

APPLICATION OF OPERATIONS RESEARCH IN E-COMMERCE TO MAKE DELIVERY MORE EFFICIENT & ECO-FRIENDLY

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Abstract

The Corona Virus 19 pandemic caused great havoc in the world and the entire planet came to a standstill. Economies crashed, jobs were lost and the disease caused several deaths worldwide. The sustainable development agenda set by the United Nations for the year 2030 also got disrupted. The thirteenth goal mentioned by the United Nations aims at climate action. During this pandemic most of the world relied on ecommerce websites to help them purchase items of necessities. Through this research paper we have tried to make the processes carried out by ecommerce delivery companies more efficient and eco-friendlier. We use methods such as the Vogel's approximation method, vehicle routing problem (CVRP) and Economic Order Quantity (EOQ) to make deliveries efficient and better for the environment.

Keywords

Vogel Approximation Method (VAM), Advanced Distribution Management Systems (ADMS), Logistics, Freight, Last mile

Introduction

The e-commerce sector is one of the fastest and largest growing sectors in the whole world. In 2021, the worldwide eCommerce industry is estimated to reach \$4.89 trillion. During the pandemic, most of the world relied on e-commerce to deliver various necessities items in a safe way. Estimates from Data analytics company GlobalData suggests that the e-commerce sales will grow 18% CAGR (compound annual growth rate) to reach \$120.1 billion by 2025. The growth is attributed to multiple reasons such as increasing affordability, internet penetration and literacy in Tier 2 and Tier 3 cities in India, that comprise two-thirds of the demand. To satisfy this demand, businesses need to ensure how to deliver the products in an efficient and cost-effective manner. This is where Operations Research comes into play.

Operations research is a form of study which uses advanced analytical methods to improve decision making. Techniques of operations research can be used to make various segments of e-commerce more efficient and ecofriendly. Through this detailed study, we have used multiple operations research techniques such as Advanced Distribution Management System (ADMS) the Vogel Approximation Method (VAM), which is

an iterative process to identify the initial feasible solution to the problem of transport. Another model that can be useful is the capacitated vehicle routing problem (CVRP) created by Dantzig and Ramser. Basic CVPR can be described as a vehicle with a total capacity of Q and a starting depot from which various deliveries go out.

The activities related to the delivery of shipments to private customer households, i.e., last-mile delivery is a hot topic in cities all over the world due to increase in volume of mega-trends-urbanisation and e-commerce activities. But this delivery method has given rise to certain problems such as congestion of city roads and burdening of existing infrastructure. Moreover, they even have harmful impact on the health and environment. The traditional attended home delivery by delivery vans is not much cost effective as well. Apart from all these physical issues, even time pressure has increased due to the rise in parcel volumes triggered by increase in e-commerce activities. The logistics service mode selection is one of the effective methods to solve the problems of last mile delivery by taking into consideration customer utility and delivery service cost. This technique for logistics service mode selection for last mile delivery is based on a “utility-cost” two-dimensional decision matrix

model by evaluating direct delivery mode, indirect delivery mode, and combination delivery mode.

Inventory refers to the goods and materials a company holds with the intention of selling, it is a common problem from organizations to determine the level of inventory to be maintained. Inventory management goals often minimize the problem whether it is more lucrative to accomplish something quickly but more expensive or gradually but less expensive. Economic Order Quantity (EOQ) model is one such approach that can guarantee the appropriate quantity of inventory is ordered every batch. The idea behind EOQ is that inventory management is confronted with a collection of competing expenses. Through this paper we aim to bridge the gap where easy to understand research papers are unavailable for under graduate students.

Literature Review

The ecommerce sector in itself has various segments where operation research can prove to be very useful in solving various problems out of which the first one is efficient freight transportation. The study *Freight Transportation Service Procurement: A literature review and future research opportunities in Omnichannel E-*

commerce (Ballot, Lafkihi, & Pan, 2019) they assessed the opportunities and challenges of freight transportation and procurement mechanisms in the industry of e-commerce. The importance of freight transportation has been magnified by the upsurge of E-commerce, particularly offline to offline (O2O) business strategies. In order to become competitive, logistics specialists have focused on enhancing customer fulfilment and satisfaction in the form of quick delivery through various distribution channels. The frequent shipments with short time frames and fluctuating volumes that come with this strategy have led to an inevitable spike in transportation costs. As per Collignon (2016), freight transportation is the largest logistics costs for most shippers and can reach up to 60% of a firm's total logistics cost. The inefficiency of freight transportation has led to economic, social and environmental unsustainability. The aim is to optimize freight transportation to simultaneously reduce logistic costs and negative social and environmental externalities.

Inefficiency of freight transportation has led to Econ, social and environment unsustainability, of which air pollution is one of the largest negative externalities. The authors through their study

titled Green Transportation and the Role of Operation Research (Khodakaram Salimifard*, 2012) have excellently studied how operation research is important and has been used to solve the problems of pollution caused during transportation. In this research paper the authors have mentioned that the environment can never get cleaner till the transportation sector reduces its emissions of CO₂. They said that OR techniques are relatively new to this sector and have a long way to go but they have already been used to deploy cleaner sources of energy in various countries. They used vehicle routing and supply chain reengineering using OR to solve the problem of pollution in transportation. Vehicle routing and scheduling problem (VRSP) is a common OR problem. Since the formulation of capacitated vehicle routing problem (CVRP) by Dantzig and Ramser. Basic CVRP can be described as a vehicle with a total capacity of Q and a starting depot from which various deliveries go out. According to the OR research the weight of the deliveries should not exceed the capacity Q for optimal cost reduction. This method of vehicle routing and OR has been able to reduce the distance travelled by delivery vehicles thereby reducing the CO₂ emissions. In their study Pollution Routing Problem - (Bektaş & Laporte, 2011) developed PRP not as a regular

solution for CVRP but took under consideration various factors such as distance travelled, emission of various other greenhouse gases. To make their solutions more practical they also involved the cost factor that would be needed to solve these problems. They shed light on various topics such as the trade-offs between various constraints like load of the vehicle, speed of the vehicle and total cost. They aim to provide an economically – environmentally feasible solution.

One of the segments in which operation research can be proven useful is inventory management. Inventory management efficiency has been a key problem in the corporate world in recent years. Turning cash into inventory is simple; the problem is turning inventory back into cash. As per the study of *Inventory Management Challenges for B2C E-Commerce Retailers* (Harish Patila, 2014) of the National University at Costa Mesa and Basel Hamdan of Argosy University on "E-commerce and Inventory Management," online merchants must account for stockouts and act accordingly to avoid losing sales or consumers.

A B2C E-commerce company faces many inventory management challenges such as demand fluctuations, inconsistent tracking, overstocking, inventory loss, limited visibility,

poor production planning, etc, which can be caused due to seasonality or product popularity, stockouts, reverse logistics, and many more. Due to these difficulties, an online store is more likely to lose sales and consumers. Inventory is a constantly changing physical asset that the firm sells or has as dead stock. It clears the way for the production process if there is a scarcity, and it also provides extra even after the production is completed. Demand and acquisition cost are the most frequent characteristics to be regarded as fuzzy variables. Fuzzy set theory is one of the appropriate methods of operation research which can be used in inventory management. Track inventory across various locations, manage to reorder points automatically, anticipate demand, and plan production and distribution to tackle the problems of inventory management. One of the most essential procedures for online merchants is inventory management to achieve better inventory turnover and just-in-time delivery standards. Because of enhanced information visibility and changing market structures, the e-commerce environment was viewed as very unpredictable.

In the rise of electronic commerce and its effective dispersion in most business activities, last-mile distribution raises increasingly more

ruckus in the metropolitan regions from one side of the world to the other. As per the study *Last-mile delivery concepts: a survey from an operational research perspective* (Nils Boysen, 2020), growing package volumes to be distributed toward client homes increase the quantity of distribution vans entering the downtown areas and along these lines add to blockage, contamination, and negative health. It is everything except astonishing that lately numerous original distribution ideas on the last mile have been enhanced and improved. Among the most leading are the automated aerial vehicles (drones) and independent distribution robots assuming control over parcel delivery. The study reviews established and novel last-mile ideas and puts special emphasis on the decision problems to be solved when setting up and operating each concept. To do as such, they methodically recorded the alternative special emphasis on the decision problems to be solved when setting up and operating each concept ideas in a reduced documentation plot, talked about the most important decision issues, and reviewed existing research on operations research methods to taking care of these issues.

The e-commerce activities are creating numerous opportunities for operation research (OR)

applications. The authors through their study titled *Prospects for Operations Research in the E-Business Era* (Arthur M. Geoffrion, 2001) have reviewed how the several factions of the profession have begun to respond to digital economy, leading to successes in areas such as network infrastructure, financial services, packaged OR-software tools, supply-chain management, electronic markets and travel-related facilities. The authors say that since OR is very much coordinated to the necessities of the digital economy and in light of the fact that specific empowering conditions are happening, possibilities are useful for OR to group with related insightful innovations and join data innovation as a crucial engine of further improvement for the computerized economy, i.e., e-commerce industry.

Methodology

The authors conducted extensive research to find reports that provided information about the monetary and environmental cost of delivery in the ecommerce sector. Based on the information found, the authors analysed the problems that exist, why they exist and suggested what kind of solutions can be undertaken to solve the issues addressed.

Analysis and Findings

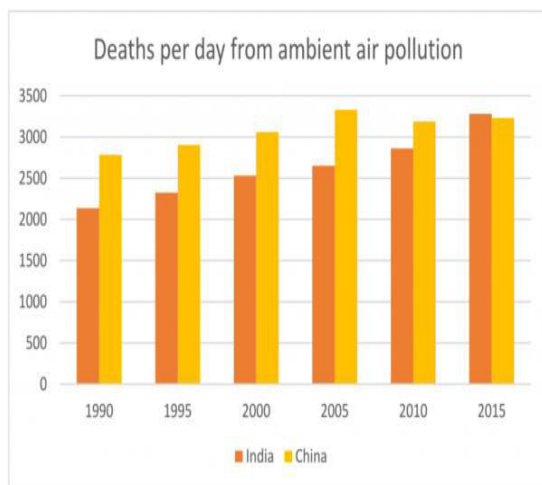
Transportation facilities are essential for e-commerce companies as they can't deliver their products without it. However, transportation carries an inevitable externality of pollution. Different forms of transport lead to different forms of pollution. The first clear impact is that of burning fuel and emitting greenhouse gases into the environment. The second is disposing off plastic and non-biodegradable waste in waterbodies and landfills. The noise caused by all transport adds to the existing noise pollution while there is always a risk of accidents in which oil spills could negatively affect the health of lives on sea and on land. Considering that the market and need for ecommerce platforms is growing, it is safe to suggest that the monetary cost as well as the environmental threat caused by the operations will grow as well. Therefore, it is imperative to find modes of transportation that will be cheaper and more sustainable to support future generations. While increasing efficiency of transportation the most typical constraints are increased fuel costs, prohibited routes, high taxation and the lack of adoption of enterprise wise transportation planning.

Typically, transportation problems are concerned with finding the most optimal method of

transferring a certain commodity from one point to another.

The graph below shows the number of deaths caused due to ambient air pollution. The numbers have continuously been rising which is an alarming sign.

Figure 1:



As many research scholars have already mentioned that ecommerce sector deliveries cause a lot of air pollution since the number of packages being delivered every day is very large. The CO₂ emissions cause by these delivery services is a real threat to the environment. Pollution Routing Problem - (Bektaş & Laporte, 2011), is one of the earliest and the most comprehensive studies that suggests efficient solutions for emission control and cost reduction during deliveries. In this paper they take under

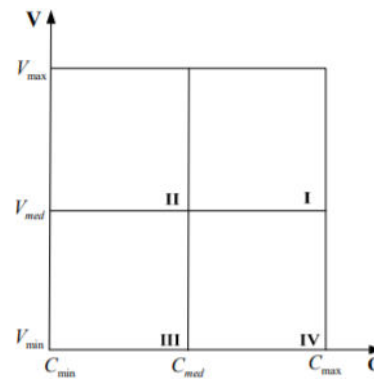
consideration various factors such as weight of the vehicle, capacity of the vehicle, etc to ensure efficiency in transportation. Another operation research model that can prove useful in increasing delivery efficiency and in the process reduce pollution is the distribution management system and Advanced Distribution Management System (ADMS). ADMS provides a system of advanced monitoring, analysis, optimization and control. It provides a clear and accurate as well as consistent views of the distribution network. It allows the various parts of the distribution network to work in sync to increase efficiency. The Vogel Approximation Method or VAM is an iterative process to identify the initial feasible solution to the problem of transport. The transportation costs are also taken into consideration here, like Least Cost Method, but in a relative way. This method can also be used to find the most optimal solution for the transportation problem. Transportation problems assume that the sources of demand and supply cannot simultaneously act at both destination whereas a Transshipment problem deals with more realistic scenarios where the destination is assumed to be the point of consumption. A solution to the transshipment problem is the dual matrix method (Gagliani, 2011).

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The logistics service mode selection is one of the effective methods to solve the problems of last mile delivery by taking into consideration customer utility and delivery service cost. This technique for logistics service mode selection for last mile delivery is based on a “utility-cost” two-dimensional decision matrix model by evaluating direct delivery mode, indirect delivery mode, and combination delivery mode. The suggested technique can assist express companies in determining the most appropriate logistics service mode for last-mile delivery at various stages, and moreover to meet the goals of cost reduction,

increased profitability, and increased customer satisfaction. Firstly, the customer utility is calculated along with the delivery service cost and it is accordingly shown in the suggested matrix model. This approach can broaden the area of theoretical research on logistics service mode selection for last-mile delivery. In practise, express companies require theoretical research findings to aid them in logistics service mode selection, and this approach may help them make the best option for last-mile delivery logistics service mode selection.

Figure 2:



“Utility-cost” two-dimensional decision making model

Inventory management is becoming increasingly crucial for businesses in real-world scenarios. Manufacturing, remanufacturing, maintenance service, and company operations, in general, are all plagued by inventory issues. When compared

to other supply chain operations, it is one of the most expensive operational expenditures for several manufacturing sectors. A company's profit may be greatly increased by properly controlling and evaluating its inventory systems. Proper and timely identification of the appropriate inventory control plan allows for the clearance of a substantial number of assets that have been frozen in the form of stocks, therefore optimizing resource efficiency.

Even though modern civilization produces millions of various sorts of items, there are just two essential decisions to be made when it comes to inventory management:

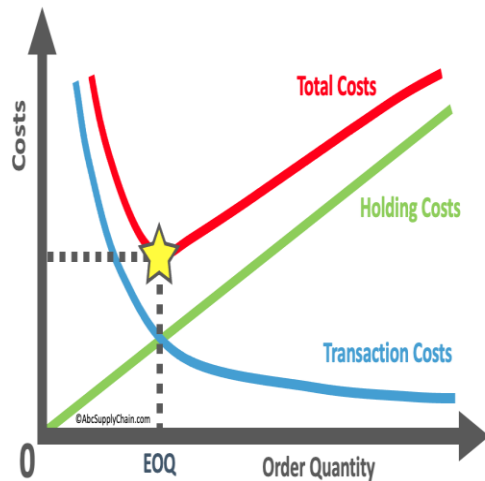
1. What is the maximum size of an inventory replenishment order?
2. When should the order be placed for inventory replenishment?

Inventory management goals often minimize the problem whether it is more lucrative to accomplish something quickly but more expensive or gradually but less expensive.

Economic Order Quantity (EOQ) model is one such approach that can guarantee the appropriate quantity of inventory is ordered every batch, so

that a firm does not have to place orders too frequently or have an excess of inventory on hand and minimizes its total costs related to ordering, receiving, and holding inventory. Economic ordering quantity (EOQ) is the order size that minimizes the average total cost of carrying inventory and ordering under the assumption of certainty and knowledge of total demand over a certain period. The goal of the EOQ formula is to decide the optimal number of product units to order. A company's expenses for purchasing, distributing, and storing units can be reduced if this goal is met. Companies with vast supply chains and significant variable costs might use the EOQ method to calculate alternative production levels or order intervals. The idea behind EOQ is that inventory management is confronted with a collection of competing expenses. The carrying cost rises as the lot size grows, but the ordering cost falls. The carrying cost, on the other hand, reduces when the lot size drops, while the ordering cost increases. The two opposing costs can be visually represented by graphing them versus the order size, as seen below.

Figure 3:



Limitations and Recommendations

The biggest limitation that we had to encounter was the lack of available research papers on the subject of operation research available for undergraduate students. While solving the transportation problem to make transport more eco-friendly one thing that could not be solved is the level of noise pollution created by various modes of transport that are used to deliver products from the manufacturers to the final consumers. While using various models to make transportation more efficient for ecommerce sector the amount of fuel burnt by various kinds of vehicles, prevailing road and traffic conditions were not taken under consideration. A study that can be conducted in the coming times is the level of improvement that can be achieved by the

introduction of electric vehicles in the field of ecommerce. Lack of communication between staff members is one of the factors that has not been touched upon in this research paper along with the delay in updating of real time data which is an important part of inventory management for a firm.

For future research, we'll look at the influence of market competition on logistics service mode selection for last-mile delivery, as well as the logistics service mode selection for last-mile delivery when compared to the logistics service mode for last-mile delivery used by competitors. In addition, new delivery service tools are emerging and these new tools will change the cost and possible logistical service mode for last-mile delivery. In future study, these delivery service tools and the logistics service mode selection for last-mile deliveries might be considered.

Conclusion

In light of the objective, it can be stated that inventory management for a firm is just as vital as maintaining an attractive, user-friendly website. Demand variations, which can be driven by seasonality or product popularity, reverse logistics and stockouts cause inventory

management problems. Due to these difficulties, an online retailer is more likely to lose sales and consumers. As a result, it is critical for an online retailer to be aware of these problems and risks, as well as to reduce them through suitable Operation research models such as EOQ model. This will safeguard the online retailers against a variety of threats while also improving consumer satisfaction levels.

For last-mile delivery, we proposed the combined logistics service mode and provide calculation models for consumer utility and delivery service cost in the combined logistics service mode. We examined the influence of consumer utility on customer selection behaviour in logistics service mode selection, which increases the applicability and practicability of logistics service mode selection for last mile delivery. Finally, we presented a delivery service quantity forecast technique based on a combination of time series and customer selection probability, which provides an acceptable basis for delivery service cost computation.

Transport is the fundamental infrastructure that enables economic and social progress. Every day, the industry carries millions of tons of freight and passengers. People go to workplaces, ship cargo

from and to plants, students attend schools, families go to shops for food, and many more activities depend on the sector. However, it is also a threat because it is one of the hugest consumers of petroleum products, and is thus a prime cause for existing hazardous particles, such as greenhouse gases and CO₂, in the air. After several years it is now that researchers worldwide are working in tandem to create a more sustainable method of transportation to save the environment. Through this research paper, we tried to resolve pollution caused by transportation and lack of efficiency in inventory management of the ecommerce sector. Although the ecommerce sector has a lot more segments that need to be more efficient for it to be more environment friendly which we hope to cover in future studies. We put emphasis on use of various techniques of operation research to solve the afore mentioned problems.

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