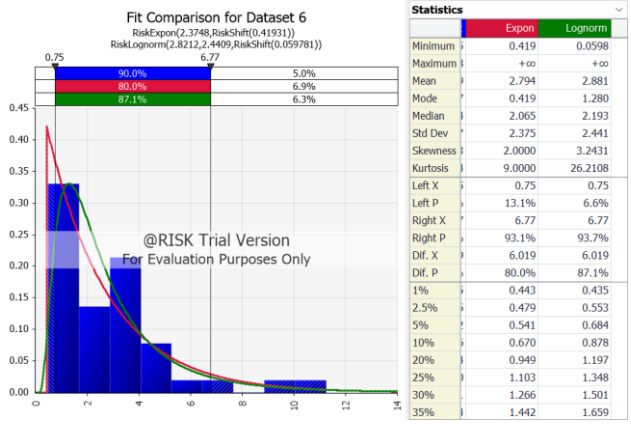
The Inter-arrival times we collected vary widely, and we saw a pattern that it decreased as the day went along, which the owner specified as one of the main problems the café has, as it leads to extremely long wait times due to the increase in orders. Due to the accuracy of our arrival times, which are down to the second means it is more appropriate to fit these to a distribution rather than taking an average. We do this using the **@Risk** computer software with our Excel Spreadsheet. When we did this, too of the most accurate distributions are the exponential and lognormal distributions, which are both useful due to their simplicity, so we attempted to fit both, picking the one that is the most accurate based on confidence analysis, as shown in the graphs below (inter arrival time=day, 5=afternoon, 6=evening, 7=night):



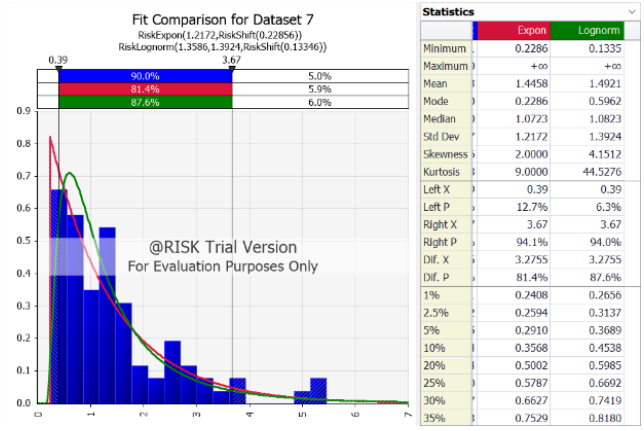
Statistics	Lognorm	Expon
Minimum	0.0830	0.112
Maximum	+∞	+∞
Mean	4.531	4.208
Mode	0.608	0.112
Median	2.265	2.951
Std Dev	7.905	4.095
Skewness	10.9425	2.0000
Kurtosis	491.4681	9.0000
Left X	0.36	0.36
Left P	4.2%	5.8%
Right X	17.71	17.71
Right P	96.0%	98.6%
Dif. X	17.350	17.350
Dif. P	91.8%	92.8%
1%	0.219	0.153
2.5%	0.293	0.216
5%	0.389	0.322
10%	0.555	0.544
20%	0.882	1.026
25%	1.058	1.290
30%	1.250	1.573
35%	1.460	1.876



Statistics	Expon	Lognorm
Minimum	0.309	0.229
Maximum	+∞	+∞
Mean	3.040	3.309
Mode	0.309	0.708
Median	2.202	1.885
Std Dev	2.731	4.829
Skewness	2.0000	8.5560
Kurtosis	9.0000	258.4768
Left X	0.43	0.43
Left P	4.3%	2.9%
Right X	10.74	10.74
Right P	97.8%	95.1%
Dif. X	10.312	10.312
Dif. P	93.5%	92.3%
1%	0.337	0.353
2.5%	0.378	0.415
5%	0.449	0.494
10%	0.597	0.626
20%	0.919	0.877
25%	1.095	1.010
30%	1.283	1.152
35%	1.486	1.307



Statistics	Expon	Lognorm
Minimum	0.419	0.0598
Maximum	+∞	+∞
Mean	2.794	2.881
Mode	0.419	1.280
Median	2.065	2.193
Std Dev	2.375	2.441
Skewness	2.0000	3.2431
Kurtosis	9.0000	26.2108
Left X	0.75	0.75
Left P	13.1%	6.6%
Right X	6.77	6.77
Right P	93.1%	93.7%
Dif. X	6.019	6.019
Dif. P	80.0%	87.1%
1%	0.443	0.435
2.5%	0.479	0.553
5%	0.541	0.684
10%	0.670	0.878
20%	0.949	1.197
25%	1.103	1.348
30%	1.266	1.501
35%	1.442	1.659



Statistics	Expon	Lognorm
Minimum	0.2286	0.1335
Maximum	+∞	+∞
Mean	1.4458	1.4921
Mode	0.2286	0.5962
Median	1.0723	1.0823
Std Dev	1.2172	1.3924
Skewness	2.0000	4.1512
Kurtosis	9.0000	44.5276
Left X	0.39	0.39
Left P	12.7%	6.3%
Right X	3.67	3.67
Right P	94.1%	94.0%
Dif. X	3.2755	3.2755
Dif. P	81.4%	87.6%
1%	0.2408	0.2656
2.5%	0.2594	0.3137
5%	0.2910	0.3689
10%	0.3568	0.4538
20%	0.5002	0.5985
25%	0.5787	0.6692
30%	0.6627	0.7419
35%	0.7529	0.8180

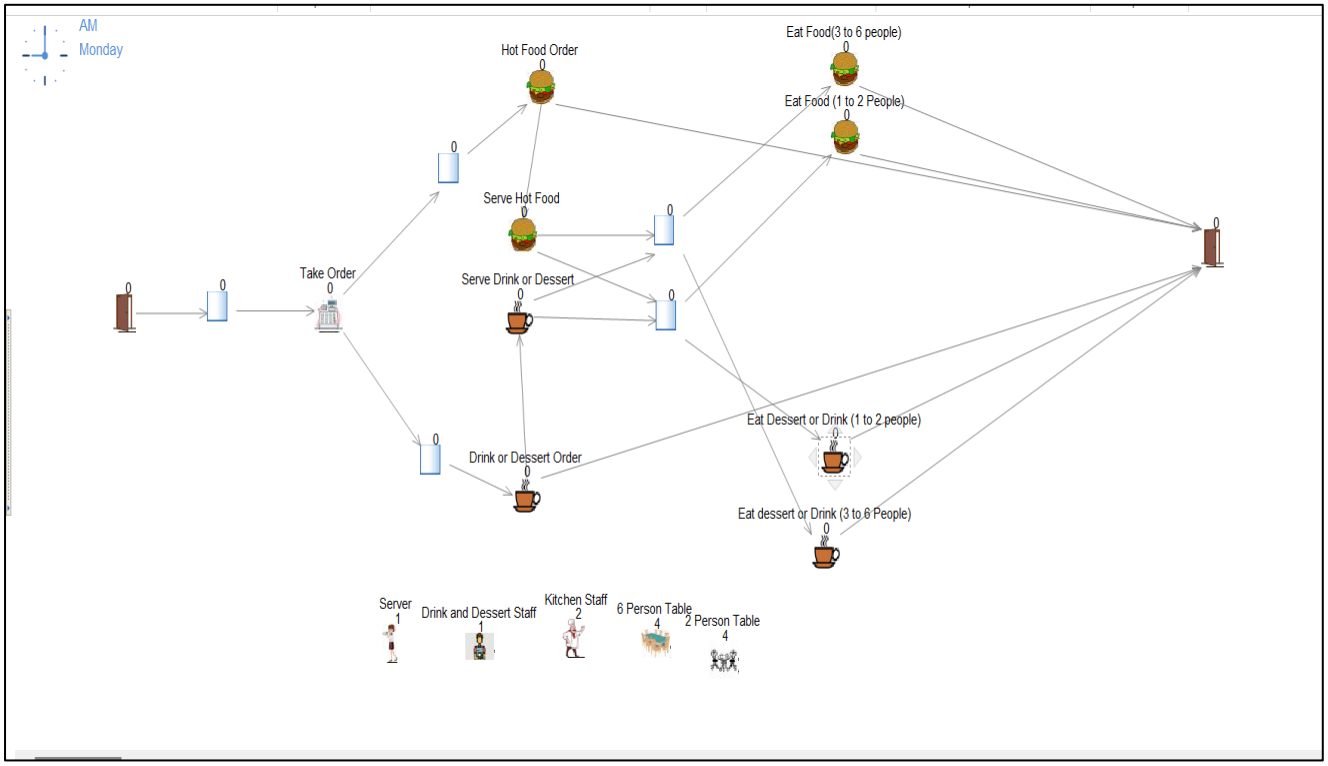
The distributions are as follows.

Time of Day	Fitted Distribution
Morning (9am-1pm)	Exponential (4.208)
Afternoon (1pm-5pm)	Exponential (3.04)
Evening (5pm-8pm)	Lognormal (2.881,2.441)
Night (8pm-11pm)	Lognormal (1.4921,1.3924)

Model Overview

- 1 entry point: Customer arrives at restaurant.
- Activities follow @risk distributions given above or average distributions (exact timings not collected, only to the nearest minute, so based on the average) given below.
- Maximum number of activities that can occur at once (due to resource limitations): Food Perpartaion-2, Drink/Dessert Preparation-1, Good Serving/Order Taking-1 of either, 3-6 people eating/drinking in café - 4, 1-2 people eating/drinking in café - 4.
- Customers partitioned after taking order, cannot change items ordered/method of delivery.
- Each activity that requires resources only requires 1 of each resource for completion.
- 1 exit point: Customer leaves restaurant after consumption, or customer leaves after collecting takeaway food.

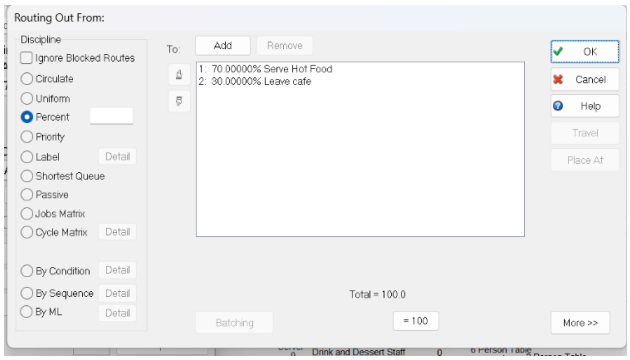
Activity	Distribution Given
Taking Order	Average (1)
Hot Food Preparation	Average (7)
Drink/Dessert Preparation	Average (3)
Serving	Average (1)
Eat Food	Average (18)
Eat Dessert/Drink	Average (10)

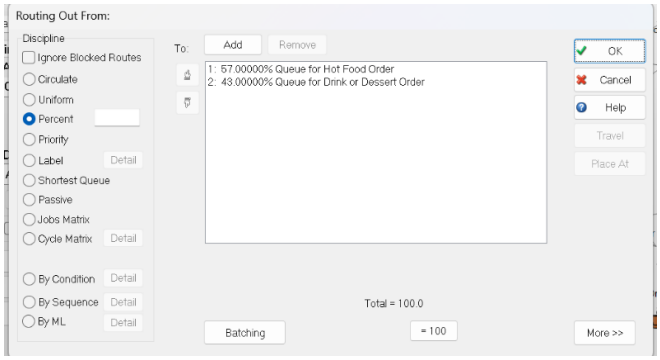


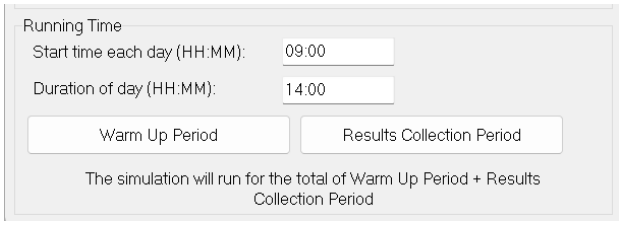
Simul8 Model

Model Explanation

Timing, Resources and Customer Percentages



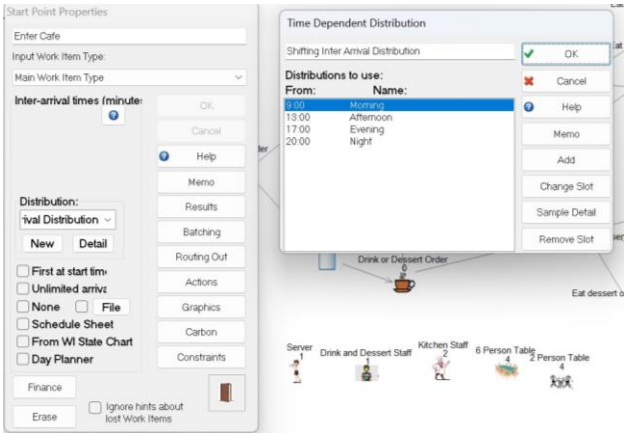


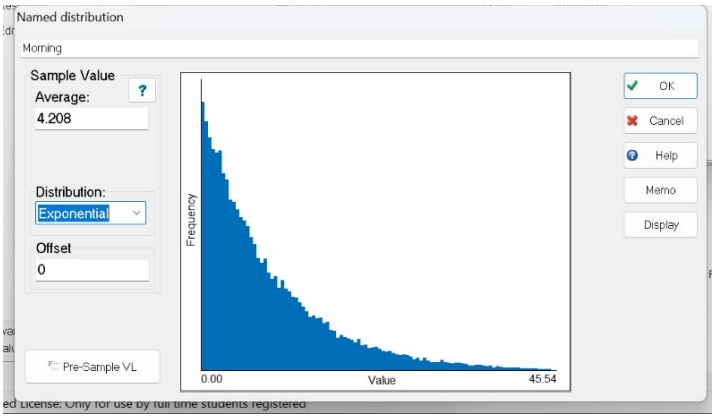


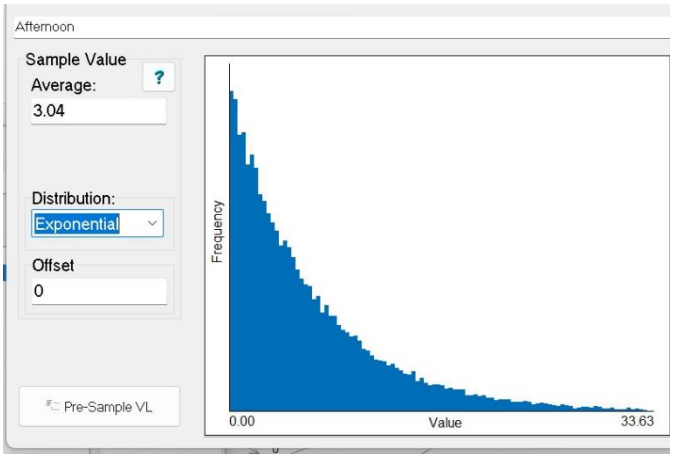
Chaiiology opens from 9am to 11pm, so opens for 14 hours, and arrival times are time based, as detailed later. As mentioned previously, wed assume staff shifts, including breaks are irrelevant, as during our interview, the owner specified that all workers have shorter shifts with no breaks and immediately leave, being replaced with a different member of staff, so it is more convenient to assume that it is the same amount of staff there all the time, that workforce comprising of a waiter/server,2 kitchen staff and a drink/dessert preparer. We also have no reason to assume the amount of tables changes, so we always assume there are 4 two person tables and 4 six person tables.

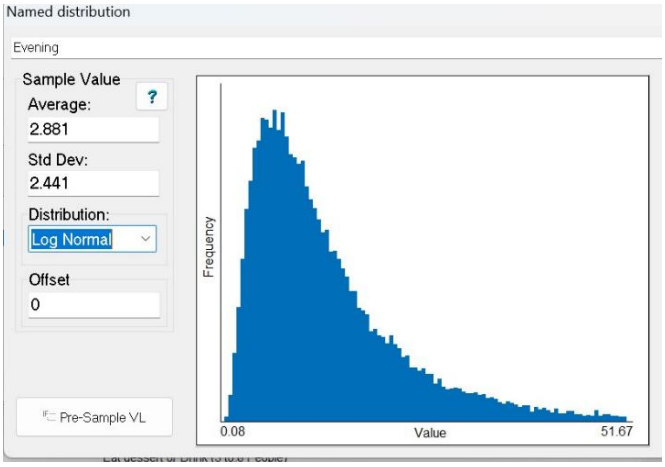
For some activities in our simulation, customers must be routed out certain activities towards different activities/queues. These activities are taking the order, where we separate food and dessert/drink orders, completion of the orders, where we separate takeaway and eat in orders, and the serving of the orders where we separate into orders with for 1-2 people less and 3+ people. For this we use Simul8's percent function to route out, using the following percentages: 57% food order, 43% dessert/drink order, 70% eat-in orders, 30% takeaway orders, 62% 1-2 people orders, 38% 3+ people orders. Additionally, we use label routing to differentiate eat in and takeaway orders, as explained later.

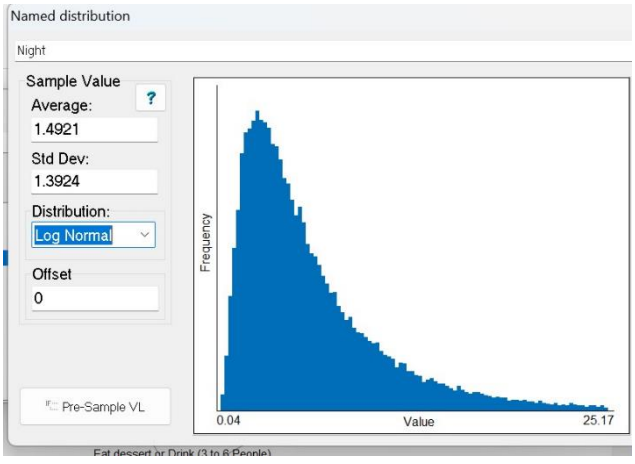
Time Based Distribution





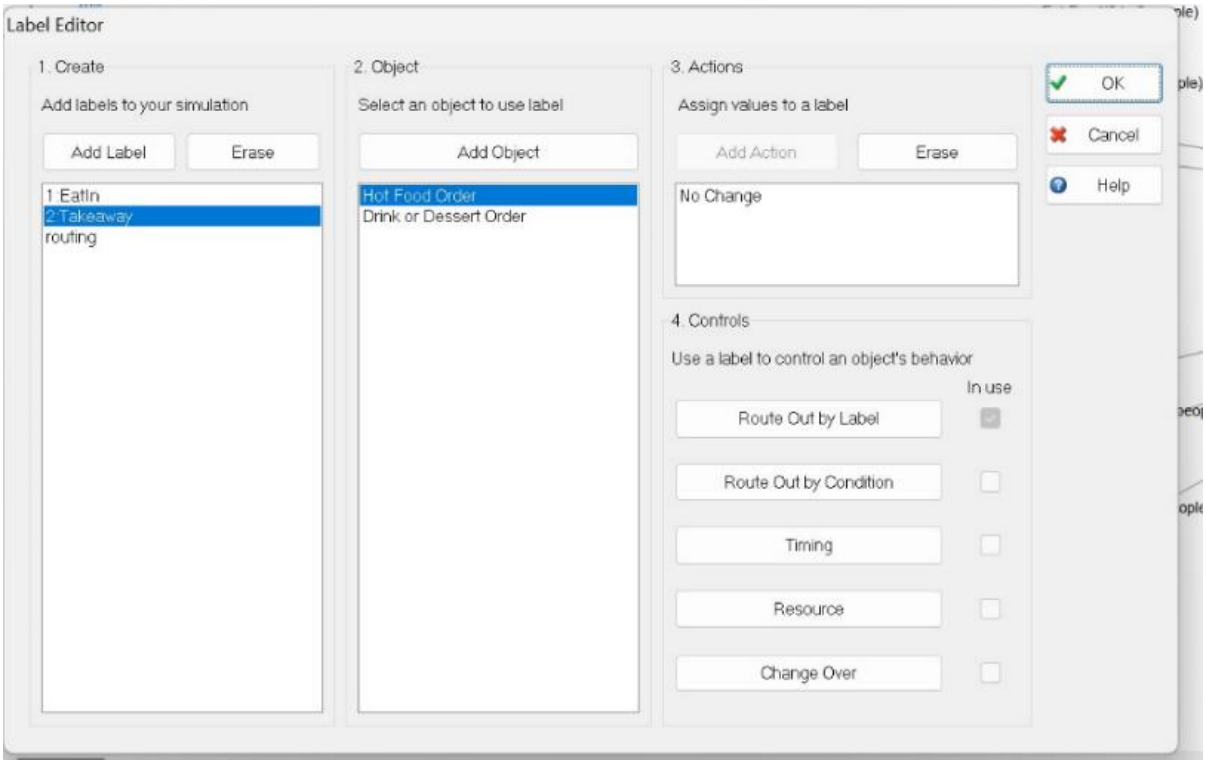


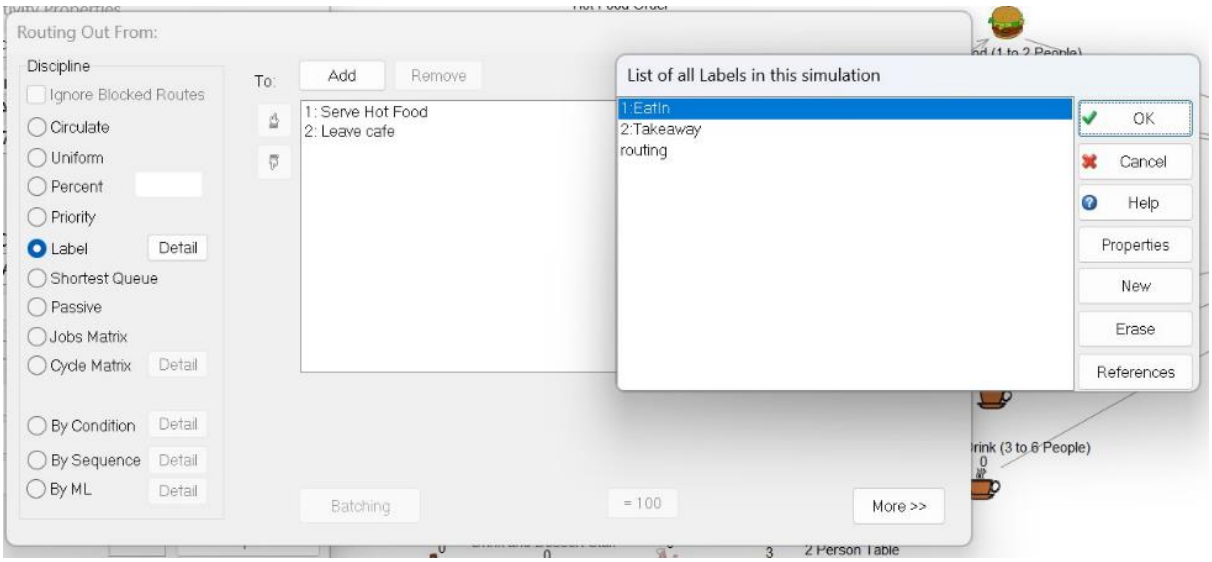




To utilise the fitted distribution from @risk, we must use the time dependent distribution function in Simul8, which we called the “Shifting Inter-arrival Distribution”. As part of this we assign “morning”, “afternoon”, “evening” and “night” distribution using the distributions calculated earlier and assign these to the clock times between 9am-1pm, 1pm-5pm, 5pm-8pm and 8pm-11pm respectively.

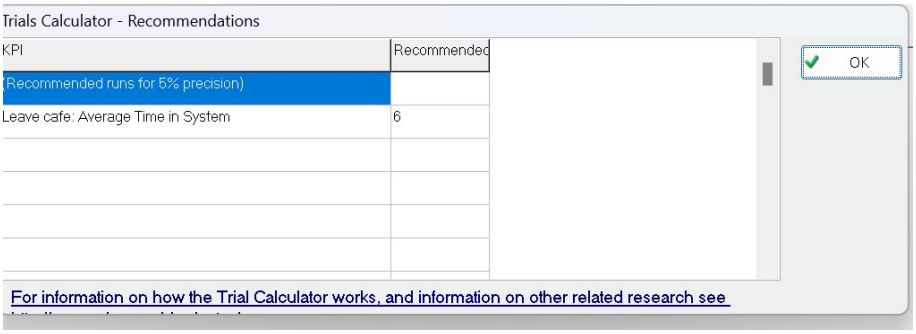
Label Routing





To make sure that eat in and takeaway orders are properly differentiated, we give them labels. Number 1 is assigned to eat in, and number 2 is assigned to takeaway. These labels are applied to both food and dessert/drink orders. Entities labelled number 1 head to serving, while number 2 entities leave the cafe.

Simulation Experiments and Results



The table above specifies that for the simulation to be accurate, it would be necessary to run our simulation 6 times to get a precise result at a precision level of 5%, so this is what we did, taking then the average of these 6 runs for the below utilization and waiting times results.

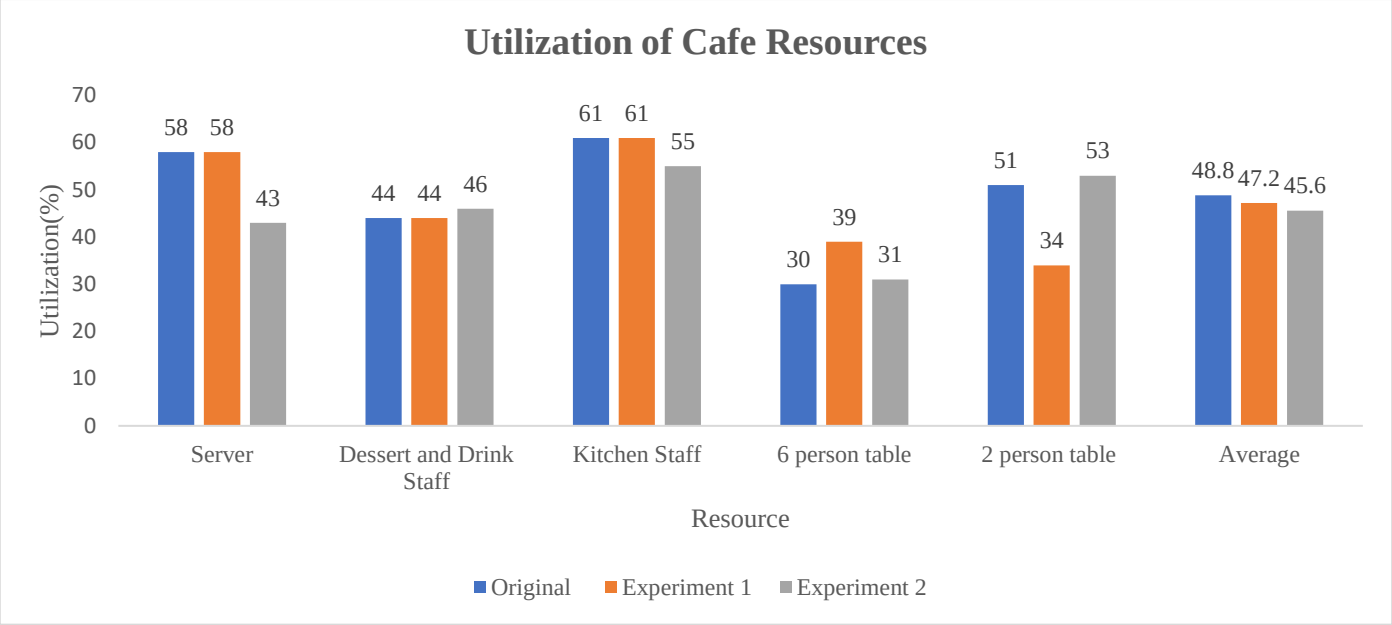
In our endeavour to understand the long waiting times and improve customer experiences, we utilized real-time data simulations that shed light on a notable trend: a surge in queues during the evening hours, particularly for food orders (5.89 minutes) and while waiting to order (2.9 minutes). These combined upticks resulted in a tangible impact on dine-in food customers. Longer wait times for two person tables (1 minute) was another prevailing issue, compelling certain patrons to pivot toward placing takeaway orders due to the scarcity of available tables.

The implications of these trends were manyfold. Not only did it create inconvenience for customers seeking a prompt dining experience, but it also signalled potential inefficiencies in the operational flow during peak hours and over utilization of certain resources, justified by our results for servers (58% utilization), kitchen staff (61% utilization) and 2 person tables (51% utilization). The decision by some customers to switch to takeaways is not only reflected the challenge of table availability but also highlighted the importance of optimizing the cafes structure for the most common customer preferences.

These observations underscore the necessity of refining our strategies to manage peak periods effectively, where there were visibly more queues formed. We aim to ensure a smoother and more satisfying experience for all customers, whether dining in or opting for takeaway services. Evaluating this data prompted us to explore measures that reduce waiting times, enhance table turnover and food preparation efficiency, aiming to balance customer demand with service capacity.

Experiment 1: Reconfigure Table Arrangements

Our initial approach to shorten witing times involved altering our table availability, replacing one of our 6-seater tables in return for a pair of additional 2-seater tables, transitioning from our existing layout consisting of four 6-seater tables and four 2-seater tables to a configuration featuring six 2-seater tables and three larger 6-seater tables. This adjustment is manageable for the floorspace available in the café ,while also showing a discernible improvement in reducing wait times for 2 person orders from a minute to virtually 0 minutes, and as they compromise the majority of the orders we receive, they take precedent over the 6 person orders, which increase from 0.11 minutes to 0.68 minutes, and both resources have under 40% utilisation, but it does fall short of delivering the desired or optimal outcomes we had envisioned overall, as there is no change in any of our other wait times.



While the modification did contribute positively by mitigating the delays experienced by patrons, it probably didn't yield results substantial enough to warrant its full-scale implementation, due to the various expenses incurred in the table modification (purchasing of new tables - £500, £300 if selling the 6 person tables). Despite the reduction in waiting times, the solution wasn't as efficient or effective as anticipated, prompting us to reassess and explore alternative strategies to alleviate the issue of extended waiting periods more substantially for customers. Further analysis and exploration are essential to devise a solution that not only reduces waiting times significantly but also proves to be a feasible and sustainable adjustment for Chaiiology.

Experiment 2: Augmenting Staff

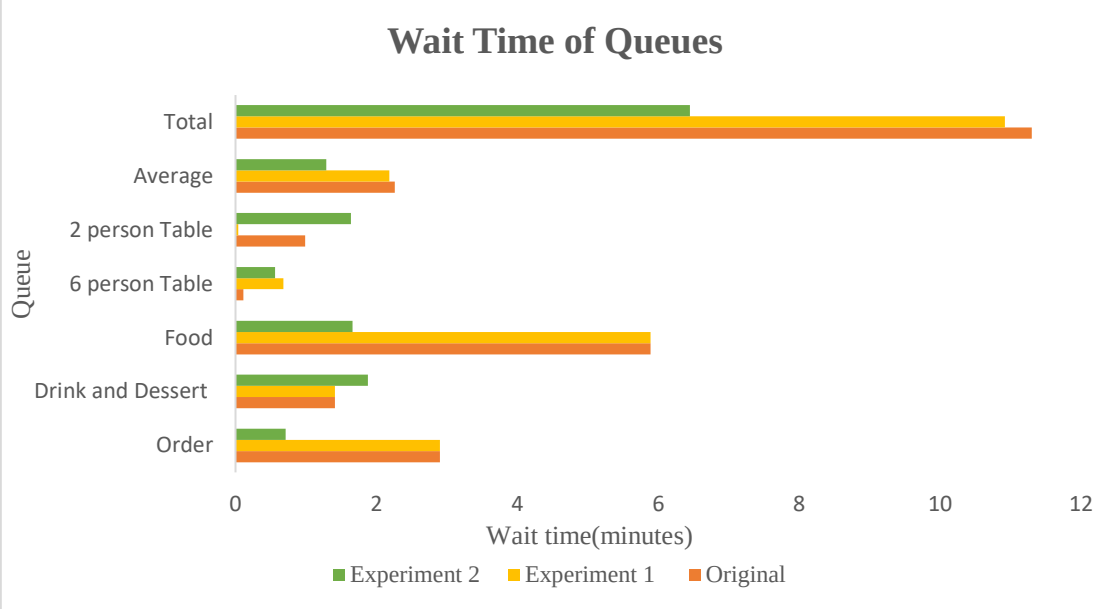
Expanding our strategies beyond table arrangements, we delved into augmenting staffing levels both in the Front of House and the Kitchen, aiming to address the persistent challenge of extended waiting periods in both areas. We introduced an extra server and an extra chef, increasing our staff count to 2 servers, 3 kitchen staff and 1 dessert/drink staff, but only for the evening hours, specifically 5pm-11pm, as that is the only time it is financially sensible. Upon the implementation of these experiments, a noticeable transformation emerged within our operational dynamics.

The additional staff deployment orchestrated a substantial reduction in food preparation times, from an average of 5.89 minutes to 1.66 minutes, and only a slight decrease in utilization from 61% to 55%. This adjustment was pivotal in alleviating the prolonged waiting periods that had been a recurrent issue during peak hours. The increase in servers also has a profound effect on our order average waiting time ,from 2.9 minutes to 0.71 minutes, but this also results in waiting time for tables only increasing slightly, suffering as a consequence of our order and food efficiency, increasing to 0.56 minutes for 6 person tables, less than with the reallocation of tables, and 2 person tables to 1.61 minutes, the largest increase, but still remaining relatively low. There is also a slight increase to the drink and dessert waiting times because of the increased customers, to 1.88 minutes. Overall, the waiting times for customers were significantly curtailed, positively impacting their dining experiences. Utilization also drops, with only the Kitchen staff (55%) and 2 person tables (53%) still having over 50% utilization.

Resource Schedule

Time	Server	Kitchen	Drink and	6 Person	2 Person
09:00	1	2	1	4	4
10:00	1	2	1	4	4
11:00	1	2	1	4	4
12:00	1	2	1	4	4
13:00	1	2	1	4	4
14:00	1	2	1	4	4
15:00	1	2	1	4	4
16:00	1	2	1	4	4
17:00	2	3	1	4	4
18:00	2	3	1	4	4
19:00	2	3	1	4	4
20:00	2	3	1	4	4
21:00	2	3	1	4	4
22:00	2	3	1	4	4

The ripple effect of these improvements extended beyond immediate customer satisfaction; it translated into increased business profits. The heightened efficiency in food preparation, combined with the enhanced order turnover, led to a more streamlined and productive service, more than covering the costs of wages for the staff increases (about £12.20 an hour for a waiter, and £13.30 per hour for a new chef) and, over time, the installation of additional workspace in the kitchen, ultimately resulting in improved financial performance and profitability for Chaiiology.



Conclusion

Our exploration into mitigating extended waiting times at Chaiiology unveiled many insights through real-time data analysis. We identified the surge in evening queues affecting food preparation and customer wait times it through our simulation and highlighted the urgency in optimizing café's operational efficiency. Initial attempts to reconfigure table arrangements, transitioning to smaller tables, showed promise in reducing wait times but fell short of the desired impact, in comparison to its expense. This prompted a shift in focus towards augmenting staffing levels in both the front of house and the kitchen. The augmentation in staffing yielded transformative results. The increased workforce significantly slashed food preparation times, directly alleviating prolonged customer waits during peak hours. This improvement didn't just increase customer satisfaction; it increased turnover and therefore profitability for Chaiiology. Thus, our recommendation for the Chaiiology owner was to augment staff levels, and, if possible, re-configure table arrangements

Appendix

- Appendix: Interview with Chaiiology owner (attached)