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IMPACT OF COVID-19 TO LOGISTICS & REDUCING CUSTOMER WAITING-TIME IN STORES WITH BASIC CONCEPT IN DISCRETE-EVENT SIMULATION.

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ABSTRACT

During the current COVID-19 epidemic, getting supply to grocery stores and supermarkets has been affected, which results in low on-premises grocery stock. Moreover, many people have hoarded groceries due to the pandemic, which affects the consumer's access to basic needs requirements. Grocery store and supermarket management have many key factors to consider to successfully grow in this competitive world. Many challenges affect the profits and losses, such as labour cost, inefficient processes, unknowing inventory, and wait time. Grocery stores consider "wait time" as a key performance indicator and challenge. Using discrete event simulation (DES) modelling of a small grocery store layout that is providing services through a queuing system, this study explores some of the potential benefits and outcomes of introducing new processes, or redesigning existing processes, for larger-than-normal waiting lines. Because customer comfort plays a major role for the growth of any kind of industry, this simulation includes comfort as a key parameter. The results suggest ideas for decision making to the stakeholders and help in determining future research scope.

Key Words: Grocery stores, queues / waiting line, customers, stakeholders COVID-19 & DES.

1.Introduction

For study considered small grocery stores to analyse the pros and cons in the present pandemic situation throughout the world. The reason behind to considering this small Grocery store for case study is because the smaller one has many limitations and less occupancy of customers especially in any hard situations unlike supermarkets/hypermarkets. However, this smaller store also consists of all items like supermarkets, but it has less varieties. So, this case study helps stakeholders of both the small & big stores in the present COVID situation. As known to everyone, coronavirus is a transmittable disease caused by severe acute respiratory syndrome. The virus spreads extremely fast between the people during close contact. To overcome this, we need to cover our mouth and maintain a social distance of minimum 6 feet. For maintaining the social distance even in the grocery stores and supermarkets, the queue & waiting time rapidly increases. So, in this pandemic situation

big grocery stores are considered for study because they has similarity to self-shopping as supermarkets.

1.1 Literature Review

In the real world we find traditional grocery stores and supermarkets or hypermarkets [1] but the majority of consumers seek the services of supermarkets, because they have a wider assortment of things for sale, including clothing, baby items, and medications all under one roof. Increased competition from a recently opened 24-hour supermarket with their special offers and discounts, which has invaded the customer base over a local traditional grocery store. Customer satisfaction will have a big impact on the retail industry as it contributes to overall performance.

But at present Coronavirus (COVID-19) disease is spreading rapidly between people. This spreads mainly due to close contact via air medium, droplets produced by coughing, sneezing, and talking. The preventive measures to reduce the chances of infection are washing hands, maintaining social distancing, practicing good respiratory hygiene, and avoiding touching of face.

Figure 1. Pictures show Social distancing practice in Grocery stores.

So, to maintain Social distance between people in public places 6 feet away stickers are pasted on the floors **(Figure 1)** to decrease the chance of spreading virus. According to the CDC, spacing of 6 ft (1.8 m) away decreases the spread of COVID-19 [2]. Individual actions include working remotely, avoiding public transportation, and staying home if you suspect you have been exposed and/or are symptomatic [3]. Community-wide measures include transition to online teaching, businesses temporarily closing, and the widespread engagement of telecommunication [4]. Multiple states are resorting to state-wide home orders being issued to minimize contact [5-7]. Due to this social distancing, it is mainly affecting the human basic needs **especially over groceries** with the increased waiting time due to larger queues. The concept of queues is the most common process before getting served. A queue is the line of people or objects that are waiting, these waiting lines are also known as queuing theory [8]. Automated queuing technology is employed for all the small and large-scale stores, which focuses on customer waiting time. In addition to waiting, a customer has other possible actions. For example, a customer may balk, renege, or jockey [9]. Customers maintain queue discipline [10]. Therefore, queuing theory can be defined by arrival and

service systems, queue disciple and customer behaviour. Generally, customers balk, but due to the pandemic situation customers' renege. There are two general methods to evaluate the queuing length which affect waiting time, such as by applying a queuing theory or using simulation [11]. This study will develop the model and analyse it by using Simul8 software which is one of the DES methods.

Discrete event simulation (DES) [12] is the process of organizing the performance of a complex system in an ordered sequence in a defined structure. There are many ways to organize DES in which Simulation is one of the operational applications and helps to identify the significant issues & resolve issues to improve the performance in real systems [13]. Building the simulation model by considering the real time factors with sufficient data and by visualizing the problems of the real system. These cases have been simulated for reducing the queue waiting time, availability of stocks, addition of resources, addition of billing counters.

1.2 Motivation and Objectives

Stating to the hard situations around the world [14] the most important daily happenings zones are affected from schools to hospitals. Unfortunately, the virtual mode involved to settling down some daily activities to overcome social distancing issues. But the grocery stores' on-line functioning was not satisfactory for customers, due to high demand for groceries in lockdown. So, in any hard situation the grocery stores must run both on-line and walk-in. In these circumstances to maintain social distancing measures were more observed in all the grocery stores with more queues. To avoid this increased waiting time issues in the stores this case study suggests the solutions and ideas. Studying the grocery store model using simulation to accommodate more customers. It is unclear how much time it takes for a customer to wait in the queue. This study accesses the (1) modifying the layout of the store (2) addition of staff members to the stores. A systematic approach of conducting simulation study which includes the subject problem, collecting data, constructing the model, calibrating the developed model, designing, and running experiments and analysing the output results (Abo-Hamad and Arisha 2013). In the next sections we will concentrate on design and development of the grocery stores using DES.

2.Methodology

Grocery Store Layout usually, all the grocery stores have the same practice which consists of entry, different sections for household items, food and billing counters. So, simple store is considered for this study where customers enter the store and move from one section to the other to purchase the items and move from one section to another section for purchasing the items, at the end go for the check-out there will be three billing counters (out of this one is for self-billing counter). Customers can seek the help of staff members if necessary. Below considerations and assumptions are made to modify the store.

2.1 Considerations and Assumptions

Baseline layout is modified with various common assumptions such as to serve the customers better ways in pandemic stores. So, it has been recommended to set three types of shopping for the customers i.e., In-store shopping, Out-store shopping, and Curbside pick-up.

Below changes remain same without any modifications during pandemic and normal conditions:

- There is no change in grocery items and its locations. Billing counters, checkout process and store hours do not vary but remain same in both conditions. Peak hours are assumed as after school, office hours and the weekend.
- The model is assumed as first in first out i.e., the customer who comes first is served during the shopping at different stations and goes out first, entrance and exit are from the same door.
- Staff perform works like loading and unloading the goods, cleaning the floors, organizing the goods during shopping hours and breaks. The time taken to reload the goods is not considered.
- Customer passing between the different grocery items stations cannot be measured as it differs from customer-to-customer shopping.

Below modifications suggested to above assumptions.

- In regular shopping customers can turn back during shopping, but now no turn back is recommended for modified layout to avoid face to face interaction.
- To avoid contact customers may enter the store with different time intervals. For example, before a pandemic each customer may arrive at the store in the range of 10-20mins but on complex days may enter between 20-40 mins.
- For Out-store shopping & curbside pickup more resources should be appointed to serve customers. Depending upon the customer requirements stores must update their services according to situations. Now based on the present situation below data is collected for simulation.

3. Store Optimization

Generally, customers look for the store, which is nearest, has short waiting time, convenient hours of operation, items in stock, and more. However, not all store locators are created equal and there are several factors considered for store optimizing. So, to validate the results of the paper and to meet the real-world condition we considered the real example, the small grocery store which is close to apartments and reachable to local pedestrians. Based on the approximate data of the store we framed the general case study (**Table 1**).

Table 1. Approximate data of the store

Shoppers/customers capacity	100-120 customers
No. Customers shop in a day	50-70 customers
Area of store	2000 Sq Ft
No. of billing counters	3 counters
Shopping Rows	4
Staff members	4
operation hours	11 hrs.
Parking space	25 cars parking lot
Working days	6 days

Based on above store information we collected the below data for case study simulation and re-modelled the existing basic layout (**Figure 3**) with few alterations for benefits of both customers and stakeholders.

4. Data Collection

The store data was collected approximately by considering the customers entering the store in regular intervals of time during shop hours. The parameters of the model include arrival time of the customers, time in queue, time spent at each station, time for billing and employee workability. The arrival time varies during the peak hours.

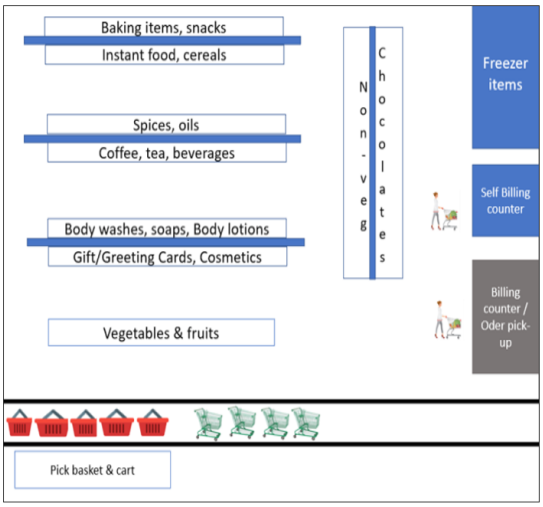


Figure 2. Basic Grocery Store Layout

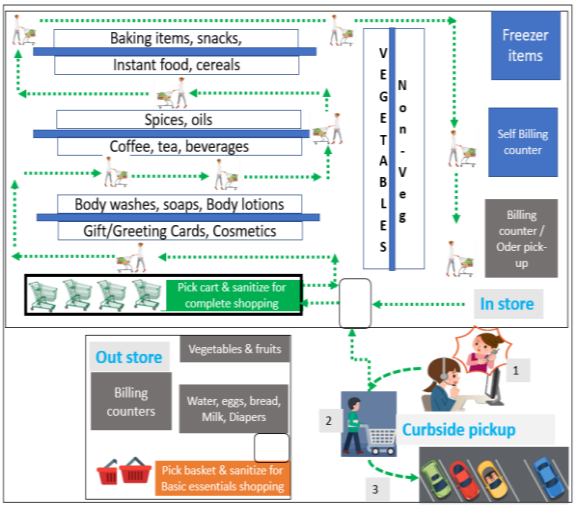


Figure 3. Modified Grocery Store Layout

The basic grocery store layout (before pandemic situation) consists of different stations with grocery items, billing counters, common entrance & exit, as shown in (**Figure 2**) here customers must enter the grocery store and pick-up the shopping cart to shop will move from one station to other station to pick up items, mostly all the customers behaviour is jockeying while billing & shopping. In this situation both customers & staff members are comfortable and don't have extra care or work to do such as more sanitization work, waiting time, more staff help and so on.

Whereas the modified layout requires few changes as explained in above assumptions to ensure the public safety. alterations like no turnback in In-store shopping, separate out-store shopping for essentials & also curb-side pickup. In detail shown (**Figure 3**), modifications are described which helps the stakeholder to get profits even during the hard time because customers often change the demand pattern due to long waits & poor-quality service. When long waiting times occur, one option may be to change the demand pattern. must wait in the queue at least with a 6 feet distance to maintain social distancing (as per WHO) [15],

The store has provided three types of shopping for the customers **1) In-store shopping 2) Out-store shopping and 3) Curbside pick-up.**

In-Store Shopping: The customers must wait in a queue line, to enter the grocery store and pick-up the shopping cart to shop. Here the store has provided tissues and hand sanitizer to wipe the cart and hands. The customer behaviour can be reneging or balking behaviour to enter the store due to a larger queue. They move from one section to the other for shopping. There will not be any turn back, but to shop the start point items must move forward to cross all ahead sections and need to come back to the start point with the same cart. At the end they go for the billing (here customers behaviour at billing counters will be jockeying) Later, the conveyor belt is cleaned for each customer after checkout.

Out-store shopping: The store has provided a separate tent house / canopy trucks arranged out of the store for shopping for minimum basic essential items like Milk, breads, Diapers, Water, Eggs. This technique helps customers to do immediate shopping outside of the store for required items and move to the billing counter provided in the tent and pay by cash or card.

Curbside pick-up / Drive thru: The store must provide curbside pick-up, for the customers to avoid entering the store for shopping. This will help the customer not to get in contact with people and can be safe. The customers can give their order to the shop over phone/e-mail and should wait at the parking lot as shown (**Figure 3**). and payment is made through on-line. As known staff members will shop for the customers and hand over the shopped items to the customers who wait at the parking lot. These curbside pick-ups not only save time but also reduce sanitization work to shopkeepers. The bottleneck stage is considered for when the peak hours are observed, where more detailed analysis is needed.

4.1 Modelling

The grocery store DES model is developed using the Simul8 software as waiting line systems become more complex, especially in the peak hours or in more demand, brief mathematical formulas in general do not exist for system performance measures. Therefore, for most waiting line systems, discrete-event simulation is often used to analyse these systems. This helps to define the system, arrival and service patterns, and other aspects of the system. Then the simulation runs similar to the behaviour of the system in existence, and the results are statistically analysed to determine system performance of the store. Based on above

considerations and **Figure 2,3** model the DES simulation trail is made for the baseline and another is modified layout the grocery store is modelled shopping the customer cannot turn back after moving to the other station.

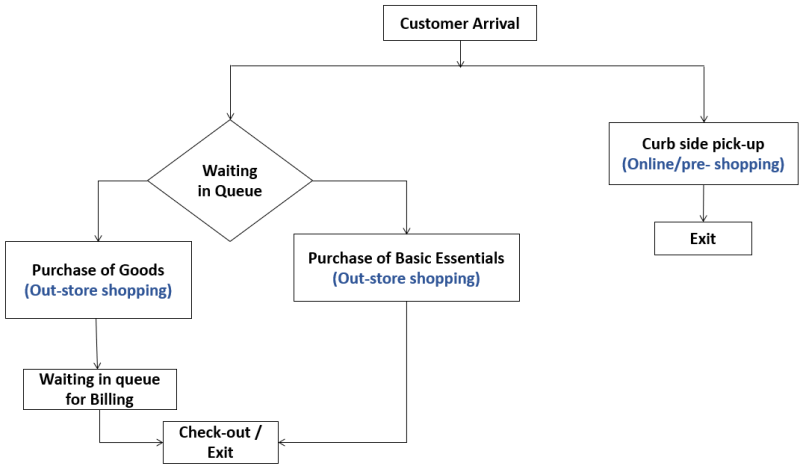


Figure 4. Flowchart

In this hard time customers make the final decision to enter the store or not as shown in **Figure 4**, Below benefits are for both stakeholder and customers with suggested modifications. Below results justify that the recommended alterations in basic layout during hard situations are good enough to obtain additional relaxations to both customer and stakeholder.

5. Simulation

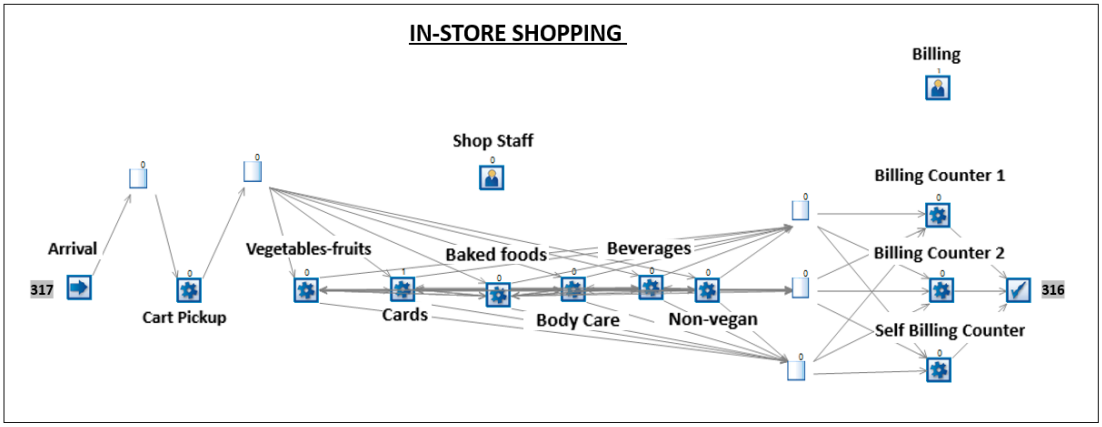


Figure 5. Grocery Layout function in Normal situation

The **Figure 5** simulation process screen shot is based on baseline model layout **Figure 2** is completed in the Process Model simulation software, the base model line (normal days situation) and the second with the recommended suggestions of layout and by queue alterations is modelled and simulated with many trails which is discussed further in the results.

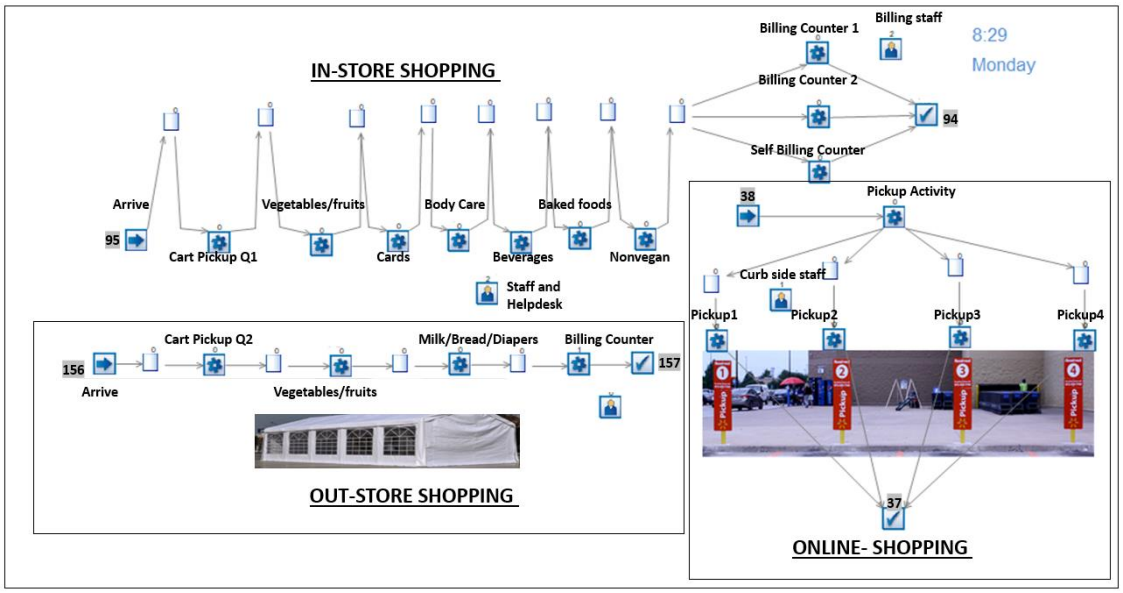


Figure 6. Grocery Layout function in complex situation

The above simulated screen shot represents the re-modelled layout & its functioning with the same 13 hours working condition which results in greater occupancy more than the baseline model.

The rate is increased as more customers can be accommodated even in the hard times. Warm up time for the model was set to 30 mins in a day. The arrival rate from simulation is checked with the real time customer's entry and average shopping time **Figure 6** shows the customer arrival from simulation, data is randomly considered according to daily shopping hours & approximate customers. This fundamentally helps to understand that grocery store management can obtain profits with customer satisfaction and comfort.

5.1 Model Elements

The grocery store DES model has model elements, or system components, that are created, like system events such as starting with customer-arrival and customer-departure. The events of grocery crew-begins-service can be a part of the logic of the arrival, fast arrival, and departure events. The events might be directly influencing the system, such as slowing down, namely number-of-customers-in-the-queue and server-status, busy or idle.

The structural components of model of this study include:

(1) Model entities: Customers and their arrival rates and timing other attributes like repetition stations, flow path, Entry and Exit.
(2) Model activities: Flow rules, serving customers in shopping and at billing counters.
(3) Model resources: Serving personnel at stations and cashiers.
(4) Queue: waiting lines at shopping stations and at billing.

6. Experiments & Results

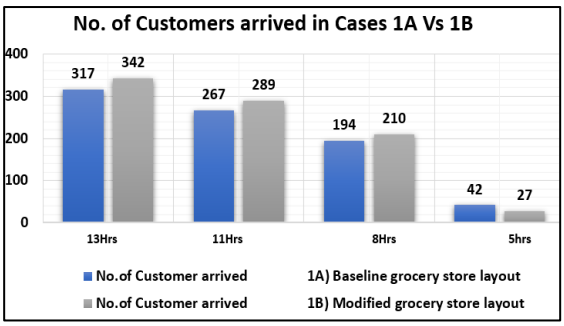
By above collected data and considering the assumptions simulation process is done with Simul8 software. Below are the measured KPI (Key Performance Indicators) results

- Number of customers entering the store.
- Number of customers waiting in the queue.
- Time taken for shopping.
- Work efficiency of resources
- Profits, revenue, and costs calculated by software.

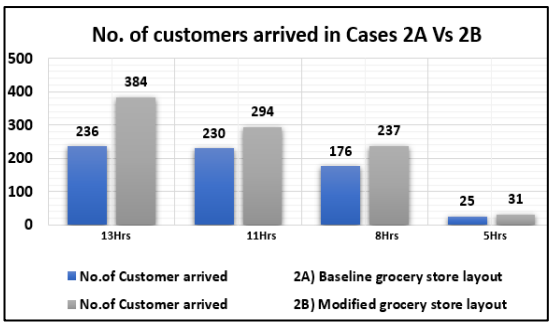
All the measured KPI's are explained more briefly with different case studies and suggestions that benefits the stakeholders in any situation as shown in

Table 2. Changes and variations considered for modelling and simulation.

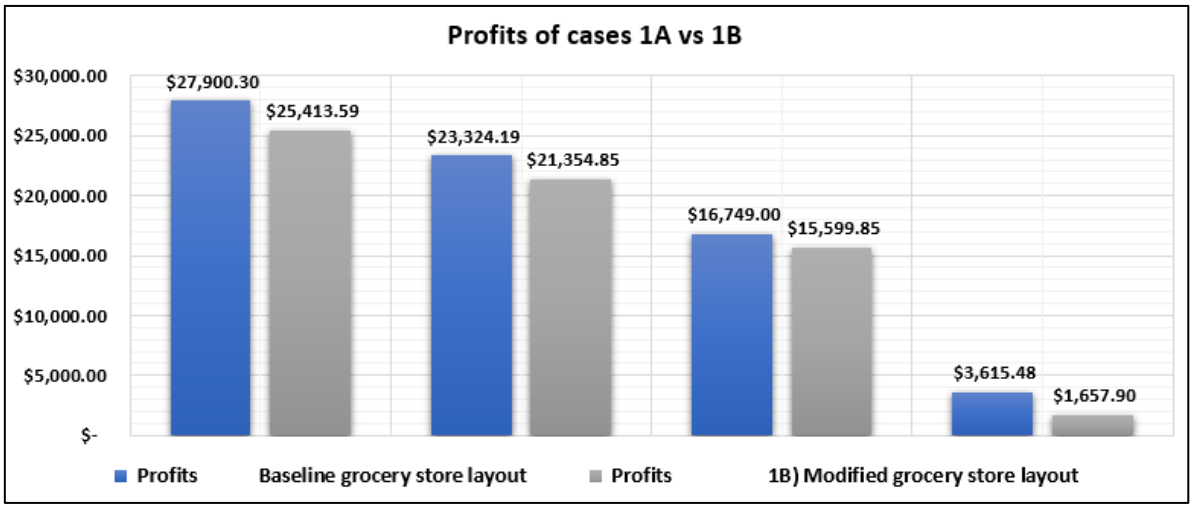
Case 1 A	A) Baseline grocery store layout								
	Change in store timings (in hours)	Working Days	customer arrival time	No.of Customer arrived	Cost (in dollars)	Revenue (in dollars)	Profits Baseline grocery store layout	No. of resources/ staff	Ways of shopping	No. of Billing counters
	13	6	10--20 mins	317	$ 3,699.70	$ 31,600.00	$ 27,900.30	3	1	3
	11	6	10--20 mins	267	$ 3,275.81	$ 26,600.00	$ 23,324.19	3	1	3
	8	6	10--20 mins	194	$ 2,650.81	$ 19,400.00	$ 16,749.00	3	1	3
	5	1	5-10 mins	42	$ 584.52	$ 4,200.00	$ 3,615.48	2	1	2
Case 1 B	B) Modified grocery store layout								
	Change in store timings (in hours)	Working Days	customer arrival time	No.of Customer arrived 1B	Cost (in dollars)	Revenue (in dollars)	Profits 1B) Modified grocery store layout	No. of resources/ staff	Ways of shopping	No. of Billing counters
	13	6	20--80 mins	342	$ 8,686.41	$ 34,100.00	$ 25,413.59	4	3	3
	11	6	20--80 mins	289	$ 7,445.15	$ 28,800.00	$ 21,354.85	4	3	3
	8	6	20--80 mins	210	$ 5,200.15	$ 20,800.00	$ 15,599.85	4	3	3
	5	1	10--35 mins	27	$ 1,042.00	$ 2,700.00	$ 1,657.90	3	2	2
Case 2 A	A) Base line grocery store layout								
	store timings (in hours)	Working Days	Change in customer arrival time	No.of Customer arrived 2A	Cost (in dollars)	Revenue (in dollars)	Profits 2A) Baseline grocery store layout	No. of resources/ staff	Ways of shopping	No. of Billing counters
	13	6	15--25 mins	236	$ 3,899.02	$ 23,500.00	$ 19,600.98	3	1	4
	11	6	15--20 mins	230	$ 3,797.46	$ 22,900.00	$ 19,102.54	3	1	4
	8	6	10--25 mins	176	$ 2,498.81	$ 17,500.00	$ 15,001.19	3	1	4
	5	1	10--15 mins	25	$ 404.87	$ 2,500.00	$ 2,095.13	2	1	3
Case 2 B	B) Modified grocery store layout								
	Store timings (in hours)	Working Days	Change in customer arrival time	No.of Customer arrived 2B	Cost (in dollars)	Revenue (in dollars)	Profits 2B) Modified grocery store layout	No. of resources/ staff	Ways of shopping	No. of Billing counters
	13	6	15--60mins	384	$ 9,168.11	$ 38,300.00	$ 29,131.89	4	3	4
	11	6	20--60mins	294	$ 7,713.77	$ 29,300.00	$ 21,586.23	4	3	4
	8	6	15--50mins	237	$ 5,836.45	$ 23,500.00	$ 17,663.55	4	3	4
	5	1	10--30mins	31	$ 1,296.16	$ 2,900.00	$ 1,603.84	3	2	3



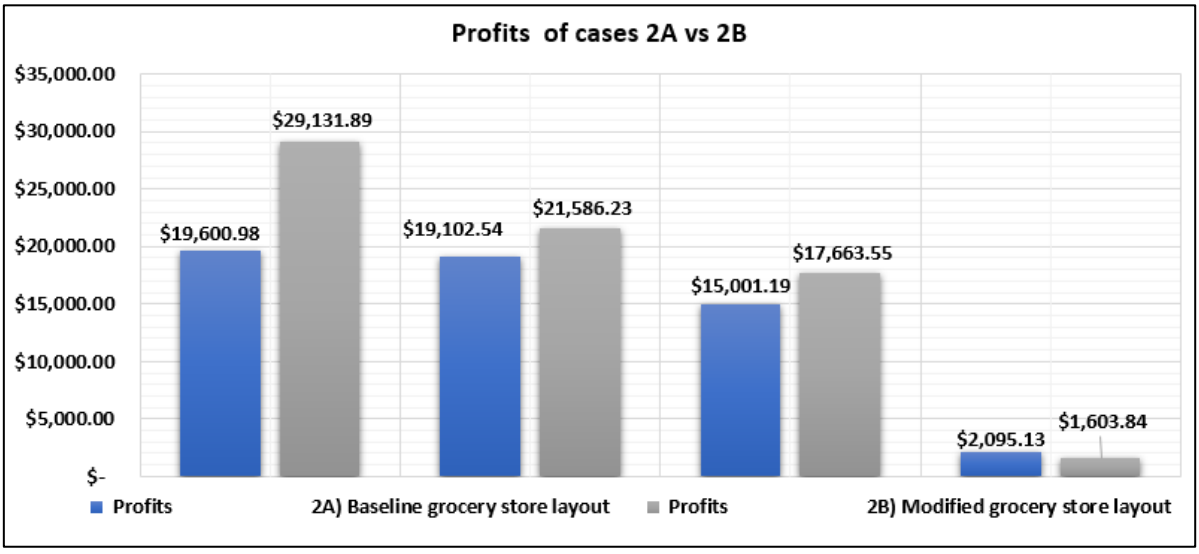
Graph 1. Customer's arrival in Case1



Graph 2. Customer's arrival in Case2



Graph 3. Profits for Case1



Graph 4. Profits for Case2

6.1 Overall experiments and results:

(1) Case 1A & 2A are baseline models whereas Case 1B & 2B are modified layout models. The only difference between A & B cases is the arrival time of customers, refer Table:1.

(2) Complex days grocery store functioning simulation process, results justify that stakeholder can get profits by arranging both out-store & curbside pick-up, because only with in-store shopping customers are accommodated very less in assumed time intervals. If stakeholders try to accommodate a greater number of customers in complex situations in short intervals as on normal days, it is difficult to maintain social distancing and also lack of sanitization. So, it is suggested to arrange additional shopping methods for profits and customer comfort.

6.2 Key common points of the four cases and discussion:

- Store timings are assumed for different intervals as 13hrs, 11hrs 8hrs for 6 working days (Monday to Saturday) and 5hrs for Sunday.
- The store layout for Base line is only one-way shopping i.e., in-store shopping whereas the store layout for Modified grocery stores has three ways of shopping a) In-store shopping b) Out-store shopping and c) Curbside pick-up, but during the weekend only two ways of shopping are open, and the curbside pick-up is closed.
- There are three Staff members.

6.3 Unique observations and discussion*:*

- The number of customers shopping varies based on arrival pattern.
- Stakeholder never meets loss in any case.

The KPI's are compared precisely in general which is understandable even to a small grocery store stakeholder based on above simulations, assumptions and results in the below table which is understandable. These profits in complex days will obtain only when suggested modifications (i.e., the out-store setup and curbside pick-up) are implemented. Due to the pandemic situation and lockdown condition many customers purchase the groceries to avoid outside food and safe home stay. So, grocery shop revenue is high even during the pandemic situation.

7. Conclusion

In any unexpected situations such as threatening diseases, or natural disasters will show a major impact on the manufacturing, logistics activities and food industry which indirectly affected the grocery stores in COVID-19 outbreak. So, few suggestions are discussed in this paper, with an action plan to stakeholders by considering the customer comfort with safety and framework to obtain good profits. Therefore, the simulation study is made with discrete-event simulation modelling for evaluation of waiting timing in complex situations of customers and stakeholders. So, this framework combines the grocery store layout, customer flow modelling and few alterations in shopping techniques to accommodate more people. So, regular shopping is recommended to be divided into three different methods for maintaining the social distance: in-store shopping, out store shopping and curbside pickup. This out store shopping helps the customer to buy immediate basic things without waiting in long queues and helps stakeholders to separate the quick shoppers from regular shoppers to accommodate more customers with necessary safety precautions. Moreover, the most common curbside pickup choice gives the extra value addition along with the out-store shopping for profits even during the hard time. Ensuring the public safety alterations in store are made like no turnback, allowing minimum shoppers in a regular interval of time and limiting the shopping time.

In addition, the benefit of calculating operational characteristics is to provide management with information to identify the required system changes which are needed for the

interactions and impact of services to the customer during peak hours. Management can change the operational performance of the waiting line system by altering any or all the following: the customer arrival rates, the number of service facilities, the number of phases, server efficiency, the priority rule, and the number of lines in the system. Based on proposed changes, management can then evaluate the expected performance of the system. Furthermore, measured, and numerical approaches can be adopted to serve more customers with safety measures and manufacturing of essential items to maintain the stock in the pandemic concerns. Our study is limited to small grocery stores, in future we may consider bigger stores.

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