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Operations Research in Food Delivery

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***Abstract*: In this paper, we discuss the use of operations research in food delivery companies and how upcoming startups can tackle various problems during the process. The transportation model identifies the source, which is the restaurant, from which the quantity of food will be delivered, and the destination, which are food delivery companies that want to expand their business by obtaining the maximum amount of quantity from restaurants that can be delivered through them to earn a profit, while restaurants can aim for cost minimization. The use of the arithmetic model helps us minimize the time, hence finding the shortest possible route for delivery. The third method, Dijkstra's algorithm is used to find the shortest path between the starting and endpoint while delivering from multiple restaurants at the same time during one order. We also look at various alternate solutions to maintain customer loyalty as consumers are likely to shift their preferences with time. However, there are no exact figures in the paper, our research is based on assumptions.**

***Keywords*: Cost minimization, Mathematical model, Food delivery companies, Transportation problem.**

1. Introduction

Online food ordering has been increasingly popular in recent years. The ease and accessibility provided by automation is one of the primary elements driving market expansion. Consumers may access a wide variety of food goods via their cellphones, with the added convenience of having it delivered to their doorsteps. It's impossible to overlook the tremendous competition in the on-demand food delivery market. Food delivery companies must priorities high-quality cuisine and service, as well as richly flavorful food delivered on time. In the face of logistical constraints, start-ups must concentrate on accessibility and affordability.

Research Paper on Operation Research in Food Delivery aims to understand the use of different techniques of OR in food delivery through which meal delivery costs can be fully optimized and cost as well as price cutting can be done to maximum efficiency to increase profits to its maximum possibility. Food delivery and rescuing is a stumbling block with various issues for start-ups such as economical routing, cost-efficient and time saving delivery and pickup junctions, fleeting of food, limited resources of transport and there is a requirement to find a solution to these in the most practical and cost-effective way.

The objective of a research paper is to understand the following:

1) Obtain knowledge from the existing research papers and implement it in our paper.
2) To recognize the various problems in the online food delivery services and to find an optimal solution for the same.
3) Using the quantitative techniques of operations research to find out how to order various restaurants at the same time.
4) Understanding the food delivery in depth using the assignment and transportation problem.
5) To learn about maintaining a loyal consumer base through the application of operations research

2. Industry Overview

By 2026, the Indian online food delivery market would have grown from US$ 4.66 billion in 2020 to US$ 21.41 billion. During the year 2020-2026, India's online food delivery industry would rise at a remarkable 28.94% CAGR. The internet meal delivery sector in India is undergoing a transformation. This market has shown great promise in recent years and has drawn significant investment.

Zomato was valued at US$ 5.4 billion with the latest investment of US$ 250 million, up from US$ 3.9 billion in December last year. Swiggy, its main competitor, is in advanced negotiations with SoftBank to invest up to US$ 450 million in the food delivery firm, valuing it at US$ 5 billion. This is one of the few industries with a double-digit compound annual growth rate. Changes in lifestyle and eating habits are driving India's internet delivery business forward. People in India are increasingly turning to ready-to-eat meals because of their hectic schedules and increased disposable money. Food delivery alternatives have grown in popularity, especially in metropolitan areas, because of being able to get it swiftly with a single click. In addition, rising digitization among millennials and a growing number of working women in India are boosting India's online meal delivery trends.

Furthermore, COVID-19 lockdowns have benefited India's online food delivery sector by satisfying the desire to dine outside. Contactless delivery services have been offered by several major businesses, including Zomato, McDonald's Corporation, and Domino's Pizza Inc.

3. Literature Review

Referring to a research paper by (Lekshmi, Rani, & Arasuraja, 2021), they have highlighted the growth of the

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India's online food sector which has happened due to the growth and development in the technology- rapid digitalization and an increase in the user base(population). To conclude, the objective was to improve the efficiency of delivery executives in the food service industry. The paper focused on the necessity of a training program and its characteristics.

Food delivery being a composite problem, several factors such as cost-effective delivery, cost effective routing, food perishability, choosing the most optimum source of transport come with it. The objective is not only identifying the most feasible, cost effective and efficient algorithm but also minimizing the wastage that takes place in the process. An operations Research paper by (Lou, Jie, & Zhang, 2020) takes two objectives into account. The first is to reduce total operational costs while considering variable productivity, which is a result of performance degradation when too many orders are issued to one rider. The second is to balance the workload among different delivery men which also helps to ensure a minimum wage for all delivery men. To acquire an optimal solution, a non-linear multi-objective optimization model is used with human factor considerations in terms of both deteriorating effect and learning effect.

Another published work by (Zhang & Chen, 2014) brings out the increase in the demand of frozen food and their delivery. They've taken into consideration a vehicle scheduling problem faced by the cold chain logistics of the frozen food delivery industry by using the optimization model that manages the delivery of variety of products to resolve the issue and get the optimal solution with the help of assumptions.

The food delivery industry is overpowered by a few well-established companies such as Zomato, Swiggy, making it challenging for the new start-ups to acquire a consumer base. The problems that the start-ups struggle with were not given adequate importance like managing customer expectations, unstable market prices, logistic issues, and customer loyalty. Choosing the best route will eliminate the extra costs which would otherwise occur on unnecessary detouring. Thus, it is our objective to find the most economical way to reach out to the ultimate consumer in the least possible time.

A non-split delivery policy using operations research will avoid any waiting time for the customer between deliveries by also reducing the number of miles travelled by a courier fleet throughout the day.

4. Methodology

The data collected by us is through the data from the secondary sources which helped us with our thorough analysis.

A. These secondary resources include

- Articles related to food industry
- Existing research papers
- Certain blogs and pieces from books

B. Tools include

The main operations research tools used here to analyze the online food delivery system is the transportation and assignment problems.

Here, we have conducted a thorough research and our analysis on the online food delivery platform, and this gives us a wider perspective on the industry.

5. Analysis

In this section, we will discuss the operations management problems in detail. More specifically, we discuss the main issues concerning related operations management problems, followed by challenges faced by new companies that want to enter the industry. We aim to analyze the competitive landscape of the food delivery market with the help of the major players operating in the market such as Zomato and Swiggy. Following points are discussed below:

A. Maintaining Customer Loyalty

Numerous new names have entered the market with various offers to attract consumers. With the number of attractive offers available in the market, the consumers are very likely to shift their loyalties among various other platforms.

Here, there is no single solution available, we need to look out for alternative solutions. This includes conducting a sequence of comparisons and selective the optimal solution possible. This is also called a heuristic solution-seeking procedure. Here, the companies can face this problem by creating a simple but compelling user interface design. An alternative solution includes the company focusing on organizing and keeping the important information above everything like advanced search options, delivery time, food items list and creating a satisfactory experience for the consumers. Another solution includes not only focusing on the consumers but also focusing on its internal staff. Consumers start trusting the company more which pays attention to its external as well as internal environment.

Another significant way to build confidence among customers is to display social proof on your website. Social proof is when someone endorses your products and shares their positive feedback about your company. After the selection of the optimal solution and the application of the same, the operational researchers are expected to oversee the implementation of the accepted solution so that if the solution requires any adjustment or modification due to a change of environment, the person can take the necessary steps.

B. Ordering food from multiple restaurants at the same time

Focusing on the multiple order feature, we formulate a solution focusing on the allocation of delivery men using Dijkstra's algorithm. This is used to find the shortest path between the start and the endpoint. It picks unvisited vertex with the lowest distance, calculates the distance through it to each unvisited neighbor, and updates the neighbor's distance if smaller. This solution will suggest how many delivery men should be allocated depending upon the number of restaurants and their distance.

The time taken for delivery will depend on:

- Distance of delivery men from the restaurant
- Distance between the restaurants
- Distance between the last restaurant and the

customer's location

Delivery men should be assigned such that one delivery man pickups all the orders within a 1.5km radius and if the restaurants are far then another man should be assigned. This is to ensure that the quality of food doesn't deteriorate and at the same time save labor energy and decreases delivery cost. The route is made such that when the delivery man picks up the order from the first restaurant and reaches the second restaurant, the food is already packed and ready.

Considering a hypothetical situation where my family and I want to order from 3 different restaurants.

- D1 (starting point) – delivery man 1
- R1, R2, R3 is 3 different restaurants
- C (endpoint) – customer's location

Let's assume the price per kilometer is Rs.20.

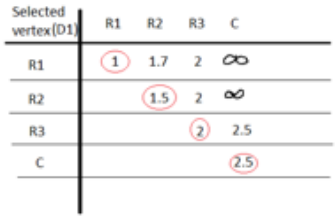

Fig. 1.

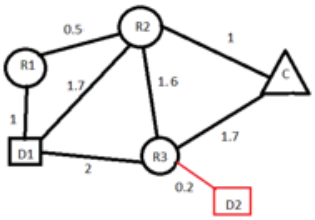

Fig. 2.

Row= selected vertex

Column= all the vertex

- Step 1: D1 being the starting point, we write down the distances to the direct next vertex and if its indirect we mark it as infinity.
- Step 2: We select the least value. In our case its 1 (R1)
- Step 3: From R1 our next direct unvisited vertex is R2. The distance from D1 to R3 through R2 is less (1.5) than the previous value of R2(1.7) and hence we note that down. Others are not directly connected to R2; hence, we write them as it is.
- Step 4: Again, we select the least value and continue the same method till the end.

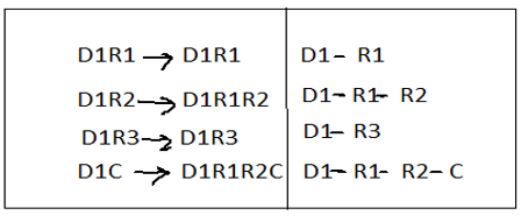

Fig. 3.

The shortest route is D1-R1-R2-C

- Step 1: To derive the route D1-C, starting from the bottom of C column(cc) we go upwards till we reach a changed/new value (infinity).
- Step 2: We go to the circled value of that row (1.5)
- Step 3: Repeating steps 1 and 2 we reach at cell r1r1 (1).
- Step 4: We first write D1 as its our starting point. Then, we write the column names of each allocated cell that we stopped at in a reverse manner. Hence our next stop is R1 (from step 3) and then R2 (from step 2) and finally C being our last stop

Now, the company assigns driver 1 (D1) who is closest to restaurant 1 (R1) moving towards restaurant 2 (R2) and reaching the destination (C) covering the shortest route. Order from restaurant 2 (R2) was picked up by delivery man 2(D2) as it could not be covered by D1.

The total distance being 4.4kms (Rs. 88)

If only one delivery man was assigned the distance travelled would have increased, more time would've taken, and the food would've gotten cold. (4.8 kms = Rs.96)

If 3 delivery men were to be assigned each restaurant, there would be unnecessary use of labor, delivery cost and distance travelled increases. (Around 5.4kms = Rs. 108)

C. Using Transportation and assignment problems in the food delivery industry

A transportation problem is a type of linear programming problem designed to minimize the cost of distributing a product from point A to point B. The main objective of the assignment problem is to assign several resources to an equal number of activities to minimize total cost or maximize the total profit of allocation.

Here, the transportation problem and assignment problem help both restaurant as well as food delivery companies, it helps the restaurant by cutting their delivery cost making fast deliveries and it helps the food delivery companies choosing the least cost and faster routes which also makes customers happy and increases the companies' and industries customer loyalty.

The calculations are based on assumptions that may differ. Sometimes the demand may not be equal to the supply, leading to unbalanced equation.

1) Transportation problem

Here we are using VAM's method as it helps us in calculating the initial feasible solution of the transportation problem.

Step-1: Aggregate demand is equal to aggregate supply. Here, the transportation problem is balanced.

	Zomato	**Swiggy**	**Uber eats**	**Supply**
Branch 1	11	13	12	150
Branch 2	8	10	9	200
Branch 3	9	12	11	275
Branch 4	14	7	6	125
Demand	250	300	200	750

Step-2: Finding Initial basic feasible solution (IBFS) by using VAM's method.

	Zomato	Food Panda	Uber eats	Supply	I(1)	I(2)	I(3)	I(4)
Branch 1	11	100 13	50 12	150-100-50=0	12-11=1	1	1	1
Branch 2	8	200 10	9	200-200=0	9-8=1	1	1	
Branch 3	250 9	12	25 11	275-250 25=0	11-9=2	2	1	1
Branch 4	14	7	125 6	125-125=0	7-6=1			
Demand	250-250=0	300-200-100=0	200-125-75=0	750				
I(1)	9-8=1	10-7=3	9-6=3					
I(2)	1	2	2					
I(3)		2	2					
I(4)		1	1					

Total cost = 6*125+9*250+10*200+13*100+12*50+11*25=7175

2) Assignment problem

There are four delivery boys in a food delivery company's database. All four different customers have placed orders. With the help of the assignment problem, we will choose which delivery boy should be chosen to deliver each order, so that the delivery of the food is done in the least possible time.

STEP 1: The given assignment problem is balanced because no. of rows is equal to no. of columns.

		Time (minutes)		
Delivery boys	order 1	order 2	order 3	order 4
1	12	16	15	12
2	17	13	10	12
3	8	15	8	16
4	12	14	17	16

STEP 2: This includes subtracting minimum time in each row from all amounts in the row (Row Minima).

		Time (minutes)		
Delivery boys	order 1	order 2	order 3	order 4
1	0	4	3	0
2	7	3	0	2
3	0	7	0	8
4	0	2	5	4

STEP 3: This includes subtracting minimum time in each column from all amounts in the row (column Minima).

		Time (minutes)		
Delivery boys	order 1	order 2	order 3	order 4
1	0	2	3	0
2	7	1	0	2
3	0	5	0	8
4	0	0	5	4

STEP 4: In this step, we allocate the orders to find out a proper optimal solution of No. of allocations being equal to the order of AP.

		Time (minutes)		
Delivery boys	order 1	order 2	order 3	order 4
1	0	2	3	0
2	7	1	0	2
3	0	5	0	8
4	0	0	5	4

STEP 5: Allocate each delivery boy with each order number.

Delivery boys	Order no.	Time
1	4	12
2	3	10
3	1	8
4	2	14
	minimum time	44

The most efficient time to deliver all orders is 44 minutes.

6. Conclusion

Through our research we studied about the methods to improvise the food delivering system, due to COVID 19 there has been a rise in demand of food ordering through which consumers get the food at their doorsteps. Some issues faced by the consumers are they don't get food on time, Cost problems and multiple pick-up issues so using operational research we have solved these problems using three methods, so to minimize the time we have to minimize the distance which we have done through transportation problem which gives a proper way to deliver food on time. Second comes the problem of achieving the minimum cost, for this we have used assignment problem which helps us to have the minimum cost of order and the last is multiple pick-up problem, we have seen that no delivery app allows to order from multiple restaurants at the

same time so for this problem we have used Dijkstra's algorithm which allows us to order from different restaurants and gives an optimal route. So other than the quantitative techniques, a qualitative aspect has been included to create a loyal consumer base. The method of heuristic solution-seeking procedure helps to cover all possible solutions implementable and grow with efficient alternative solutions. Today, to survive in this increasing competition, we need to think out of the box, different from the rivals. Thus, it is very important to look for alternative solutions and find the optimal solutions.

7. Limitations and Recommendations

1. Dijkstra's algorithm performs an obscured exploration that consumes a lot of time while processing. The complexity that's included might give its competitors and advantage and an opportunity to over power.
2. Loyalty program data typically provides a skewed picture of clients' general purchasing habits. The data may not be accurate.
3. The scope of the research paper is limited as the analysis is done using assumptions and not actual data.
4. Since secondary resources are being used, the authenticity of information on the internet is not completely reliable.
5. The use of transportation problem is based on certain assumptions like fixed quantities and only a few parties involved which may not hold true in real life thus making the decision making and the problem more complex.

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