PROJECT REPORT ON UNIVERSITY BOOK STORE

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EXECUTIVE SUMMARY

University Book Store, located around the corner across from the Purdue Memorial Union, is a one stop destination for textbooks, t-shirts, sweatshirts, and gift. As the tagline says, "We've got all your Purdue gear needs covered!" supplying the campus since 1939 they are official textbook source for Purdue Athletics. Providing free delivery to any campus dorm. They are also located near Mackey Arena.

We visited the store on multiple occasions and found data with respect to queuing analysis. We assumed many parameters mentioned in following paragraphs to calculate the models and come up with a solution.

Queuing analysis: Also known as waiting line analysis, is the study of queues or waiting lines. It involves analyzing how queues form, progress, and dissipate. Queuing theory helps businesses optimize service processes, reduce customer wait times, and allocate resources effectively.

OBJECTIVE

1. Understand the customer demand and service parameters during the busiest and regular weeks.
2. Conduct queuing analysis to calculate key metrics like average waiting time, number of customers in queue and system.
3. Determine the optimal number of servers needed to balance utilization and customer satisfaction.

DESCRIPTION AND ANALYSIS

Observations And Assumptions

We visited the bookstore multiple times to see the working operation of the billing counters. Following observations are considered:

Busiest Week:

1. Average Demand: 400 customers/hr.

2. Average Arrival time (a): 0.15 mins/customer
3. Average Service time (p): 1 min
4. Average Service rate (μ): 60 customers/hr.
5. Number of cashiers (m): 7, 8, 9, 10

During the busiest week, which comes in the month of August (Boiler Rush Hour) where there is a huge influx of students purchasing books and supplies for the beginning of the semester as well as parents buying t-shirts and merchandise. The service time at each cashier is relatively stable around 1 minute per customer.

Regular Week:

1. Average Demand: 50 customers/hr
2. Arrival time (a): 1.2 mins/customer
3. Average Service time (p): 1 min
4. Average Service rate (μ): 60 customers/hr
5. Number of cashiers: 1, 2, 3, 4

During a regular week, the demand reduces significantly, arrivals are more sporadic with larger gaps. The service time remains similar for each cashier.

ASSUMPTIONS

1. Considering stable queue analysis (Demand <= Supply).
2. Assuming purchase price and salvage price.
3. The number of cashiers can be varied during both weeks to handle the differing customer demand levels.
4. The arrival of customers follows a normal distribution during both the busiest and regular weeks. This is evidenced by the average arrival rates provided.

CALCULATIONS

Post analysis of the data, we observed that as the number of cashiers increases, utilization reduces that leads to lower waiting times. But adding cashiers also increases the operational cost for the bookstore. It is important to achieve the optimal balance between customer satisfaction and profits.

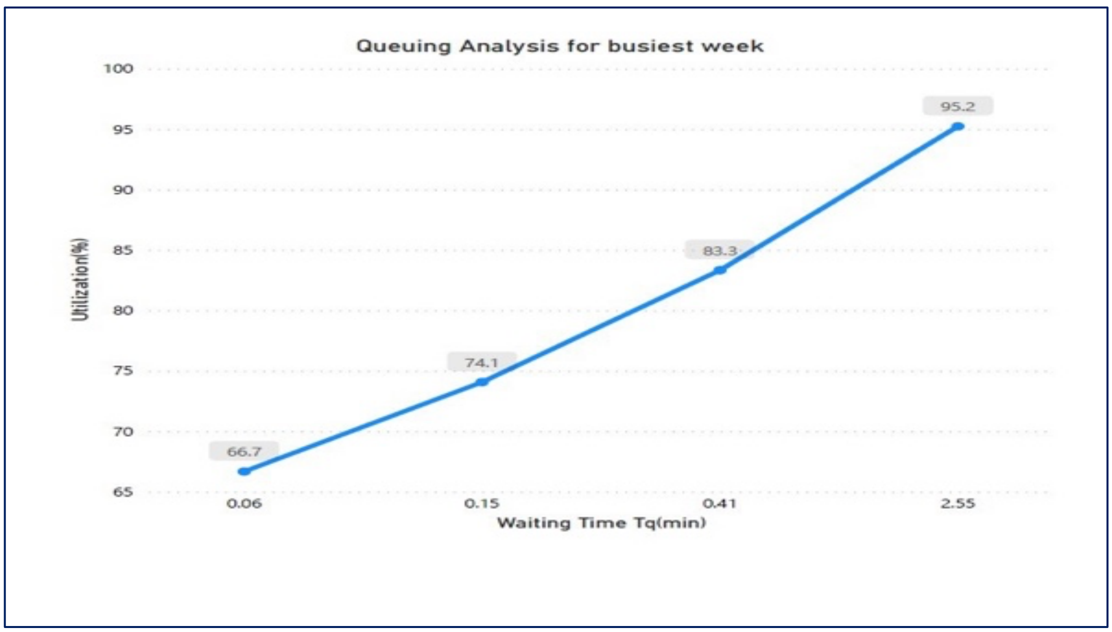
Busiest Week: During the busiest week, the following queuing analysis was conducted:

# of servers	Utilization	Tq (min)	T(min)
7	95.23%	2.55	3.55
8	83.33%	0.41	1.41
9	74.07%	0.15	1.15
10	66.67%	0.06	1.06

With 7 servers (Assuming CVa = CVp = 1) :

- Utilization = (Demand/Service rate) x 100 = (400/420) x 100 = 95.23%
- Tq = Activity time x (Utilization / 1 - Utilization) x ((Cv_a^2 + Cv_p^2) / 2) = 1 x (0.9523 / 1 - 0.9523) x ((1^2 + 1^2) / 2) = 2.55 mins
- Average time in system (T) = Waiting time + Service time = 2.55 + 1 = 3.55 mins.
- Similar calculation was done for 8, 9 and 10 servers. As the number of servers increases, utilization decreases and Tq reduces significantly from 2.55 mins to 0.06 mins.

- **Average no of people in the queue (Iq)** = Waiting time (Tq) / arrival time (a)
  = **17** (#7), **3** (#8) and so on.
- **Average no of people in the system (I)** = Total time in the system (T) / arrival time (a)
  = **24** (#7), **10** (#8) and so on.



Graph 1: The graph exhibits the analysis of waiting times and utilization for a peak busiest week in the month of August with increasing number of 'm' at each plotted point.

Regular Week: During a regular week, the following queuing analysis was conducted:

# of servers	Utilization	Tq (min)	T(min)
1	83.33%	4	5
2	41.66%	0.25	1.25
3	27.78%	0.044	1.04
4	20.83%	0.01	1.01

With 1 server (Assuming CVa = CVp = 1):

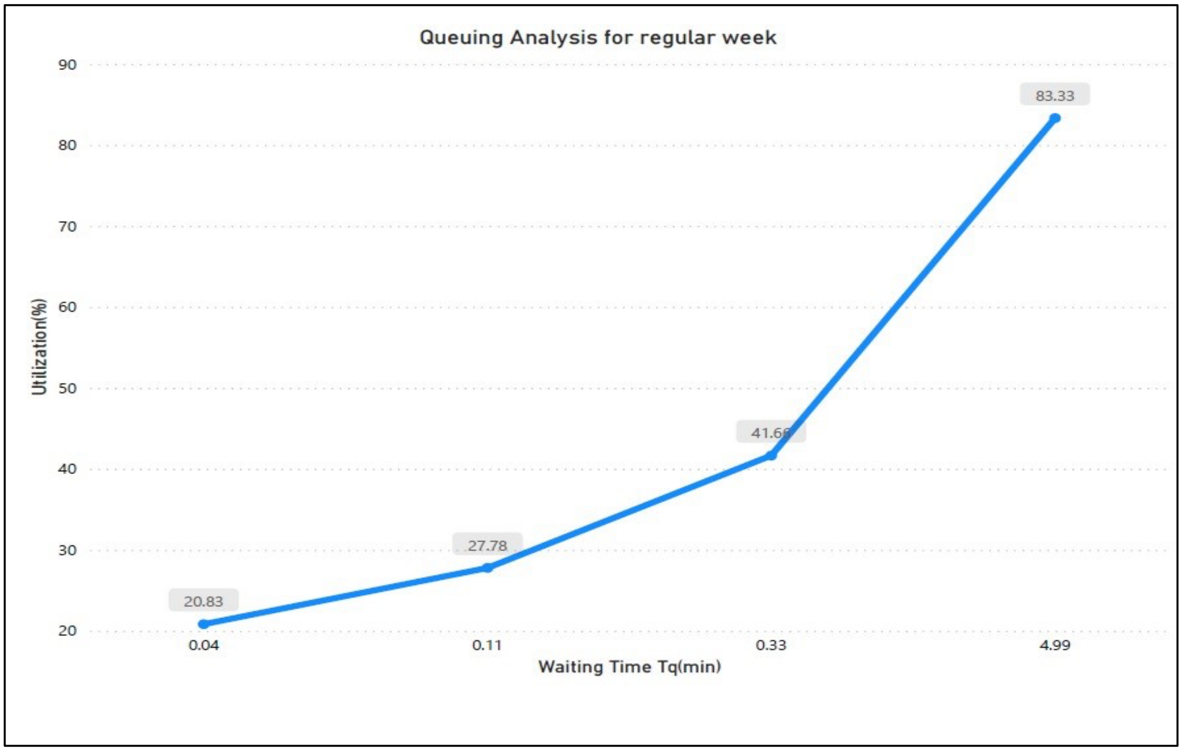
- Utilization = (Demand/Service rate) x 100 = (50/60) x 100 = 83.33%
- Tq = 1 x (0.8333 / 1 - 0.8333) x ((1^2 + 1^2) / 2) = 4 mins
- T = Tq + Service time = 4 + 1 = 5 mins

Similar analysis is done for 2, 3 and 4 servers. As servers increase, Tq and T reduce significantly.

- Average no of people in the queue (Iq) = Waiting time (Tq) / arrival time (a)

  = **4.15** (#1), **0.28** (#2) and so on.
- Average no of people in the system (I) = Total time in the system (T) / arrival time (a)

  = **5** (#1), **1** (#2) and so on.



Graph 2: The graph exhibits the analysis of waiting times and utilization for a peak regular week in the month of June with increasing number of 'm' at each plotted point.

RECOMMENDATIONS

1. For a regular week: Currently the store utilizes 3-4 servers, even though the utilization is coming to approximately 20% since there are many factors not being considered like the servers are utilized in other work at the store such as stocking inventory, stacking of materials managing billing details, customer service etc. After personally visiting the store, we would like to keep the same number of servers.
2. For a busy week: the number of servers utilized during a busy week are 7-10. It is recommended to have same number of servers depending on the peak hour arrivals in evening. The utilization is calculated to be approximately 60-90%.