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Optimization of Waiting Time at Drive Thru Fast Food Restaurant using Queuing Model

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Abstract

In a society where the working population faces time constraints due to constant work demands, there is a high demand for fast food and convenient products that align with their busy lifestyles. This necessitates a focus on minimizing customer waiting times, a concept rooted in queuing theory, a mathematical theory dedicated to analyzing waiting lines. The study aims to identify the optimal waiting line model for reducing customer waiting times and to understand the factors. Queuing theory has two main categories single queue theory and multiple queue theory. Employing descriptive analysis as the primary tool for data collection, the research specifically utilizes the single-queue theory. The study, conducted exclusively during the lunch hour peak from 12 p.m. to 2 p.m. at McDonald's Kota Bharu over five days, employs Excel for data analysis. To further enhance the customer experience, McDonald's will implement an observation and simulation model approach to minimize waiting times.

1. Introduction

Fast food restaurant waiting lines are often busy, especially during peak times when there is a great demand for meals such as during lunch. During this time, fast food restaurant become crowded with customers that are waiting for their orders at the queue line, including at the drive-thru. [1] Customers aim to receive their order within a short period, but if they spend longer time waiting for it, they might cancel the order and change another restaurant for a meal. Numerous complaints about long waiting times are often made, even outside the peak hours. This can lead to dissatisfied or negative feedback among customers that are queuing up to buy food over the counteror in the drive-thru line. Poor customer service also reflects a long waiting time as thestaff sometimes are unable to handle a crowded situation.

Relate to this study, a fast-food restaurant, mostly serve the food in two different ways which are dine-in service and drive-thru service. Dine-in options are typically located in malls or kiosk restaurants, featuring fancy seating areas for customers to enjoy their meals. [2] The drive-thru service provides an efficient and convenient experience, where customers queue up, place orders, pay, receive their orders, and exit the system without leaving their vehicles.[3] The primary objective of queuing models is to solve important problems, related to the efficient of shorter waiting times while increasing service effectiveness. A waiting line's duration depends on a number of variables, such as how popular the service is, how many resources are available, how efficient the system is overall, and how much demand there is.

Additionally, fast-food restaurants are also known for their quick service and affordability and because of that, there are too many fast-food restaurant outlets nowadays and becoming a famous restaurant for everyone to go. [4] They are often located to accommodate people on the go which is frequently situated in busy places such as shopping center, town, airports also rest spots along highways. They are popular because the food is easy to get within a short period. It also comes from variety of food options that consumers can choose food according to their preferences in terms of taste and price. People today live in fast-paced world and this includes eating their meal in a quick time. [5] They choose a fast product that fits their lifestyle, so that they can have their meal in a short period. In this study, we have selected McDonald's as a fast-food restaurant of focus due to its success and global popularity as the leading fast-food chain. Since its founding, the McDonalds brand has been widely recognized and has maintained a strong presence in popular culture. One of the factors that contribute to people's affection for McDonald's is the food itself. McDonald's always has their signature foods that cannot get anywhere from another fast-food restaurant. [5]

In a queuing system, the dynamics of customer wait times are intricately tied to the popularity of the service, the availability of service resources, the overall efficiency of the system, and the demand level. [6] Queuing theory, grounded in mathematical principles, provides a systematic approach to address these complexities. It enables businesses to analyse and predict the length of waiting lines, guiding strategies to minimize wait times and elevate service quality. By focusing on the interplay between these factors, queuing theory facilitates a comprehensive understanding of the dynamics within waiting lines, offering businesses a strategic framework for effective management and continuous improvement in customer service delivery.

Therefore, in this study, a queuing theory approach is implemented to address the intricacies of managing customer queues at the fast-food restaurant during the selected days from Saturday to Wednesday. The study of queuing theory employs a simulation model utilizing a single-server system in Excel. By looking to the simulation, the aim is to analyse and optimizing the drive-thru service's performance, considering factors such as arrival times, service start times, waiting times, and overall average during the specified time periods. This approach to achieve the study's objective of reducing waiting times and customer satisfaction, for operational improvements within the fast-food restaurant's drive-thru service. The simulation model in Excel provides a practical and adaptable into the complex of the queuing system.

2. Methodology

The application how queuing theory is put to use in practice is the examination of wait times at McDonald's drive-thru services. Important information, such as service durations and inter-arrival times, was obtained by closely observing the operational at a chosen McDonald's drive-thru. This observational study offers a practical basis for implementing the ideas of queuing theory to comprehend and improve the waiting experience for customers. Queuing theory is helpful in assessing and improving McDonald's efficiency by taking lessons from real drive-thru operations.

2.1 Data Collection

During peak hours from 12 pm to 2 pm, each customer arriving at a drive-thru service is associated with the following time measures including the arrival times, service start time, waiting times, service times and also waiting time in the system.

By selecting Saturday to Wednesday as day to observe of the operational drive-thru system's performance. These days including both weekend and midweek periods which is 3 days from Monday, Tuesday and Wednesday. Saturday and Sunday part of the weekend typically increased the quantity of cars that entered of the service. Comparing between work days and the weekend at peak hour will allow the study the different of drive-thru simulation.

The data was collected in one of the places at McDonalds restaurant by the workers and the target consists of customers entering the drive-thru service during within observe hours.

Table 1 shows data starting from Saturday until Wednesday within 12pm to 1pm which insist arrival times and service times each one hour over 5 days.

Table 1 Collected data from McDonalds Restaurant

DAY/DATE	TIME	ARRIVAL TIMES (cars)	SERVICE TIMES (min)
Saturday	12:00 PM	6	10
	1:00 PM	7	12
	2:00 PM	9	11
Sunday	12:00 PM	8	7
	1:00 PM	7	10
	2:00 PM	9	8
Monday	12:00 PM	8	10
	1:00 PM	6	11
	2:00 PM	10	9
Tuesday	12:00 PM	9	6
	1:00 PM	8	11
	2:00 PM	10	10
Wednesday	12:00 PM	7	9
	1:00 PM	8	11
	2:00 PM	5	7

2.2 Computing using Excel

Excel was an effective tool for data and analysis that was used to arrange and carefully review the information that was collected from drive-thru services. The process involved carefully organizing various data points into an Excel spreadsheet. Using Excel's built-in functions and formulas, we calculated average of arrival rate and service rate for each day.

2.3 Single Server

A single queuing model is also known as a single server queuing system (M/M/1) thathas a single server or service facility that serves a queue of customers. The average waiting time, average service time, utilization, and queue length are some of the performance indicators of the queuing system that may be analyzed using a single queuing model. This approach is frequently utilized in a variety of applications, including call centers, hospitals, retail establishments, and banking institutions. Workers can improve the system's design and operation to shorten wait times by understanding the performance of measurements used in the queuing system. The single server can be suits in situations which have a condition that can be applied [8] .

2.4 M/M/1 : Model for single servers queue

An essential and frequently used analytical tool for systems with a single server is the M/M/1 queuing model. The average number of customer arrivals per unit of time is represented by the Poisson process with a rate of λ in this model. The average number of customers the server can serve in a given amount of time is represented by the mean service rate of μ, and service times are assumed to be exponentially distributed. First-come, first-served (FCFS) procedures supports the system, guaranteeing that the first-arriving customer gets served first. Service starts when the customer enters an empty system, and they stay in the system until the service is finished. The M/M/1 model is a useful tool for studying queue dynamics and offers insights into performance metrics like average customer count, average system utilization, and average time spent in the system. The following performance metrics are noteworthy for the M/M/1 queue model :

U = Utilization factor , $\rho = \lambda / \mu$ (1)

Probability that there are n customers in the system,

$$P_n = P_0 \rho^n \quad (2)$$

Average number of customer in the system (in waiting line and being served) , Ls

$$\rho / (1 - \rho) = \lambda / (\mu - \lambda) \quad (3)$$

Average number of customers in waiting line service, $L_q =$

$$\rho^2 / 1 - \rho = \rho\lambda / \mu - \lambda \quad (4)$$

Average time a customer spends in waiting line waiting for the service, W_q

$$W_q = \rho / \mu - \lambda \quad (5)$$

Average time a customer spends in the system (in waiting line and being served), $W_S =$

$$W_s = 1 / \mu - \lambda \quad (6)$$

3. Result and Discussion

The order placement unit serves as the first point of contact between customers and McDonald's drive-thru service. The order of cars joining the drive-thru line is first-in, first-out (FIFO), and they must wait to make their requests until they get to the order station. Customers proceed to confirm and finish their orders including any customizations or special requests after getting to the front of the line. First-time customers receive a new order profile.

Table 2 outlines the arrival rate, service rate, utilization per minute, queuing waiting time per minute, service waiting time per minute, and the average number in the queue and in service for the drive-thru service at McDonald's spanning from Saturday to Wednesday.

Table 2 Queue characteristic of single server

Day	Arrival Rate, λ	Service Rate, μ	Utilization	Wq	Ws	Lq	Ls
Saturday	7	11	0.636	0.159	0.25	1.11	1.75
Sunday	8	9	0.889	0.889	1.00	7.11	8.00
Monday	8	10	0.800	0.400	0.50	3.20	4.00
Tuesday	9	11	0.818	0.409	0.50	3.68	4.50
Wednesday	6	9	0.667	0.222	0.33	1.33	2.00

On average arrive over five days at drive-thru service at McDonald's Restaurant, the average time a customer spends waiting in the queue before being served by the workers is 0.416 times unit or 24.96 minutes. Arrival times and services times are lower than working days which an average utilization of 0.762 or 76.2%. Therefore, with the service times of customers spends on being served is 0.516 times unit also can convert to 30.96 minutes, we can conclude that the average number of cars served per hours entering drive-thru service during the time 12pm-2pm over the five days is 10 cars.

A simulation model is used to analyze the system [9] by entering formula to generate the output. In Excel, the arrival rate and service rate simulated using the formula. These a simulation using Excel starting from Saturday until Wednesday by entering the numbers of the cars that entering the drive-thru service over 5 days.

The Fig. 1 - Fig. 3 show a single server simulation within Saturday until Wednesday using Excel by simulate a system by inputting the arrival rate and service rate formulas, helping you analyze how quickly cars enter and are served in a drive-thru.

Enhanced Knowledge in Sciences and Technology Vol. 4 No. 2 (2024) p. 134-140

Arrival rate, λ	7
Service rate, μ	11

MODEL						
ar	rand()	Arrival time	TBA	Start Service	Service Time	End Service
1	0.68	0	0.16	0	0.30	0.30
2	0.46	0.16	0.09	0.30	0.02	0.32
3	0.30	0.25	0.05	0.32	0.00	0.32
4	0.63	0.30	0.14	0.32	0.16	0.49
5	0.95	0.44	0.44	0.49	0.04	0.53
6	0.23	0.88	0.04	0.88	0.02	0.91
7	0.28	0.92	0.05	0.92	0.08	1.00
8	0.61	0.97	0.13	1.00	0.12	1.12
9	0.49	1.10	0.10	1.12	0.01	1.13
10	0.53	1.20	0.11	1.20	0.01	1.21
11	0.53	1.31	0.11	1.31	0.14	1.44
12	0.11	1.41	0.02	1.44	0.05	1.49
13	0.47	1.43	0.09	1.49	0.25	1.74
14	0.21	1.52	0.03	1.74	0.13	1.87
15	0.43	1.55	0.08	1.87	0.06	1.94
16	0.04	1.63	0.01	1.94	0.07	2.01
17	0.32	1.64	0.06	2.01	0.39	2.40
18	0.55	1.69	0.12	2.40	0.05	2.45
19	0.72	1.81	0.18	2.45	0.09	2.54
20	0.22	1.99	0.04	2.54	0.24	2.78
21	0.68	2.03	0.16	2.78	0.02	2.80
22	0.67	2.19	0.16	2.80	0.07	2.87
23	0.45	2.35	0.09	2.87	0.12	2.99
24	0.29	2.43	0.05	2.99	0.15	3.14

(a)

Arrival rate, λ	8
Service rate, μ	9

Chart Area

ar	rand()	Arrival time	TBA	Start Service	Service Time	End Service
1	0.58	0	0.11	0	0.02	0.02
2	0.37	0.11	0.06	0.11	0.14	0.24
3	0.34	0.17	0.05	0.24	0.18	0.42
4	0.09	0.22	0.01	0.42	0.17	0.60
5	0.88	0.23	0.27	0.60	0.55	1.15
6	0.14	0.50	0.02	1.15	0.05	1.20
7	0.51	0.52	0.09	1.20	0.06	1.26
8	0.50	0.60	0.09	1.26	0.02	1.28
9	0.59	0.69	0.11	1.28	0.11	1.39
10	0.91	0.80	0.30	1.39	0.14	1.53
11	0.10	1.10	0.01	1.53	0.00	1.53
12	0.47	1.12	0.08	1.53	0.02	1.56
13	0.35	1.19	0.05	1.56	0.02	1.57
14	0.75	1.25	0.18	1.57	0.15	1.72
15	0.24	1.42	0.03	1.72	0.09	1.81
16	0.48	1.46	0.08	1.81	0.05	1.85
17	0.73	1.54	0.16	1.85	0.09	1.95
18	0.20	1.70	0.03	1.95	0.08	2.03
19	0.86	1.73	0.24	2.03	0.01	2.04
20	0.68	1.97	0.14	2.04	0.15	2.19
21	0.68	2.11	0.14	2.19	0.10	2.28
22	0.45	2.26	0.07	2.28	0.15	2.44
23	0.34	2.33	0.05	2.44	0.08	2.51
24	0.96	2.38	0.39	2.51	0.03	2.54

(b)

Fig. 1 Figure description (a) Simulation M/M/1 Server on Saturday ; (b) Simulation Excel M/M/1 on Sunday

Arrival rate, λ	8
Service rate, μ	10

MODEL						
Car	rand()	Arrival time	TBA	Start Service	Service Time	End Service
1	0.40	0	0.06	0	0.05	0.05
2	0.45	0.06	0.08	0.06	0.02	0.08
3	0.73	0.14	0.16	0.14	0.08	0.22
4	0.46	0.30	0.08	0.30	0.07	0.37
5	0.45	0.38	0.07	0.38	0.11	0.49
6	0.48	0.45	0.08	0.49	0.08	0.56
7	0.75	0.53	0.17	0.56	0.05	0.61
8	0.21	0.71	0.03	0.71	0.03	0.74
9	0.87	0.74	0.26	0.74	0.20	0.93
10	0.61	0.99	0.12	0.99	0.12	1.11
11	0.97	1.11	0.43	1.11	0.08	1.20
12	0.19	1.54	0.03	1.54	0.10	1.64
13	0.08	1.56	0.01	1.64	0.10	1.74
14	0.83	1.57	0.22	1.74	0.13	1.87
15	0.42	1.80	0.07	1.87	0.33	2.20
16	0.74	1.86	0.17	2.20	0.04	2.25
17	0.74	2.03	0.17	2.25	0.28	2.53
18	0.73	2.20	0.16	2.53	0.00	2.54
19	0.45	2.36	0.07	2.54	0.05	2.59
20	0.10	2.43	0.01	2.59	0.06	2.65
21	0.31	2.45	0.05	2.65	0.01	2.66
22	0.30	2.49	0.05	2.66	0.12	2.78
23	0.84	2.54	0.23	2.78	0.16	2.93
24	0.25	2.77	0.04	2.93	0.12	3.06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(a)

Arrival rate, λ	9
Service rate, μ	11

art Area

MODEL						
)		Arrival time	TBA	Start Service	Service Time	End Service
1	0.47	0	0.07	0	0.02	0.02
2	0.20	0.07	0.03	0.07	0.01	0.08
3	0.21	0.10	0.03	0.10	0.15	0.25
4	0.91	0.12	0.26	0.25	0.04	0.29
5	0.53	0.38	0.08	0.38	0.19	0.58
6	0.57	0.47	0.09	0.58	0.36	0.94
7	0.51	0.56	0.08	0.94	0.01	0.95
8	0.75	0.64	0.15	0.95	0.18	1.13
9	0.91	0.79	0.27	1.13	0.59	1.72
10	0.09	1.06	0.01	1.72	0.09	1.80
11	0.81	1.07	0.18	1.80	0.08	1.88
12	0.29	1.25	0.04	1.88	0.20	2.08
13	0.75	1.29	0.15	2.08	0.20	2.29
14	0.46	1.45	0.07	2.29	0.07	2.36
15	0.30	1.51	0.04	2.36	0.00	2.36
16	0.61	1.55	0.10	2.36	0.06	2.42
17	0.76	1.66	0.16	2.42	0.22	2.64
18	0.59	1.82	0.10	2.64	0.06	2.70
19	0.53	1.92	0.08	2.70	0.01	2.71
20	0.13	2.00	0.02	2.71	0.00	2.71
21	0.58	2.02	0.10	2.71	0.13	2.84
22	0.62	2.11	0.11	2.84	0.08	2.92
23	0.90	2.22	0.26	2.92	0.28	3.20
24	0.97	2.48	0.38	3.20	0.01	3.21
25	0.36	2.87	0.05	3.21	0.05	3.27
26	0.82	2.92	0.19	3.27	0.09	3.35
27	0.46	3.11	0.07	3.35	0.11	3.47

(b)

Fig. 2 Figure description (a) Simulation M/M/1 Server on Monday ; (b) Simulation Excel M/M/1 on Tuesday

	Arrival rate, λ	6				
	Service rate, μ	9				
MODEL						
ar	rand()	Arrival time	TBA	Start Servic	Service Tin	End Service
1	0.16	0	0.03	0	0.17	0.17
2	0.81	0.03	0.28	0.17	0.17	0.34
3	0.01	0.31	0.00	0.34	0.24	0.58
4	0.65	0.31	0.18	0.58	0.09	0.67
5	0.19	0.48	0.03	0.67	0.00	0.67
6	0.20	0.52	0.04	0.67	0.08	0.75
7	0.96	0.56	0.52	0.75	0.01	0.77
8	0.85	1.08	0.32	1.08	0.17	1.25
9	0.37	1.40	0.08	1.40	0.06	1.45
10	0.29	1.47	0.06	1.47	0.09	1.56
11	0.58	1.53	0.14	1.56	0.07	1.63
12	0.22	1.67	0.04	1.67	0.14	1.81
13	0.70	1.71	0.20	1.81	0.03	1.84
14	0.60	1.92	0.15	1.92	0.01	1.92
15	0.61	2.07	0.16	2.07	0.00	2.07
16	0.57	2.23	0.14	2.23	0.02	2.25
17	0.60	2.37	0.15	2.37	0.04	2.41
18	0.91	2.52	0.40	2.52	0.00	2.52
19	0.32	2.92	0.06	2.92	0.03	2.96
20	0.64	2.99	0.17	2.99	0.01	2.99

Wednesday

Fig. 3 Figure description of simulation M/M/1 server on Wednesday

Fig. 4 illustrates the probability distribution of the average over a span of 5 days, with each data point representing the occurrence of 10 cars. This graphical representation has been generated using Microsoft Excel, where the x-axis depicts the average values, and the y-axis showcases the corresponding probability of observing such averages.

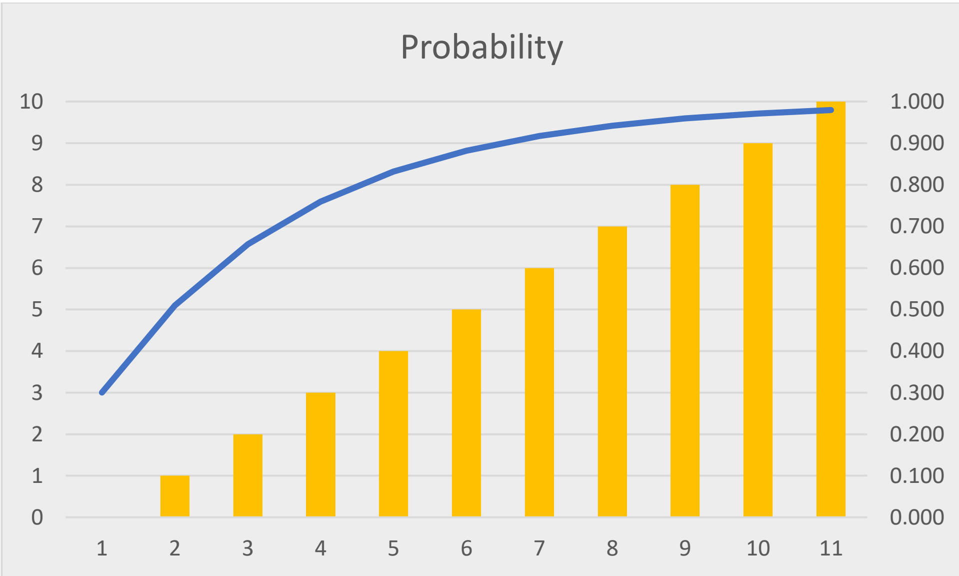

Fig. 4 Probability of average over 5 days by 10 cars

4. Conclusion

In conclusion, queuing theory proves valuable for fast-food restaurants , to optimize operations and boost customer satisfaction in drive-thru services. Utilizing models like M/M/1, which consider factors such as customer arrivals, service times, and server utilization, allows businesses to strategically manage queues and expedite service [10]. By analyzing these variables, fast-food establishments can reduce wait times, optimize staffing, and enhance overall service quality.

The drive-thru service's five-day examination showed differing degrees of customer satisfaction and operational effectiveness. On Sunday, there were notable wait times and a higher average number of cars in line and being served despite higher utilization, which may indicate operational issues. On the other hand, Wednesday showed reduced utilization and more efficient service dynamics due to a lower arrival rate.

Recommendation to enhance drive-thru service at McDonald's is optimizing the efficiency and customer experience in drive-thru operations at fast-food restaurants requires careful consideration of drive-thru lane design. Multiple drive-through lanes can facilitate quicker traffic flow through the restaurant and efficiently handle more orders during peak hours while also reducing overall customer service time. Next, creating an app that allows users to place orders in advance can be a great way to improve drive-thru service. Customers can order ahead of time using an app, saving them time while waiting in line to read the menu and consider their options in the drive-thru lane.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design, data collection****: Nurul Ain Athirah Binti Zulkarnain* ***analysis and interpretation of results, draft manuscript preparation****: Nurul Ain Athirah Binti Zulkarnain and Azila Md Sudin. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Atiqah Mazlan, N., Nur Ezaty, S. T., Majid Khan, M. A., & Mohd Tahir, I. (2020). Queuing Application In Mc Donald'S Sungai Dua, Penang. In N. Baba Rahim (Ed.), *Multidisciplinary Research as Agent of Change for Industrial Revolution* 4.0, vol 81. (pp. 701-710). https://doi.org/10.15405/epsbs.2020.03.03.82

[2] Ishak, F. A. C., Lah, N. A. C., Samengon, H., Mohamad, S. F., & Bakar, A. Z. A. (2021). The Implementation of Self-Ordering Kiosks (SOKs): Investigating the Challenges in Fast Food Restaurants. *International Journal of Academic Research in Business and Social Sciences*, 11(10), 1136–1150

[3] Nurashikin Abdul Basir, R Chandrashekar (2020), Simulation Model in Reducing Customer Waiting Time in Fast Food Drive-Thru System: A Case Study In Bangi. *Faculty of Technology Management and Business*, 1(1), pp 80-91.

[4] Varsha Ganatra, Kok Ban Teoh, Nur Batrisyia Sapian , Daisy Mui Hung Kee, Nur Aqilah Mas Ud , Nur Darwisyah Zulkepli , Nur Farhah Fadhilah Mokhtar , Kavita Jaiswar (2022). Contributing Factors to Customer Loyalty in Fast-Food Restaurants: A Study of KFC. *Faculty of Economy and Business*

[5] Serban Raicu, Dorinela Costescu, Miheala Popa (2022). Effects of the Queue Discipline on System Performance: Doctoral School of Transport, *Polytechnic University of Bucharest*, *3*(1), 37-48; https://doi.org/10.3390/appliedmath3010003

[6] Abhishek Rajawat, Daisy Mui Hung Kee , Muhammad Zulhilmi Bin Abdul Malik , Muqlis Alhayul Qayumm Bin Mohamed Yassin , Mai Shazatul Inaz Binti A. Shaffie , Maizatul Husna Binti Fuaat , Noof AlDosari , Maria Elisabeth Jessica Santoso (2020) .Factors: Responsible for McDonald's Performance. *Journal of the Community Development in Asia* 3(2): 11-17 10.32535/jcda.v3i2.806

[7] Mohammad Shyfur Rahman Chowdhury (2013). Queuing Theory Model Used to Solve the Waiting Line of a Bank- A Study on Islami Bank Bangladesh Limited, Chawkbazar Branch, Chittagong. *Department of Business Administration, International Islamic University, Chittagong, Bangladesh*. Vol.2 No.3

[8] Mohammadkarim Bahadori, Seyed Mohsen Mohammadnejhad, Ramin Ravangard, and Ehsan Teymourzadeh (2014), Using Queing Theory and Simulation Model to Optimize Hospital Pharmacy Performance. *Department of Health Management and Economic*. doi: 10.5812/ircmj.16807

[9] Qamar Iqbal, Lawrence E. Whiteman, Don Malzah (2012) , Reducing Customer Wait Time at a Fast Food Restaurant Campus. *Journal of Foodservice Business Research*. 20:1

[10] Davis, M.M. and Vollmann, T.E. (1990), A Framework for Relating Waiting Time and Customer Satisfaction in a Service Operation, *Journal of Service Marketing* , Vol. 4 No. 1, pp. 61-69.