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9A97E042

TEACHING NOTES

QUESADA: KEEPING UP WITH BURRITO DEMAND

Team 12 wrote this teaching note as an aid to instructors in the classroom use of the case Quesada Burritos & Tacos, No. 9A97E042. This teaching note should not be used in any way that would prejudice the future use of the case.

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SYNOPSIS

Quesada is a Mexican fast-casual franchise-based business with operations across Canada. One London-based franchise owner, Fred Valdez, was surprised by the fact that his business had high levels of demand but was generating lower revenue and profits when compared with other Quesadas in the London area. As a result, Fred feared that there may be issues with his franchise's operations such that they were costlier, or that there were issues with processing orders such that the restaurant could not keep up with the high levels of demand. In turn, Fred tasked operations consultant Kyla Barrow with gathering and analyzing data on past operations to see if it was feasible to improve revenue and profitability.

LEARNING OBJECTIVES

- Gain a deeper understanding of a business' operations and how to use simulation to deduce the total process time of these operations.
- Apply the conclusion from the simulation to the business problem to help Quesada improve operations.
- Use optimization to maximize profit using the conclusions of the simulation.
- Explain the tradeoffs involved with the optimization model as well as ways to improve it.

POSITION IN COURSE

This case can be used in an introductory operations or art of modelling class, for undergraduate and master's level students.

Any course which teaches the concepts of probability, simulation and optimization and their application to business problems can use this case as a basis for teaching.

RELEVANT READINGS

Peter C. Bell and Gregory S. Zaric, "Simulating The Future," chap. 6 in Analytics for Managers with Excel, 1st ed. (New York, NY: Routledge, 2013), 166-207

Ahsan, Md Manjurul & Islam, Md & Alam, Md. (2014). Study of Queuing System of a Busy Restaurant and a Proposed Facilitate Queuing System. IOSR Journal of Mechanical and Civil Engineering. 11. 31-35. 10.9790/1684-11623135.

Hasugian, V. (2020). Analysis Of Queuing Models Of Fast Food Restaurant with Simulation Approach. IOP Conference Series. Materials Science and Engineering, 851, 12028–. https://doi.org/10.1088/1757-899X/851/1/012028

ASSIGNMENT QUESTIONS

1. We currently have three workers (assuming one worker for order, one for payment and one for food preparation processes 1-4), simulate the operation and calculate the average queue time of the operation.
2. What is the business implication of this model?
3. Simulate the operation with one additional worker and determine if it is profitable for the store to add one additional worker. If yes, what are the implications for business operations and at which part of the food preparation process should we staff the additional worker to minimize queue times and maximize profit?
4. Given the process allocation of workers with the lowest queue times, what is the maximum profit we can generate with the addition of extra workers?

TEACHING PLAN

The first portion of the class should cover how to build a simulation model based on the information provided. Effectively mapping Quesada's operations using a combination of random variables is somewhat challenging, and professors should walk students through the process to ensure they did not miss anything. This explanation could take 15-20 minutes.

Once Quesada's current operations have been simulated and the average queue time deduced, students should simulate three other scenarios to show the average queue times of each scenario. Through a comparison of the average queue times, the best scenario is chosen. As this is a reapplication of the concepts covered in Question 1, the explanation should take 10-15 minutes, mostly covering the comparison of the different processes.

With the allocation of staff established, and the operational system with the lowest average queue times revealed, an optimization model can be built with the assumptions outlined in the case. Students can build models for all four scenarios, or just the scenario that has the lowest average queue time. Walking through how to build this profit model based on the assumptions, as well as a discussion of the model's implications, can take up to 20-30 minutes.

Discussion Points	Time (Minutes)
Introduction	5
Assignment Question 1	25
Assignment Question 2	10
Assignment Question 3	30
Assignment Question 4	15
Conclusion	5

ANALYSIS

Assignment Question 1

Students should use the constraints found in exhibits 2 and 3 of the case to simulate the entire operational process for 320 customers or until the store closes (arrival time column reaches over 21:00:00). They can begin the simulation by using the data file provided and using RANDBETWEEN formulas for the interarrival times based on ranges provided in the case, as well using RANDBETWEEN on order time, tortilla time, protein time, veggies time, wrap time, and pay time (students can refer to case exhibits 2&3 for the ranges). The interarrival times should be pasted as values thereafter to prevent the timings from continuously oscillating between 11am to 2pm, 2pm to 5pm, and 5pm to 9pm. For wrap time and pay time columns, they will need to input IF formulas in addition to RANDBETWEEN in order to account for the probability and variability of the different wraps and payment options (refer to case exhibit 2 for different options).

After random numbers have been generated, students need to input the correct formulas for queue times. Since this scenario contains three workers and ordering and payment must always have a worker at those stations, worker two will be solely responsible for all food handling processes (processes #2-5). Queue time for ordering can be calculated by taking the max of 0 and the order finish time of the last customer minus the time to line-up for the new customer. This means that order time is 0 for a new customer if the new customer arrives after the old customer has already taken their order. If the old customer is taking an order while the new customer has already arrived, then the new customer’s queue time will increase as a result of this formula (exhibit 1).

For the second worker, the queue time for tortilla will be the same formula as worker one, except that it will be the max of 0 and the wrap finish time (process 5) less the tortilla arrival time (process 2). This is because there is only one worker responsible for all food handling in this current scenario. As a result of this, the queue time columns for protein, veggies, and wraps should be left at 0 for all customers (exhibit 2). The queue times will also change based on the probability and type of tortilla ordered as some tortillas will take longer to prepare than others as provided in exhibit 2 of the case write-up.

For the last worker, the queue time for payments will follow the same pattern as workers one and two wherein the queue time will be the max of 0 and payment finish less the pay arrival columns. If the previous customer has not completed their payment yet, then the next customer will have to wait in line thus increasing the queue time for payment (exhibit 2). As evidenced by exhibit 2 in the case write-up, payments of cash will take significantly longer than payments by debit card.

After the queue times have all been set up, the simulation model is complete. The next step is to add all the queue times to get the total queue time for each customer. Additionally, only the customers who arrived during hours when the restaurant was open would get serviced and as a result, students would need to include a column which acts as a counter and counts by one only if the customer arrives before the restaurant’s closing time. In the solution model, this is done in column AR. After this, the total queue time can be divided by the count of customers serviced (customers that arrived while the restaurant was still open). This average time represents the time, on average, it takes each customer to arrive at the restaurant, complete their order, and make a payment for their purchase.

Lastly, this average queue time can be simulated thousands of times to account for the variations of ordering different tortillas, the different payment options, the different order times of customers, and the different food handling times. With many random variables in the model, it makes sense to simulate the average customer queue times for a day in order to determine the average queue time for a customer on any given day of the year. Students can do this by inputting a data table with the changing variable being the recently calculated average queue time. For our solution model, we simulated the average queue time 2000 times. Upon doing this, the students can find simple statistics of the simulation such as average, standard deviation, maximum, and minimum queue times. Students should also create a frequency table to see the effects of the simulation and the distribution of queue times. As per the solution model, the average queue time for operations was just over 33 minutes, and the distribution graph shows the most likely queue times to be between 33 and 34.5 minutes (exhibit 4).

Students should make the connection between the qualitative case information and the average queue time for customers being over 30 minutes. It is evident that queue times with just three workers at Quesada are too high, which is why the business is getting complaints about the waiting times from customers. Students should take the next logical step by trying to reduce the queue times by adding an additional worker and seeing what impact that can have on profits.

Assignment Question 2

There are several points that can be discussed regarding the simulation of Quesada London's current operations. First, the average queue time is 30 minutes and 44 seconds while the last few customers arriving at the restaurant would have to wait for more than 1 hour and 40 minutes. For a fast-food restaurant like Quesada, having a queue for longer than five or ten minutes would be a problem and will create a negative reputation for the franchise location. On top of that, there could be a loss of customers due to the long food preparation time. With shortened preparation time, Quesada could benefit from higher revenues by serving more orders that offsets the wages it pays to hire an extra worker. In order to avoid leaving money on the table, Valdez should run simulations of a new operating system – with one additional worker in the food preparation stage.

Assignment Question 3

There are multiple ways to allocate an additional worker and students must simulate all different allocation scenarios to know which parts of the food preparation process minimize queue times and maximize profits the most. The allocation of one worker for the order and payment stations is fixed. Therefore, for the total number of four workers, there are three different allocation scenarios. The allocation table is presented in exhibit 5.

The simulation process is similar to the process in question one. Since we are allocating one additional worker to different steps in the food preparation process, the queue time calculation is different depending on where the staff is allocated. For example, in allocation scenario two, where one worker is responsible for the tortilla and one worker is responsible for the remaining process, the queue time for the tortilla is no longer zero (in question 1) but the maximum of (0, previous tortilla finish time – new tortilla arrival time). The total queue time for the remaining food preparation process would be the maximum of (0, previous wrapping finish time - new protein arrival time) and is taking place at the protein process step. Consequently, the queue time for the vegetable / salad process and the wrapping process should be zero as this worker would continue from process to process once he/she starts the protein stage. The changing of queue times for the food preparation process (processes 2-5) should be applied to allocation scenarios three and four as well according to the different allocations of the additional worker (exhibit 5).

Once all three simulations are established, we can then compare the different average queue times for different allocation scenarios. The average queue times for each allocation scenario are displayed in exhibit 6. Evidently, allocation scenario three generates the lowest average queue time of 45 seconds.

Next, students must examine which allocation scenario maximizes Quesada's profits. This can be done by calculating the cost of staff and lost revenue due to queue times for each allocation scenario and finding the allocation which leads to the lowest loss of profits. Our assumptions include the following: 1) for each order lost, we lose 5 dollars and for every 1 second average queue time for the customer, we lose one order, 2) the hourly wage for the staff is $12/hour, and 3) we have 320 customers on average every day. Based on our assumptions, we calculated the potential loss under each allocation scenario in exhibit 7. Allocation scenario three also generates the lowest loss of $704 due to queue times which, in turn, leads to the highest profit.

In conclusion, adding one more worker is necessary for Quesada, and allocation scenario three is optimal as it generates the lowest average queue time and highest profit.

Assignment Question 4

With the simulated queue times for each of the four scenarios established, the one that lowers queue times most---scenario three---can be used as the basis for an optimization model. The average process time for each step generated by the simulation, as well as the average queue time, are central to this model. Quesada has provided us with a few key assumptions that serve as the basis for building this model. The first is that if the average process time is lowered by one second, queue time is also lowered by one second. One second of the average queue time equates to one lost order, with each order being worth, on average, $5. Additionally, staff must work 10-hour shifts, with all staff costing $12 per hour. All staff have the same productivity level. The final assumption is that all lost demand due to queue times will be turned into revenue if queue times are lowered. The combination of these assumptions allows us to build a model where we maximize the additional profit gained by adding staff. The cost of the model includes the cost of adding additional staff. The revenue portion of the model is based on the assumption that lowering process time increases revenue by allowing the firm to take on additional demand. In turn, every second you decrease process time by, you decrease queue time by the same amount, raising $5 with each second you decrease this queue time by. In effect, process time and its effects on queue time are a proxy for how much more time of the day can be used to service customers. Regarding the solver formula, the objective function is the profit cell and the variable cells are the number of staff at each process step. The variable cells must be greater than one and must be integers. GRG non-linear was used as the solver method. The optimization model for scenario three---the one with the lowest queue times---is listed in exhibit 8. This structure is just meant to serve as a guide, as any optimization model based on these assumptions can be built to deduce the maximum additional profit that can be gained.

Consequently, adding five additional staff to the process steps outlined in the exhibit 8 allocation scenario three results in labor costs of $600 per day, but lowers process time by 271 seconds. In turn, the new average queue is –225 seconds, reflecting how we can take on 225 additional orders in the day given how much we have lowered process times by. Each second of process time decrease results in saving one second on all the 300+ orders the business receives in a day. As a result, each second Quesada can save on process time generates an additional 300 seconds (five minutes) that can be used to serve more customers. This new level of demand converted into revenue results in an additional daily revenue of $1,356.67. Given the cost of additional workers, this operational strategy results in an additional profit of $756.67 if the new level of demand Quesada can reach in a day is completely met.

While unnecessary for students, this solution report has built models for the maximum additional profit associated with each of the four scenarios. Importantly, in every scenario, there is profit to be made by hiring additional staff, given the loss of revenue associated with the higher queue times. However, it is important to note that this model also relies on the assumption that all ‘missed demand’ due to queue times converts into new orders. This conversion may not be the case in practice, and it is important for students to highlight how this optimization model requires them to capture the demand they are missing due to long queue times. Qualitative suggestions as to how to ensure customers still order from Valdez’ Quesada location are beneficial to discuss at this point. For example, as the model reveals, there is huge profit to be made each day by lowering queue times. In turn, Valdez can invest some of that profit in a marketing campaign or an online ordering system to ensure he maintains high levels of demand as he takes on more staff. Even if Quesada is only able to capture 50% of the revenue outlined in the model due to there not being enough demand, the addition of extra staff would still result in a profit. Going above and beyond, students could make assumptions as to how much of the ‘missed’ demand Quesada will capture through more efficient operations and optimize their models to reach different conclusions on the optimal number of workers to service lost demand. However, as was outlined in the case, creating additional demand is not what Valdez is most worried about, instead it is keeping up with demand.

WHAT HAPPENED

Kyla Barrow was able to deduce why Valdez' Quesada operations were failing to keep up with demand---the queue times were too long due to not having enough staff. Kyla then found the optimal allocation of staff at each process given the addition of one more staff member. Moreover, Kyla was able to deduce through an optimization model how much revenue the Central London Quesada was missing due to these long queue times, and how many more people they could serve by lowering their process times. As the Central London Quesada had extremely high demand yet was unable to keep up with it, the changes to operations that Valdez enacted as a result of Kyla's suggestions allowed him to capture much more profit each day. At the same time, customers were incredibly happy with how quickly they were able to get their food from Quesada, leaving positive reviews.

EXHIBIT 1: WORKER ONE QUEUE TABLE

Worker 1					
Time to Line	Queue	Order Start	Order Time (s)	Order Time	Order Finish
11:03:46		11:03:46	20	0:00:20	11:04:06
11:07:40	00:00:00	11:07:40	30	00:00:30	11:08:10
11:11:04	00:00:00	11:11:04	30	00:00:30	11:11:34
11:11:24	00:00:10	11:11:34	30	00:00:30	11:12:04
11:15:12	00:00:00	11:15:12	30	00:00:30	11:15:42

EXHIBIT 2: WORKER TWO QUEUE TABLE

Worker 2																								
Tortilla Arr	Queue	Tortilla Sta	Tortilla Tim	Tortilla Tim	Tortilla Fini	Protein Arr	Queue	Protein Sta	Protein Tin	Protein tim	Protein Fin	Veg+Sal Ar	Queue	Veg + Sal S	Veg Time (	Veg Time	Veg + Sal F	Wrap Arriv	Queue	Wrap Start	Wrap Time	Wrap Time	Wrap Finis	Wrap Type
11:04:06		11:04:06	11	00:00:11	11:04:17	11:04:17		11:04:17	17	00:00:17	11:04:34	11:04:34		11:04:34	32	00:00:32	11:05:06	11:05:06		11:05:06	41	00:00:41	11:05:47	Bowl
11:08:10	00:00:00	11:08:10	8	00:00:08	11:08:18	11:08:18	00:00:00	11:08:18	20	00:00:20	11:08:38	11:08:38	00:00:00	11:08:38	40	00:00:40	11:09:18	11:09:18	00:00:00	11:09:18	62	00:01:02	11:10:20	Quesadilla
11:11:34	00:00:00	11:11:34	13	00:00:13	11:11:47	11:11:47	00:00:00	11:11:47	39	00:00:39	11:12:26	11:12:26	00:00:00	11:12:26	29	00:00:29	11:12:55	11:12:55	00:00:00	11:12:55	51	00:00:51	11:13:46	Quesadilla
11:12:04	00:01:42	11:13:46	15	00:00:15	11:14:01	11:14:01	00:00:00	11:14:01	15	00:00:15	11:14:16	11:14:16	00:00:00	11:14:16	36	00:00:36	11:14:52	11:14:52	00:00:00	11:14:52	35	00:00:35	11:15:27	Burrito
11:15:42	00:00:00	11:15:42	25	00:00:25	11:16:07	11:16:07	00:00:00	11:16:07	41	00:00:41	11:16:48	11:16:48	00:00:00	11:16:48	39	00:00:39	11:17:27	11:17:27	00:00:00	11:17:27	55	00:00:55	11:18:22	Quesadilla
11:16:04	00:02:18	11:18:22	16	00:00:16	11:18:38	11:18:38	00:00:00	11:18:38	43	00:00:43	11:19:21	11:19:21	00:00:00	11:19:21	50	00:00:50	11:20:11	11:20:11	00:00:00	11:20:11	25	00:00:25	11:20:36	Bowl
11:17:58	00:02:38	11:20:36	13	00:00:13	11:20:49	11:20:49	00:00:00	11:20:49	45	00:00:45	11:21:34	11:21:34	00:00:00	11:21:34	50	00:00:50	11:22:24	11:22:24	00:00:00	11:22:24	51	00:00:51	11:23:15	Quesadilla

EXHIBIT 3: WORKER THREE QUEUE TABLE

Worker 3						
Pay Arrival	Queue	Pay Start	Pay Time (s)	Pay Time	Payment Finish	Payment Method
11:05:47		11:05:47	10	00:00:10	11:05:57	Debit
11:10:20	00:00:00	11:10:20	10	00:00:10	11:10:30	Debit
11:13:46	00:00:00	11:13:46	15	00:00:15	11:14:01	Debit
11:15:27	00:00:00	11:15:27	15	00:00:15	11:15:42	Debit
11:18:22	00:00:00	11:18:22	12	00:00:12	11:18:34	Debit

EXHIBIT 4: DISTRIBUTION OF QUEUE TIMES FOR SCENARIO 1

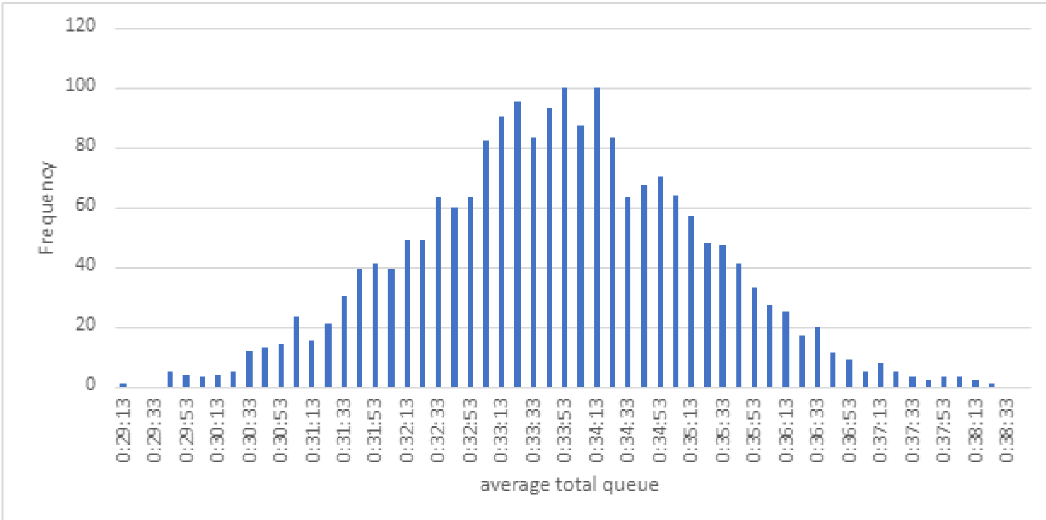

EXHIBIT 5: ALLOCATION SCENARIOS

Workers Allocation					
	Order	Food Preparation		Payment	
Allocation Scenarios					Total # of Workers
1	1	1		1	3
2	1	1	1	1	4
3	1	1	1	1	4
4	1	1	1	1	4

EXHIBIT 6: AVERAGE QUEUE FOR EACH SCENARIO

Allocation Scenarios	Total # of Workers	Average Queue
1	3	0:33:44
2	4	0:13:12
3	4	0:00:45
4	4	0:01:04

EXHIBIT 7: TOTAL LOSS FORCASTED FOR EACH SCENARIO

Allocation Scenarios	Average Queue	average que (s)	total que (s)	Staff Cost	Lost orders	Lost Revenue	Total Loss
1	0:33:44	2023.848994	647631.678	$360	2023.85	10119.24	$10,479
2	0:13:12	792.1175216	253477.6069	$480	792.12	3960.59	$4,441
3	0:00:45	44.86053233	14355.37034	$480	44.86	224.3	$704
4	0:01:04	63.64181443	20365.38062	$480	63.64	318.21	$798

EXHIBIT 8: OPTIMIZATION MODEL

	Order	Tortilla	Protein	Veg	Wrap	Pay	Total	
Process Time (s)	44	62	86	99	118	56	465	Length of original process
Staff	1	3		3		2	9	Variable Cells: # of Staff at Process Step
Time w/ Staff (s)	44	20.67	28.67	33	39.34	28	193.67	Process Time / # of Staff
Difference (s)							271	Length of Original Process - Process Time w/ Staff
New Que							-225	Average Queue Time (46 s) - Difference
Benefit of Changes:								
Workers Cost	$600.00	# of new staff X Worker Cost per day						
Additional Revenue	$1,356.67	Difference (s) * $5 order						
Profit	$756.67	Objective cell: Maximize (Revenue - Cost)						

Key Facts:
1 second decrease in Process Time = 1 second decrease in Average Queue Time
1 second decrease in Average Queue Time = 1 additional order
1 order = 5$
1 worker = $12 an hour