Operations research in food delivery

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ABSTRACT

In this paper, we explore the use of Operations Research in food delivery companies and how restaurants can choose between emerging food delivery companies using Transportation problems. The model used identifies the source that is the restaurant from where the quantity of food will be delivered to the destination that are the food delivery companies that want to grow their business by getting maximum amount of quantity from restaurants that can be delivered through them so that they can earn their profit and the restaurants can aim for cost minimization. The creation and use of a mathematical model helps in understanding the logical and systematic process and approach that can be used by food deliveries and business to make a decision regarding the decision of distribution. However as there are no exact figures used in this paper, this just gives an overview of how transportation modelling can be used in the decision making of the food delivery companies and restaurants.

Keywords— Food delivery companies, Cost minimization, Mathematical model, Transportation problem

1. INTRODUCTION

With the increasing change in trend and fashion in today’s world, Food has become one of the important elements used to define one’s lifestyle and standards. In ancient times, food was only a source of energy and living. But now, deciding ‘what to eat’ is a very essential part of a person’s daily routine. Alongside the changing needs and wants of people, the food industry has grown tremendously. Every city has multiple food joints, cafes, and restaurants which offer a variety of menu to serve their customers. Cuisines from all over the world are being served at a single place. The presentation of food also matters while the quality of food is now a big challenge to the food industry with a growing awareness of health and fitness.

All of this has led to immense competition among the food producers. Producers are competing by price cutting, cost-cutting, improvement in quality, better ambience and better service. Price Cutting is essential to increase demand of a particular product over its competitor’s product. Cost cutting is done through the efficient use of raw material and decreasing production cost and transportation cost. Need for better service has led to the formation of a new service industry known as food delivery. (Whitten, 2018)

Food Delivery: Worldwide, the market for food delivery stands at €83 billion, or 1% of the total food market and 4% of food sold through restaurants and fast-food chains. (Mckinsey, 2016) People today want food right at their doorstep without having to step out of the house. Therefore the service of delivering food from any place to any other place was formed. This has given rise to some very popular Start-Ups like Zomato, Swiggy and Uber Eats. These websites or Apps offer a direct comparison between the prices and rating of different restaurants serving the same dishes and allows you to make a choice based on these options. The restaurants compensate these firms by a particular margin for every dish ordered from their restaurants from these websites. In spite of the high traveling and vehicle costs, these delivery companies are making profits up to 30% (Mckinsey, 2016) Also, other services which involve supplying other cooking essentials like vegetables and fruits at your doorstep have been locally started by various people. India's online food ordering sector has grown around 15% on a quarterly basis from January to September last year, according to a report from RedSeer Consulting. (Peermohamed, 2018)

“It is becoming increasingly clear that food tech is more and more of a logistics play, restaurant discovery is not a deep competitive advantage. There are clear trends on customer and seller satisfaction supported by the better delivery speed and compliance that vouch for the superiority of the captive delivery model in the Indian market,” said Anil Kumar, founder, and chief executive officer, RedSeer. (Peermohamed, 2018)

Operations Research (OR) is an analytical method of solving problems and decision-making that is useful in various organizations from the management perspective. In operations research, problems are broken down into basic components and then solved in defined steps by a proper mathematical analysis. As far as the Food Industry is concerned, OR is very helpful in solving transportation problems by finding the least expensive and the fastest route to deliver food and raw material which will further help in reducing production cost. (Rouse, 2011)
The objective of a research paper is to find the answers to the following questions:

1. How can operations research be used in the food industry in solving the following problems:
   (i) Transportation problem: We will be using the model building to understand how transportation cost can be minimized while delivering food from the restaurant’s kitchen to the customer. It will also help us derive the route to be chosen for the delivery so as to decrease the delivery time.
   (ii) LPP: we will discuss how linear programming can be used to arrive at the maximum profit. By deciding how much to produce. This can be determined through ISO Proffer and ISO Cost lines
   (iii) As everything is based on assumptions random number generation has been used to predict future demand and supply. As there can not be an optimal solution to the problem, our model is based on simulation.
   (iv) We will also be discussing the network analysis problem as a network of food delivery change is being built.

2. The scope and limitations of these problems and methods mentioned above.
3. Analyzing how the research can help restaurants as well as the food delivery companies at the same time.

2. INDUSTRY OVERVIEW

As of today, 2018, names like Swiggy, Foodpanda, Zomato, Uber Eats have created their importance in the Indian sustainable ecosystem. Had this same statement been made in 2010, it would have sounded too whacky an idea for startups like this to even sustain. There wasn’t even much of any statistical evidence, but yet the Indian market evolved an industry, today is known as the food delivery industry. (Kashyap, 2017)

All of this is supported today with statistical and mathematical evidence, with figures like the (Yoy) Year on year growth rate, revenue, expected revenue, market volume, and global comparisons among the many others available. As of today, the food delivery industry earns an annual revenue of US$ 7120m. Observing the previous years’ trends, this industry has a revenue (Yoy) Year on year growth of around 20%. Till 2022, there is an expected average revenue growth rate of 11.8%. (Online Food Delivery, 2018) The Online Food Delivery Industry can be very basically defined as connecting the end-consumer and Restaurants or food-chains, i.e. food that was ordered online for direct consumption. The eServices segment of online food delivery for prepared meals can be categorized into the following: (i) Restaurant-to-consumer Delivery and (ii) Platform-to-consumer Delivery. Revenue includes those that are earned through the online platform. The restaurant-to-consumer segment includes the services provided by restaurants or food-chains to deliver directly from their respective online platforms. As per the Indian marketplace, the restaurant-to-consumer platform mainly includes the Fast Food restaurants and a few other food-chains. Dominos, McDonald's, Faasos have been some of the early market movers of this particular segment. The platform-to-consumer delivery market segment includes those online platforms which deliver ready food from the maker to the consumer. There has been a significant presence of startups in this segment of the market. Swiggy and Foodpanda being amongst the first movers, competition has grown to Zomato and now Uber Eats as well. (Bureau, 2018)

Over the years, significant developments have been made in this field. Startups have been pumping a lot of capital as well. Several promotion offers have been running on these online giants. Dominos as an example, have online offers like special Tuesdays, the weekend offers among the many few which are only promoted for online orders. Zomato orders also gaining a lot of public with the offers they provide which include discounts on online orders. Foodpanda also having deals like desserts @₹9 and quite a few others. The internet is the heart of these food delivery sources, ordering is usually done through the internet website on a computer and mainly, app-based orders. Ordering food in India had never been so easy, now available at the fingertips. The online food ordering industry has grown a lot over a couple of years and is expected to grow a lot in the coming years as well. The demand for food, along with the population demographics of a young nation, the younger generation has never been so connected to the internet.

The online food ordering industry has almost penetrated every metropolitan city in India ranging for Delhi in the north to Chennai in the south. From the point of the Internet of Things, this industry has proven itself in countries like China and America. In a developing nation like India, this industry has done wonders and is yet going to do wonders, with respect to providing ease, the growth of GDP, providing employment, and convenience among the many benefits.

3. LITERATURE REVIEW

Food delivery and rescuing is a complex problem with various aspects such as cost-effective routing, cost-effective delivery and pickup nodes, perishability of food, limited transport resources and there is a need to identify feasible as well as efficient solution methods to solve them. Forecasting models are proposed for handling uncertainty in donation of food products in respect to food rescuing, efficient and cost-effective algorithm through allocation and routing problems that aims at identifying optimal solutions and near-optimal solutions by identifying routes that minimize operation costs and accounting for perishability of products. The objective is not only to identify an optimal schedule but also account for the frequency of underruns and overruns and minimize wastages of resources. Recent studies focus on optimizing collection with delivery schedules for food relief organizations. The location routing problem is ideal for food banks as concluded. The Periodic unpaired pickup and delivery vehicle routing problem is a planning problem for designing routes for each day of the planning horizon and is extensively used. The Traveling Salesman Problem (TSP) is used in the delivery of milk and eggs, transportation of sand, vaccines, and gas. They propose the use of integer linear programming formulations along with an enumerative branch to solve optimality conditions for up to 40 customers. The variant of VRP is PDVRP which consists of two subclasses- first being when the products are associated with one another and there is a pair formed between delivery and pick up customers and second when the pair is not formed. An approach based on the greedy algorithm improved with a k-optimality criterion is also suggested. Various algorithms used are GRASP, IMSA, and VNS. The method developed was an initial schedule and feasible schedules were generated through linear programming and a local search on point move operator. The initial solution is created by minimizing the maximum difference in pickup and delivery demand serviced per day during a particular planning period. While creating an initial solution, different phases are present- creating a pre-processing
stage which sorts the customer nodes placed at various angles and a rotating virtual ray is centered there. The second phase is the iterative process and the main idea is to generate k’ which implies the number of vehicles available. The feasibility conditions include: the total duration of the vehicle route mustn’t exceed the maximum tour duration, the load must be a non-negative value, the amount of perishable product delivered is within the upper and lower bounds and the load must be greater than the delivery request. In case of the food rescue network, various OR models like SEM, ANN, FFNN, GRNN has been used. This paper addressed the concerns of food delivery through optimal routes matching daily demand and supply. (D.J. Nair, 2017)

In this research paper quantitative operations management in food delivery and distribution are reviewed and the challenges with the industry. Decisions on three levels are discussed: strategic network design, tactical network planning, and operational transportation planning. Transportation planning is a short-term planning of distribution of actual customer orders including the loading and routing of vehicles. A study by Zhang in food delivery by penalty function in the objective function or as a constraint to limit the degradation has been highlighted. Nearly two-thirds of the world’s logistics cost accounts for transportation planning in food delivery. It is highly dynamic and frequent reconsidertations take place. The typical decisions include the sequence of orders, which vehicle, delivery routes and exact time of delivery. Vehicle Routing Problem (VRP) is extensively used including delivery time windows. Binary decision variables are used in the formulation. The objective is to minimize the total duration of routes and the total distance traveled with the minimization of the total vehicles used for the food deliveries. The food deliveries also take into account the time difference between rush and no rush hours, vehicle capacity and refrigeration capabilities. (Renzo Akkerman, 2010)

An important application of linear programming, physical distribution delivery of goods. (Sharma, 2016) Transportation problem is devised to deal with the transportation of goods from different sources to different destinations having relevant data like available quantities at various sources and demand at each destination along with the cost of shipping at each route and non-availability of certain resources (Vohra, 2010) In food delivery, Vehicle routing problems are solved which is used to serve various customers through a fleet of customers (Bruce Golden, 2008) during this process infeasible solutions are allowed as the algorithm considers various adjacent routes (Madeleine E Pullman, 2010)

4. METHODOLOGY
The data will be collected through secondary research as the nature of the research does not lend itself to primary sources. Through secondary research, we will identify the application of Operations Research in Food delivery industry and its advantages and uses to the restaurants that are considering to do home delivery and the food delivery companies.

4.1 Sources of secondary research
- Previously published Research Papers
- Articles
- Blogs
- Book

4.2 Tools used
Use of transportation problem to analyse how a restaurant can choose between different food delivery companies so that their cost is minimized.

4.3 Analysis
In this paper, we will study the role operation research plays in food delivery business. Consumers, nowadays want convenience as well as different options for food being delivered at their doorsteps. To satisfy that demand and to increase their customer base as well as profits mostly all restaurants and cafes have started delivery of food.

The delivery can be through 2 ways either the restaurant itself introduces a new supply chain through which they introduce the option of home delivery with heir workers going to delivering the food to customers or the way that is being widely used is through third parties. There are third party delivery companies like Zomato, Swiggy, Uber Eats that have emerged and are helping that business that doesn't have the resources available to built in-house fleet. So this is a quick and efficient solution for the restaurants.

"The transportation problem is a special type of linear programming problem where the objective is to minimize the cost of distributing a product from a number of sources or origins to a number of destinations", (Vishal Pandey) The structure of transportation problem allows a complex problem with many constraints and variables to be solved faster and with a more economical algorithm.

The transportation problem deals with the transportation of the goods to different markets on the basis of the requirement of the markets (demand) and quantity that the business can send to the market (supply). "A typical transportation problem is like this: A matrix is given where sources are given row wise, destinations are indicated column wise and unit cost of transportation from each source and demand at every market". (Vohra, 2010)

Transportation problems are solved only if the supply is equal to demand, that is that they are balanced, if it isn't balanced the problem can't be solved and to solve it a dummy source or destination will have to be added. We will be using a transportation problem to understand how restaurants can choose between different delivery companies to minimize their cost and deliver the food to the customers.

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4.4 Model building
Considering a restaurant for our analysis as XYZ Ltd, XYZ Ltd. is a restaurant with 5 branches in Mumbai, which don't have the option of food delivery. But with the growing demand of customers to have food at their own convenience and at home so the business decided to start food delivery through food delivery companies. Each branch has the option to send deliveries out through different available third-party delivery companies that charge a price to the business and carry out the task of transporting the food at the customer's chosen address.

For the application of transportation problem in this industry, we will set some assumptions. The first assumption is that there is a set limit of food items that are available for home delivery from each branch, which will be the supply by the business. Each branch cannot exceed the set supply as other food items are only available at the restaurant for dine-in purpose or takeaway. The second assumption is that each food delivery company has set targets from each branch. They can only deliver a fixed quantity of food from each branch to customers. This will be the demand for food delivery companies.

The other assumptions with respect to the model of transportation can be made:
- To find the most cost-effective and profitable route, only one restaurant is compared to the available food delivery applications
- The restaurant must have one or multiple outlets/franchises
- More than one food delivery method must be available to the given restaurant.
- The outlets/franchises of restaurants must be widespread.
- Outlets of close proximation also should be included. For eg. An individual who stays in Worli and has the option of food outlets from Lower Parel and Prabhadevi. Using Transportation Problem, the most effective cost problems can be solved.

So the matrix is that there are 5 branches and 4 food delivery companies that the business has chosen for the delivery of food. Assuming the 4 food delivery companies to be Swiggy, Uber Eats, Zomato and Food Panda.

Now the business after deciding the food delivery companies will have to see how much quantity each branch (source) will send to each company (destinations) depending upon the unit cost of transporting from each source to each destination.

**Step 1:** Will be to make the demand equal to the supply, that whatever the 5 branches are supplying has to be equal to demand of the food delivery companies. If they don't match then the problem is unbalanced and cannot be solved further. So to make it balanced a dummy source (if demand is more than supply) and dummy destination (if supply is more than the demand) will have to be introduced.

**Step 2:** Finding the initial solution through Vogel's Approximation Method (VAM). "VAM is an iterative procedure calculated to find out the initial feasible solution of the transportation problem". (Business Jargons) VAM considers the opportunity cost between the two least cost and allocations are then made. The matrix will look like this:

<table>
<thead>
<tr>
<th>Table 1: Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources</td>
</tr>
<tr>
<td>Supply s_1</td>
</tr>
<tr>
<td>Supply s_2</td>
</tr>
<tr>
<td>Supply s_n</td>
</tr>
<tr>
<td>Costs c ij</td>
</tr>
</tbody>
</table>

\[ \sum a_i = \sum b_j \]

\[ \text{Demand} = \text{Supply} \]

Balanced

\[ C_{ij} \] shows the cost of transporting 1 unit from each branch to the food delivery companies.

\[ a_i \] shows the quantity that can be supplied by each branch.

\[ b_j \] shows the quantity that is required by each of the food delivery company

(Transportation Problem, 2015)
Through VAM now the difference between the minimum cost values of each row and column will be determined. The largest cost difference will be selected and in that row or column whatever is selected the allocation will be made to the least cost cell. After the allocation, the quantity allocated will be subtracted from the demand and supply and if it satisfies the demand or supply fully then the row or column will be deleted. The process will be repeated until the whole quantity that is supplied by the branches is equal to the demand of the delivery companies.

This way XYZ Ltd can determine through which delivery company they can send the maximum quantity of food at the least cost and through which branch.

**Step 3:** To determine whether the allocations made are optimal and least cost by the business is achieved or not the optimality is tested. It will help determine if there are other solutions available that can further help the business in reducing the cost. Optimality is checked through $U_i$'s and $V_j$'s value which is the breakup of the cost per unit. After the calculation of $U_i$ and $V_j$ value, $\Delta_{ij}$ is determined which is $\Delta_{ij}=U_i+V_j-C_{ij}$. So if for all cells $\Delta_{ij}$ is less than 0 then the solution is optimal and this is the least cost which the business will incur and if not the solution can be improved through MODI method which is creating loops and changing allocations to reach to the minimum cost for the business. Also if $\Delta_{ij}$ is equal to 0, then there will be an alternative solution that is chosen.

In our example, the cost per unit of transporting through the different delivery company will be given by the delivery business. From that cost, the manager can determine that from which branch to which delivery company it is cheaper to send how much of quantity that is available for delivery. Use of modeling and using this method will help the business determine the least cost and act accordingly rather than choosing only one food delivery company which may have higher cost or which may not be able to deliver the set target of deliveries that the business wants per day. Therefore, through the use of transportation problem, it will be easier for XYZ Ltd. to choose between different suppliers and likewise the food delivery companies can make use of transportation problems to choose between the many different restaurants that want to delivery through their company and then charge prices for delivery and quantities to be delivered accordingly.

5. CONCLUSION

There is a rise in demand of food being delivered at the doorstep of consumers and looking at this opportunity many businesses are tapping this market and thus many food delivery companies are emerging and eventually the competition between them is increasing. Increased competition means that these companies try to offer minimum cost and more benefits to the restaurants so that the restaurants choose that particular delivery company for food delivering.

For restaurants and cafes also, the consumer base will increase if they start food delivery because they will be to serve more consumers and also those regular customers that may not visit the restaurant every day. Moreover choosing a third party food delivery company will be more beneficial rather than the business itself starting to deliver because the cost of hiring people for delivery, managing them and arrangement of vehicles will add to the cost.

From the above analysis and research, we can conclude that operations research can be used by the business to determine how they can decide between different food delivery companies to minimize the cost and earn greater profit margins and how food delivery companies can compete by offering low cost per unit to get maximum food delivered through their company. The use of modelling, in this case, use of transportation problem, can be very useful for the business to determine the alternative options that the business has while deciding on the quantity of food to be delivered by one particular food delivery company. Also, modelling saves cost compared to the costs that would incur if different alternative solutions are implemented in real life. So the manager has the option of considering all the costs offered by different food delivery companies and then determining the solution that will minimize the cost and if the food delivery company changes the cost or the quantities are changed so rather than disrupting the whole system, use of transportation problem can help in determining the other best solution for the business. (Kavitha Chetana Didugu, 2017)

The aim of this paper was to analyse how operations research can be applied in food delivery industry, especially by demonstrating the transportation of the food from restaurants to the delivery companies and how decisions on that basis can be made. We have proposed a small problem with certain assumptions and how the application of transportation problem can be applied in that problem so that business can achieve its cost minimization objective. However due to lack of quantitative data available the figures of how much cost will be minimized and what quantity will be sold cannot be determined and thus further analysis is required to decide whether this model is helpful for the business or not and its impacts.

6. LIMITATIONS OF THE RESEARCH

- Due to lack of accurate primary data, secondary sources of information used as a medium to collect information thus findings maybe influenced by conclusions of previous research papers.
- Since secondary resources are being used, the authenticity of information on the internet is questionable. Consideration of resources chosen is thus imperative
- While factual figures or representation of certain documents may be reliable, different sources may present varying information on the same topic.
- The analysis is done using assumptions and the mathematical model prepared is not with actual data thus the scope of the research paper is limited.
- Chances of attribution, exaggeration in prior research studies.
- Biases played into the conclusions of previous research papers forming our source for data.
- 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.
7. REFERENCES


