Bi-Objective Optimization Model for Store Selection for BOPS Service in Omni-Channel Retail Chain

***Abstract*— Owing to the relentless stress on innovative solutions for businesses to succeed in a highly customer-dominated market, the process of having an omni-channel supply chain has become crucial for the Indian retail industry. But channel integration requires careful restructuring of the supply chains. Thus, retailers are finding ways for launching services like Buy Online Pickup in Store (BOPS) in such a way that they are beneficial for them. The problem addressed in the current research is that of a multi-channel retailer who wants to provide a BOPS fulfilment option to its customers. The pickup points are to be set up at the existing retail store locations of the retail firm. For this purpose, a bi-objective mathematical programming model is developed for: (i) identifying existing retail stores which should be expanded as pick-up points, and (ii) determining the expansion capacity of the selected retail stores. Weighted goal programming technique is utilized to achieve a trade-off between the objectives of cost minimization and utility achievement of retail stores under various constraints incorporating demand requirements, budgetary restrictions on expansion, optimum capacity utilization, and the performance scores of the retail stores evaluated by the decision makers on the basis of criteria like accessibility, attractiveness, etc. The model is validated with the help of a case of an Indian multi-channel retail firm. From the results obtained, it can be concluded that adopting an all-inclusive strategy for retail store selection is not beneficial for retailers. Also, the results point out that the performance of the retail store is an important factor to consider while selecting the retail store for pickup points.**

***Index Terms*— Bi-objective Model, BOPS, Capacity Expansion, Facility Selection, Goal Programming, Omni-channel Retailing**

***Managerial Relevance Statement*- The study aims to provide the decision makers of multi-channel firms with an understanding of the issues at the strategic and operational levels so that they can effectively offer the BOPS option to their customers as a part of their omni-channel initiative. From the practical perspective of BOPS adoption, the study highlights the importance of retail stores' appropriateness to function as pickup points. The study helps the managers in understanding that selecting retail stores for expansion as pickup points solely on the basis of cost will not be beneficial. Further, when deciding which retail stores should be expanded, the retailers may be tempted to expand all of their retail stores in anticipation of gaining profits. However, adopting this all-inclusive strategy may lead to conflicts between demand, unavailability of product for walk-in customers, reduced workforce efficiency, and so on and it incurs a large amount of capital investment. Our bi-objective optimization model assists the retail firms in deciding which retail stores should be expanded considering various factors like demand, available capacity, expansion cost, etc. Apart from selection, the model also helps the managers in deciding the expanded capacities of those retail stores. Thus, the current research helps the managers in retail firms in selecting the retail stores for expansion as pickup points to handle both traditional and BOPS types of demand. It helps them in deciding the expanded capacities of the selected stores and how they can manage the BOPS type of demand of non-selected stores.**

I. INTRODUCTION

WITH changing market trends, there have been many innovations in processes and operations of retail Supply Chains (SCs). In the global context, retail has moved from a purely traditional retail format to retail across multiple channels [1]-[2]. These multiple channels maybe well synchronized and integrated in developed nations but may need more refining in emerging economies such as India [3]. In a survey by Ernst & Young (EY) in collaboration with The Consumer Goods Forum (CGF), it was found that although online channels are expected to grow at a faster rate as compared to the traditional offline store-based channel in emerging economies, store-based sales will continue to dominate the market (EY) [4]. Brands like D Mart, Reliance Retail, Croma Electronics, Pantaloons, Allen Solly etc. are planning to open more retail stores in 2022 [5].

This may be because of fierce competition due to globalization, the presence of unorganized players in the market, and the transformation of retail SCs. Customers' desire to buy at their convenience has reached the point of wanting to experience the benefits of multiple fulfilment options simultaneously, which has given rise to Omni-Channel Retailing (OCR) [6]. In OCR, the multi-channel retail firm synergistically manages its two or more channels for providing the customers additional fulfilment options apart from the existing traditional ones [7]. For instance, brands like Nike have launched their Nike+ application to provide customers an end-to-end support. Sephora captures the in-store data of its customers, including products they examined and then Sephora utilizes that information to re-engage those customers by offering them product-specific promotions. Timberland has launched "Touch Walls" in their stores where customers can scan the product and find its features online; Ikea provides planning studios and other retailers offer a variety of other such customer-centric features [8]. Therefore, in OCR, the firm tries to capitalize all the possible touchpoints; hence, it is often considered as a holistic form of retailing [9]. Owing to the relentless stress on innovative solutions for businesses to succeed in a highly customer-dominated market, the process of having an omni-channel SC is even more crucial to the Indian retail industry. While traditional forms of retailing still dominate the Indian retail market, the share of omni form of retailing is gaining a lot of significance [3]. For example, the firm Shoppers Stop has embraced new technologies and infrastructure which has led to 188% growth in its omnichannel sales [5]. India has the largest millennial population and hence offers tremendous growth potential for OCR [10]. For this purpose, firms such as Shoppers Stop, Ezone, V-Mart Retail are venturing into OCR in India [11]. However, OCR is still at a nascent stage in emerging economies like India. This is because the retail firms lack the required infrastructure and technical support needed to merge the two channels and to provide a holistic customer experience. The integration of multiple channels poses a major challenge in the logistics design of the retail SC [4].

Omni-channel retail firms across the globe have adopted various fulfilment options for OCR such as Buy Online Pickup in Store (BOPS) adopted by Walmart, Target, Petco, Scooter Hut, etc. [12]; Ship from Store is used by Target, Walmart, Kohl's, The Gap, Inc., etc. [13]; Buy Online with Drop Shipping (BODS) is offered by Spocket, AliExpress, etc. [14]; and In-Store Purchase with Home Delivery (ISPHD) [15]. This research is focused on the BOPS fulfilment option under OCR, because OCR is one of the main options that firms are aspiring to adopt in India [16]-[18]. In this type of fulfilment, customers place their orders through the retail firm's online channel and can pick their orders from the firm's retail stores dedicated to function as pickup points. Therefore, in this fulfilment option the retail firm takes advantage of its online channel to connect with its offline customers. It helps the firm in matching the supply and demand and reducing the chances of product unavailability [19]. Another advantage of BOPS over other fulfilment options is that it boosts sales at the retail stores as it promotes upselling and impulse buying [20]. This customer behavior was experienced by the brand Lululemon and it was analyzed that 20% of the customers who came to pick-up their orders made additional purchases from the retail store [21]. Customers prefer BOPS as it guarantees product availability when they visit the retail store and enables quick delivery with easy returns [20, 22]. BOPS provides ease to the customers whereby they can avail the benefits of both the channels simultaneously. Moreover, BOPS service is the most preferred mode of shopping during this pandemic as it is considered a safe shopping experience with limited human interactions [23]. In a report by Kibo Commerce, they state that retail firms experienced 563% surge in BOPS type of orders during the peak of the pandemic [24]. Even in today's time, customers remain cautious and physical movements are being kept to the minimum to avoid the spread of COVID-19; thus, BOPS has become the most preferred mode of shopping. BOPS provides the dual ease of ordering the article online which saves time and effort and buying offline after verification of the article's quality. It also provides added benefits in terms of no shipping fees, no waiting for delivery, and no risk of packaging theft [21]. However, the transition towards OCR necessitates the reconfiguration of the SC by the retail firms [25].

Reconfiguration of the SC is one of the biggest challenges faced by multi-channel firms venturing into OCR [4]. In a survey by EY and CGF, they found that 76% of the multi-channel retail firms' owners all over the world believe that to successfully implement OCR, they will have to transform their entire SC network instead of adopting small incremental changes [4]. This is because both the channels differ significantly in terms of delivery of information regarding the product and the way in which product fulfilment is performed [26]. Due to its unique operational capabilities along with supply demand matching ability across channels, this new form of SC is strikingly different from traditional online and offline SCs [27]. In case of BOPS, in which offline stores of the retail firm are utilized to fulfil online orders, the key challenge for the retail firm is to reconfigure its SC so that the demand of one channel does not interfere with the demand of the other channel. Adoption of BOPS strategy by the retail firm requires substantial investments, so the tactical planning decision of choosing the most suitable offline stores as pick-up points must be made with due consideration of the influential store characteristics and budgetary constraints [28].

Therefore, the first step in this reconfiguration of the SC is to analyze the pick-up store-space requirement as per the additional demand from online orders; then, capacity expansion of the retail stores must be planned. Adopting an all-inclusive policy of expanding all the retail stores will incur an excessively high cost; hence, the retail firm should instead expand a limited number of its retail stores. Apart from high cost of setting up pickup points, other factors like insufficient availability of resources such as inventory carrying capacities, workforce, and so on at the retail stores may also obstruct the efficient implementation of BOPS [24]. It may lead to unavailability of products due to stock-outs, untimely delivery of online orders, and improper assistance for walk-in customers which will affect both online as well as offline sales and customer satisfaction [19], [29]-[30]. Therefore, the strategic decision of setting up of the best pickup points for adding BOPS fulfilment option is a crucial step in the restructuring of the SC. The setup of these pickup points will immensely affect the responsiveness and efficiency of the supply chain network developed. Thus, there is a need for an analytical model which can help a multi-channel retail firm in determining the optimal number of pickup points to be set up and deciding which retail stores should be expanded given the firm’s financial restrictions, demand, capacities, and so on. This paper contributes to the area of OCR in this regard.

A number of researchers have empirically pointed out how multi-channel retail firms in developed countries can implement BOPS option as a part of their omni-channel strategy [25, 28, 31, 32]. But no researcher has discussed the case of a retail firm focused on the adoption of this type of retailing in emerging economies like India [33]. There is a need for such case studies as retail firms in emerging economies lack the experience, infrastructure, and other resources which can aid in the restructuring of the SC network. Current market conditions demonstrate that OCR has been adopted by multi-national firms in such economies, but local firms are still struggling with this change in the retail scenario. Therefore, it becomes crucial to conduct a study that can aid decision makers in emerging economies in a successful adoption of OCR. Moreover, there are very few studies in which a robust mathematical framework has been developed to help the decision makers in restructuring their SC network configuration for integrating offline and online SC networks [25, 34]. Also, no study focuses on the strategic decision of selecting the retail stores to be expanded as pickup points to minimize the cost of the restructured SC network based on the suitability of the retail store to act as a pickup point. Hence, the research questions addressed in this research are:

- How can multi-channel retail firms in emerging economies like India restructure their SCs to adopt OCR?
- How many pickup points must be set up by the retail firm?
- What should be the location of these pickup points under budgetary restrictions, taking into account the customers' preferences?
- What should be the optimal capacity expansion of the selected retail stores based on demand, expansion cost, and infrastructural limits?

To answer these questions, a bi-objective mathematical programming model is developed to help decision makers in selecting retail stores for expansion from among the available ones. The model aims at minimizing the total cost of the SC network and maximizing the aggregated performance score (measured in terms of the utility degree) of the selected retail stores under a set of well-defined constraints reflecting the managerial requirements of the firm. The trade-off between the conflicting objectives is achieved by using goal programming. This model is validated with the help of a multi-channel Indian retail firm dealing in women's ethnic clothing having an INR 300 crores of annual turnover. It is generalizable for any similar retail firm under similar context.

The main contribution of this paper is the development of a mathematical model with the aim of helping a multi-channel retail firm for the strategic decision of setting up its pickup points for BOPS order fulfilment as a part of restructuring the SC for OCR. Although authors like [33, 35, 36] have proposed mathematical models for the location of pickup points, none has considered the trade-off between conflicting objectives of minimization of the additional cost incurred by the retail firm due to restructuring of SC and maximization of the utility of the selected pickup points. In [30], the authors developed a trade-off between cost minimization and value maximization; they define value in terms of the monetary benefit the firm will achieve by selecting a store as pickup point for providing BOPS option to its customers because of reduced shipping and travel and increased convenience. In the present study, utility scores are calculated for retail stores based on a number of factors like accessibility, attractiveness, workforce availability and so on. In comparison to [30], the utility scores quantified in our study represent the appropriateness of a particular store to act as pickup point more effectively. Moreover, [30] does not consider capacity expansion which is an important aspect of facility selection for pickup for BOPS because dedicated counters are required for handling BOPS type of demands. Further, the inventory must be maintained to avoid stockouts for walk-in customers and so on. Therefore, it is important to understand the feasibility of capacity expansion at the retail stores along with their utility while selecting a store for expansion as a pickup point, which is the highlight of this study. Additionally, for ensuring customer reachability of the pickup points, the retail stores under study are divided into retail zones, and at least one retail store in each retail zone is selected for expansion. Thus, the bi-objective model developed in this study helps the retail firms in

- Evaluating the retail stores on the basis of a number of criteria like accessibility, attractiveness, magnets near the store, and so on. These scores are maximized as utility objective in the mathematical model.
- Ensuring the reachability of BOPS service across the whole region.
- Determining the expanded capacity of the selected retail stores required for operating as pickup points.

To attain the best possible solution based on decision makers' preferences, a weighted goal programming technique has been utilized in this study as an effective solution methodology for attaining a compromised solution subject to constraints like budgetary restrictions, capacity restrictions, and demand satisfaction. Moreover, very few researchers have validated their models based on the case study of an Indian apparel retail chain.

The manuscript is organized as follows: section II gives the background of the study which highlights the extant literature related to BOPS fulfilment. The case description highlighting the problem definition and proposed network design is given in section III along with the mathematical model developed in this paper. Section IV describes the goal programming formulation used to solve the developed model. Results and discussions are provided in section V. The managerial and theoretical implications derived from the study are presented in section VI. The research is concluded in section VII highlighting its limitations and future scope.

II. Background

In this section, we discuss adoption of the BOPS system in context of various retailing options. We also discuss SC restructuring in relation to BOPS, and we consider the research gap and motivation behind this study.

A. Facility Location for Capacity Expansion

Facility location selection is a well-researched and developed field in SC literature [37]. Researchers have developed models for capacitated facility location [38], facility location selection for waste collection [39], facility location selection for relocation [40], facility location selection for closed loop SC [41], facility location selection from the perspective of triple bottom line [42], and so on. Our research is focused on facility location for functionality expansion. A number of researchers have discussed facility location for capacity expansion. For instance, [43] have developed a mathematical model to determine the expansion size of the existing facilities, whether or not they should remain open, and which new facilities should be opened. According to [43], extant capacity expansion studies can be categorized into: node capacity expansion problems and node number expansion problems. In node capacity expansion problem, the existing nodes are expanded to augment their capacities, in turn increasing the capacity of the network. Whereas, in node number expansion problem, new nodes are added in the network to expand the capacity of the network. For the node capacity expansion problems, authors in [44] proposed a production capacity expansion model and solved it using an improved heuristic algorithm they proposed. Authors in [45] developed a three-stage production-distribution network planning model with node capacity expansions. The model is solved using relaxation-based heuristics. Authors in [46] presented a node capacity expansion problem for a reverse logistics distribution network in which warehouses and repair centers are regarded as expandable nodes. The problem is solved using genetic algorithm-based heuristic. A number of researchers have studied node capacity expansion problems, but they have not discussed the problem of functionality expansion for a node. The current model contributes to the SC literature for facility location selection through which the existing facilities of any firm can be selected for expansion to increase the scope of operations of that facility. Moreover, from the above discussion it is visible that retail facility expansion is still an undiscovered topic in supply chain literature. Very few researchers, for example [30] and [33], have explored retail facility location problem. But none has proposed an integrated model for retail store selection for capacity expansion. In the current study, retail stores are selected in a two-stage manner, in which they are first evaluated on the basis of a set of criteria and then are selected using a bi-objective model of expansion cost minimization and performance maximization.

B. Adoption of BOPS in Omni-Channel Supply Chain

A number of researchers have conducted studies to understand the different types of fulfilment options emerging as a result of OCR [47-50]. In one such study conducted by [19] based in USA and Europe, it was found that store pickup service has become the most preferred omni-channel fulfilment option for the retail firms as well as the customers. Further, [51] conducted a study to understand customers' channel preference based on their characteristics. They concluded that BOPS can be a very profitable omni-channel option for retail firms. The author in [8] has highlighted various scenarios in the competitive market under which BOPS can be successful. Store-pickup has become the most preferred omni-channel fulfilment option by the customers; therefore, retail firms are directing their attention towards its effective and efficient adoption [52]. Therefore, researchers have conducted a number of empirical studies to help these firms in understanding the challenges, factors, and characteristics that play a role in BOPS implementation. For instance, in a study by [53], a survey was conducted in USA to establish how the perceived risk associated with online shopping and innovative characteristics can affect the customers' intention to use BOPS fulfilment option. Similarly, in a study by [54], the researchers have used cart abandonment rate of offline and online channels to understand the impact of BOPS in terms of cross-selling effect and channel-shift effect. Authors in [28] have used a combination of propensity score matching and difference-in-difference approaches to quantify the impact of BOPS on subsequent purchase behaviors of the customers. These empirical studies have been supported by the development of various mathematical models by the researchers. For instance, using different mathematical models, [55] explained the conditions under which a multi-channel retailer should take up BOPS fulfilment strategy. Further, [32] examined if a retailer should adopt BOPS strategy in competitive market scenario along with the associated pricing strategy. In [56], the authors explored the conditions under which BOPS adoption will be profitable for a retailer when there are two competing retailers, and they considered the return probability and cost of return collection. Similarly, in [31], authors discussed the best market conditions and opportunities for the implementation of BOPS and the optimal pricing and service strategies for the same. On the other hand, the issue of how sales and returns of both the offline and online channels are affected by the introduction of BOPS, is the subject of work by [57]. In [22], authors studied the impact of BOPS on price, quality, demand, and profit of both the manufacturer as well as the retailer. In another study by [24], the authors developed a pickup service scale for BOPS and found that customers determine the quality of BOPS service on the basis of three factors: quick service, efficient system, and convenient experience. The need for the current study is to mathematically develop the concept of BOPS. It can be observed from the extant literature that few mathematical models have been developed for capacity expansion of retail stores as pickup points for online orders in an omni-channel SC. More so, none of the studies addresses the unique challenges prevalent in emerging economies like India.

C. Retail Chain Restructuring for BOPS

Various researchers in the available literature found that while adopting BOPS fulfilment option, firms are facing challenges related to the restructuring of their SC [9]. Firms have to develop an integrated system which requires vigilant planning and execution [9]. While restructuring the SCs to integrate online and offline channels, retail firms face issues related to the availability of product, integrated delivery options, integrated returns or reverse flows, and inventory across channels [9]. Based on the research conducted by [58], customers play a direct role in the omni-channel SC which changes the flow of products from the earlier traditional distribution network to a more complex network. They found that multi-channel retailers manage these challenges by utilizing and harmonizing their tangible and intangible assets to gain competitive advantage. In BOPS, bricks and mortar stores of the retail firms are utilized to conduct last mile delivery of online orders and, thus, they play a major role in the physical distribution process of the retail firm [59]. Researchers in [28] found that offline store characteristics can play a role in the relationship between BOPS usage and offline and online purchase behaviors of the customers. Therefore, few researchers have focused on how these retail stores can be effectively utilized for efficient implementation of BOPS fulfilment option. For instance, [60] conducted a study to understand the factors which play a major role in determining the size of the service area of the retail store to fulfil both traditional and BOPS orders. They found that the size depends upon the unit inventory carrying cost at the retail store and the arrival rate of customers for collecting their BOPS orders. In another study by [29], researchers have developed a mathematical model to determine the optimal number of picking waves along with their timings a retailer should execute at his/her retail store in an ordering cycle to fulfil all the BOPS orders. The model also helps to determine the minimum picking rate that should be adopted in the retail stores for achieving a desired service level of BOPS orders. In a study by [34], the authors presented a mathematical model to allocate the store shelves and available inventory for offline and BOPS type of orders. Similarly, authors in [21] discussed the best suitable inventory policy for retailers implementing BOPS. On the other hand, authors in [15] established a mathematical model to determine the discount that the retail firm should offer to attract customers towards BOPS based on their travel distance for order collection.

The success of BOPS depends highly upon how the firms restructure their SCs in terms of conversion of their retail stores into pickup points, because BOPS may reduce a retailer's profit when customers face stock-outs and inconsistent experience [50]. However, very few researchers have conducted studies to identify the most suitable locations for pickup points for BOPS type of orders. For instance, while checking out on the online website, which retail stores should be presented to the customer for picking their order has been decided in [35] with the help of a mathematical model. The retail stores are presented to the customers on the basis of their geographical locations and distances. In another study by [36], a mathematical model is proposed to optimally locate and schedule their trucks for providing self-picking service to customers. But none of the studies has focused on the selection of retail stores to be expanded as pickup point for BOPS fulfilment option. In a study by [33], a mathematical framework has been developed by the authors to rank the available retail stores on the basis of various criteria for acting as pickup points for BOPS orders. The research gap and motivation behind this study is given below in detail.

D. Research Gap and Motivation

It can be observed from the above review that there is need for development of analytical models for selection of retail stores for expansion to function as pickup points for BOPS fulfilment option. As adopting BOPS strategy by the retail firm requires substantial investments; therefore, firms should consider the store characteristics to create value by providing such service [28], [33]. Thus, apart from the strategic decision of selecting which retail stores should become pickup points, capacity expansion decisions should also be considered simultaneously, and, to the best of our knowledge, this consideration has not been pursued by any other researcher. Moreover, the selection and capacity expansion decisions are greatly impacted by the predicted offline and BOPS demand at the retail store, available capacity, budgetary restrictions, and the suitability of the retail store for expansion. There is no comprehensive study that considers all the above factors in selection of retail stores for expansion as pickup points. This study fills that gap and provides significant implications for effective implementation of BOPS fulfilment option by the retail firm. Because selection and expansion of retail stores are strategic decisions, they require extensive and robust analytical modelling to select the best suitable stores. Thus, in this research a bi-objective mathematical model is proposed to select the most suitable retail stores for expansion as pickup points and to determine their expanded capacities based on multiple factors like demand, budget, accessibility, attractiveness, and so on. The model is validated using a case of an Indian multi-channel retail firm. There are limited studies that focus on the adoption of OCR in Indian context, especially case specific research [3]. Our study fills this gap by presenting the case of an Indian multi-channel retail firm willing to venture into OCR by introducing BOPS service for its customers.

III. Case Description

In this study we have worked with a well-established Indian multi-channel retail firm ABC Ltd. (name cannot be disclosed due to reasons of confidentiality) offering a wide range of women's ethnic clothing. ABC Ltd. is a leading retailer in this area having an INR 300 crores of annual turnover. The firm offers various types of ethnic women clothing like casual wear, work wear, and festive wear. With the retail sector growing rapidly in India and with increasing competition due to globalization, it has become imperative for firms like ABC Ltd. to adopt innovative strategies to enhance customer experience. The firm is efficiently managing its online and offline SCs which gives the firm a competitive edge. But after analyzing the current demands of both the channels along with their distribution network and comparing them with its global counterparts, the firm recognized that providing an omni-channel experience to its customers will lead to better utilization of available resources and increased sales. Currently, the firm offers two types of fulfilment options to its customers: pure online and traditional offline. In pure online fulfilment, customer places the order through the firm's web portal and the order is delivered to his/her desired location. On the other hand, in traditional offline fulfilment option, a customer visits the retail store and buys the desired product himself/herself. Due to increased customers' expectations, market competence and associated benefits, the firm wants to introduce an option of picking online orders from the firm's retail stores. BOPS fulfilment option provides the right opportunity for retail firms to cater to the rising demand for omni-channel. It has already been proved to be an extremely successful option in developed countries [61]-[62]. In fact, for customers' convenience, BOPS fulfilment option has become a mandatory fulfilment option for retail firms in countries like USA and UK [61]. According to this rising trend, retailers all over the world are becoming more customer-centric and thus are adopting this form of fulfilment [62]. As per a report by [63], by the year 2025, 10% of all the sales in UK will be fulfilled by the BOPS option of retailing. Firms like WalMart, Target, Ikea, etc. in USA have also invested heavily in developing their BOPS capabilities [61]. Apart from the potential economic benefits due to fewer returns, decreased shipment costs, and so on, adding BOPS option will lead to in-store upselling at the time of collection and higher customer satisfaction [64]. Therefore, to realize the potential of achieving high productivity due to an integrated channel fulfilment option, firms like ABC Ltd. in emerging economies like India are also planning to invest in this option. Learning from the experiences of the firms in developed nations, retail firms in developing countries are looking for strategies to provide the BOPS fulfilment option to their customers. In order to do so, logistics network of the existing SC needs to be redesigned and critical strategic decisions must be made. This is the problem faced by the retail firm considered in the study. The decision makers of the retail firm under due deliberation have proposed that the existing retail stores can be expanded as pickup points so as to provide the BOPS option.

A. Problem Description

The firm's decision of providing BOPS fulfilment option is driven by rising customer demand and intense competition in the retail sector. The decision regarding which retail stores should be selected for expansion as pick-up points is influenced by many factors such as (i) how many retail stores must be expanded as pickup points, (ii) at what locations pickup points should be set up, and (iii) what should be the capacity of these pickup points. Most importantly, these decisions are to be made with the primary objective of cost minimization. The objective should be achieved considering various constraints incorporating demand requirements and optimum capacity utilization. In view of this, a mixed integer programming model is proposed for:

- Selecting suitable retail stores for expansion as pickup points, with adequate infrastructure, to provide a seamless shopping experience to customers having different preferences.
- Determining the number and location of pickup points to be opened.
- Deciding the expansion capacity of the retail stores selected to function as pickup points considering optimal utilization of resources.

B. Proposed SC Network Design and Configuration

The existing SC network of ABC Ltd. is depicted in Fig. 1. Currently, online orders are being distributed to customer locations from the firm's distribution centers. The firm now wants to provide online customers the option of picking up their orders on their own. Setting up new pickup points for such orders will incur significant cost; therefore, existing retail stores with appropriate expansion of space and infrastructure can function as pickup points for BOPS orders. However, adopting an all-inclusive policy will result in higher cost and wastage of resources; hence, not all retail stores can function as pickup points. Thus, the modified SC network of the firm, designed to address the above concerns is shown in Fig. 2. In this modified SC network, pure online demand is directly being delivered to customers' location from the distribution center. On the other hand, the other two types of demand, i.e., traditional offline and BOPS, are being collected by the customers from the firm's retail stores and pickup points respectively.

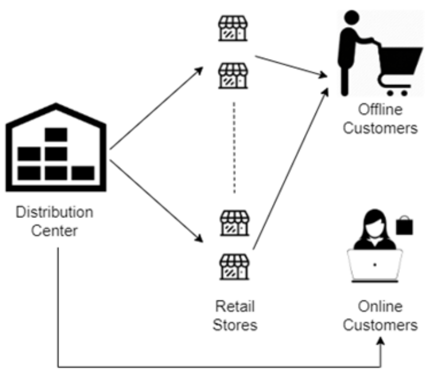

Fig. 1. Current supply chain network

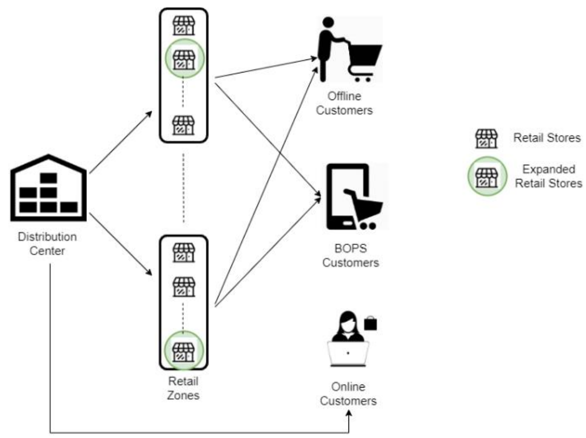

Fig. 2. Modified supply chain network

To test the effectiveness of the proposed model, ABC Ltd.'s retail stores located in the National Capital Region (NCR) of India have been considered in this paper. The firm has 47 retail stores in NCR, but upon multiple discussions with the decision makers of the firm, it was concluded that only some of the retail stores will be considered for expansion. They decided the retail stores eligible for expansion on the basis of a number of criteria like cost which includes operational, expansion, and inventory carrying cost; population characteristics of the area where the retail store is located like the age group, income, whether they own a car or not, etc.; retail stores' accessibility; their attractiveness, described as the presence of some public places nearby like schools, parks, offices, etc.; and some other factors. After these discussions, the firm decided to select retail stores for expansion from among the 19 retail stores (listed in Table I).

TABLE I: RETAIL STORES CONSIDERED FOR EXPANSION

S. No.	Retail Store	Retail Store Location	S. No.	Retail Store	Retail Store Location

1	RS1	Great India Place, Noida	11	RS11	City Square Mall, Rajouri Garden
2	RS2	Mall of India, Noida	12	RS12	Select City Walk, Saket
3	RS3	Pacific Mall, Subhash Nagar	13	RS13	DLF Mall, Saket
4	RS4	Janak Palace, Janakpuri	14	RS14	Khan Market
5	RS5	Sector 5, Dwarka	15	RS15	DLF Promenade, Vasant Kunj
6	RS6	Ambience Mall, Gurugram	16	RS16	MGF Mall, Gurugram
7	RS7	M G Road, Gurugram	17	RS17	E Block, Cannaught Place
8	RS8	Galleria Market, Gurugram	18	RS18	B Block, Cannaught Place
9	RS9	Unity One Mall, Rohini	19	RS19	Model Town
10	RS10	Rajouri Garden			

For selecting the retail stores for expansion as pickup points, an optimization model is formulated for configuring the proposed SC network. The model also helps in determining the optimum number of retail stores to be expanded and the level of capacity expansion for each of the selected retail stores. The detailed model development is given in sections C, D, and E based on the notations provided in Tables II and III.

TABLE II: NOTATION OF PARAMETERS USED IN THE MODEL

Symbol	Description	Symbol	Description
i, j	Index representing retail stores	$C^{penalty}$	Penalty cost for under-utilization of resources
L	Index representing distribution center	C_i^u	Upper limit on the expansion of capacity of the i^{th} retail store
O_{ij}	Cost of satisfying the BOPS demand at j^{th} retail store from i^{th} retail store	C_i^l	Current capacity of the i^{th} retail store
P_i	Per unit packaging and handling cost at i^{th} retail store	u_i	Performance score of the i^{th} retail store
T	Transportation cost per unit distance	α	Maximum number of pickup points to be set
d_{il}	Distance between distribution center and i^{th} retail store	N	Total number of retail stores
E_i^f	Fixed expansion cost of i^{th} retail store	β_i	Percentage of BOPS orders at i^{th} retail store
E_i^v	Variable expansion cost of i^{th} retail store	D_i	Total demand at the i^{th} retail store

TABLE III: NOTATION OF DECISION VARIABLES OF THE MODEL

Symbol	Description
G_{ij}	1, if BOPS orders at j^{th} retail store are satisfied from i^{th} retail store and 0, otherwise
A_i	1, if the i^{th} retail store is selected for expansion and 0, otherwise
X_i^{pac}	Total number of BOPS orders packed at i^{th} retail store
X^{Total}	Total number of BOPS orders packed
M_i	Capacity expanded for i^{th} retail store

C. *Assumptions*

The developed model is based on the following assumptions:

- Locations and capacities of the distribution center and the retail stores are known.
- Retail zones have been determined *a priori*.
- The cost parameters are deterministic.
- The demand at each retail store is known.
- Backordering is not allowed.

D. Requirement Space Modelling

Based on the discussions with the firm's decision makers, the following set of constraints were developed to mark the requirement space of the firm:

1) Retail store selection constraints

$$\sum_i A_i \geq 1 \quad (1) \quad \text{and} \quad \sum_i A_i \leq \alpha \quad (2)$$

Constraint (1) ensures that at least one retail store should be selected for expansion as pickup point. Constraint (2) limits the maximum number of retail stores to be expanded.

2) Demand allocation constraints

$$G_{ij} = A_i \quad \forall i = j \quad (3)\,; \quad \sum_i \sum_j G_{ij} = N \quad (4)\,; \quad \sum_i G_{ij} = 1 \quad \forall j \quad (5)$$

Constraints (3)-(5) make sure that the BOPS demand at retail stores not selected for expansion is allocated to exactly one pickup point. The non-selected retail stores will continue to function as traditional retail stores for offline demand.

3) Demand satisfaction constraints

$$X^{Total} = \sum_i \beta_i D_i \quad (6)\,; \quad \sum_i X_i^{pac} = X^{Total} \quad (7); \quad X_i^{pac} = \sum_j \beta_j D_j G_{ij} \quad (8)$$

Constraints (6)-(8) ensures that the total BOPS demand, calculated as a fraction of the total demand at the retail store, is all satisfied.

4) Scope of expansion constraints

$$M_i \leq C_i^u A_i \quad \forall i \quad (9)\,; \quad M_i \geq C_i^l A_i \quad \forall i \quad (10)$$

Constraints (9) and (10) provides the limits on the minimum and maximum scope of expansion of each of the retail stores.

5) Capacity constraint

$$X_i^{pac} \leq M_i \quad \forall i \quad (11)$$

Constraint (11) represents the capacity restriction on the pickup points.

Further, upon discussions with the decision makers of the firm it was recognized that it may happen that the retail stores selected for expansion are located in and around a particular region of NCR. This will lead to decreased customer reachability and may result in lost sales as a customer living in the North region will not prefer to pick his/her order from the South region of NCR. Thus, for achieving a higher coverage of demand, retail stores from different regions of NCR should be selected in an evenly fashion. For this purpose, the 19 retail stores considered for expansion have been divided into clusters by the decision makers of ABC Ltd. (shown in Fig. 3). The retail stores are clustered into 7 retail zones. The firm has decided to select at least 1 retail store and at most 2 retail stores from each of the zone. Since, the number of selected retail stores will be increased, thus, the firm was asked to provide the allocated budget value for the whole project. The decision makers of the firm decided to allot INR 7,00,000 for establishing pickup points for BOPS orders as a part of their supply chain restructuring. The modified requirement space incorporating the above-mentioned changes is given below.

E. Modified Requirement Space

Based on the discussions with the decision makers, constraints for defining the modified requirement space are as follows based on the notations given in Table IV:

TABLE IV: NOTATION OF PARAMETERS AND DECISION VARIABLES USED IN THE MODEL

Symbol	Description
	Parameters
K	Index representing retail zones
η_{ik}	1, if the i^{th} retail store is in the k^{th} retail zone and 0, otherwise
α_k	Maximum number of pickup points to be set in k^{th} retail zone
N_k	Total number of retail stores present in k^{th} retail zone
B	Total budget for expansion
γ_i	Accessibility score of i^{th} retail store
γ_k^T	Threshold value for accessibility score for retail stores located in k^{th} retail zone
δ_i	Attractiveness score of i^{th} retail store
δ_k^T	Threshold value for attractiveness score for retail stores located in k^{th} retail zone
	Decision Variable
X_k^{Total}	Total number of BOPS orders packed

1) Retail store selection constraints

$$\sum_i A_i \eta_{ik} \geq 1 \qquad \forall k \qquad (12) \; ; \qquad \sum_i A_i \eta_{ik} \leq \alpha_k \qquad \forall k \qquad (13)$$

Constraint (12) ensures that at least one retail store should be selected for expansion as pickup point from each of the retail zones. Constraint (13) limits the maximum number of retail stores to be expanded in each retail zone.

2) Demand allocation constraints

Constraint (3) for demand allocation remains the same in the modified requirement space.

$$\sum_i \sum_j G_{ij} \eta_{ik} \eta_{jk} = N_k \qquad \forall k \qquad (14)\,; \qquad \sum_i G_{ij} \eta_{ik} = \eta_{jk} \qquad \forall j,k \qquad (15)$$

Constraints (3), (14)-(15) makes sure that the BOPS demand at retail stores not selected for expansion is allocated to exactly one pickup point in their zone. The non-selected retail stores will continue to function as traditional retail stores for offline demand.

3) Demand satisfaction constraints

$$X_k^{Total} = \sum_i \beta_i D_i \eta_{ik} \qquad \forall k \qquad (16)\,; \quad \sum_i X_i^{pac} \eta_{ik} = X_k^{Total} \qquad \forall k \qquad (17)$$

Constraint (8) for demand satisfaction remains the same in the modified requirement space also. Constraints (8), (16)-(17) ensures that the total BOPS demand, calculated as a fraction of the total demand at the retail store, is all satisfied.

4) Budget constraint

$$\sum_i \left(E_i^f + \left(M_i - C_i^l \right) E_i^v \right) A_i \leq B \qquad (18)$$

Constraint (18) represents the budgetary restrictions on the total cost of expansion of retail stores which includes the total fixed and variable costs of expansion. Along with these, the scope of expansion and capacity constraints define the requirement space for the problem under study.

F. Objective Function Formulation

The objective of the optimization model is to minimize the total cost of the SC network given in (19). The total cost comprises of fixed and variable cost of expansion of selected retail stores, penalty cost for under-utilization of capacities of selected retail stores, packaging cost of BOPS orders at the pickup points, transportation cost from distribution centers to pick-up points, and the cost of transferring the BOPS demand of a retail store not selected for expansion to one of the selected retail stores.

Minimize:

$$f_1 = \sum_i A_i \left[E_i^f + \left(M_i - C_i^l \right) E_i^v + C^{penalty} \left(C_i^u - M_i \right) \right] + \sum_i P_i X_i^{pac} + \sum_i d_{il} A_i T + \sum_i \sum_j O_{ij} G_{ij} \beta_j D_j \tag{19}$$

Upon further analysis and discussions with the decision makers of the firm, it was understood that the selection of retail stores for setting up pickup points for BOPS should not be dependent solely upon cost. The retail stores considered should be evaluated on some other criteria as well such as the retail stores' accessibility, their attractiveness which is described as the presence of some public places nearby like schools, parks, offices; population characteristics of the area where the retail store is located like the age group, income, whether or not they own a car, and so on. Along with these criteria, operational and inventory carrying cost at the selected retail stores also play an important role in selection. The model minimizes the expansion cost and the additional cost that the firm will have to bear for satisfying BOPS type of demand. Therefore, the decision makers of the firm were asked to provide zone wise utility score of each of the retail store considered for expansion on the basis of the criteria listed in Table V. The weights of these criteria are calculated using Analytical Hierarchy Process (AHP). Since there are huge number of criteria, we have first classified the criteria into five key criteria for applying AHP. The list of the key criteria and their respective weights is given in Table XII in Appendix. The utility scores of the retail stores have been determined based on these criteria using Complex Proportional Assessment (COPRAS) zone-wise. Table XIII in Appendix gives the final zone-wise utility values of the retail stores based on the criteria listed in Table XII in Appendix. Therefore, a second objective function to maximize the utility scores of the selected retail stores is defined as follows: Maximize:

$$f_2 = \sum_i u_i A_i \tag{20}$$

TABLE V: EVALUATION CRITERIA

Criteria	Description	References
Inventory Carrying Cost	The per unit inventory carrying cost at the retail store	[65], [66]
Expansion Cost	The per square foot expansion cost of the retail store	[65], [67], [68]
Labor Charges	The monthly average labor charges at the retail store	[65]
Operational Cost	The average monthly operational cost of the retail store	[65]-[67], [69]

Workforce Availability	The availability of additional workforce at the retail store	[70]
Scope of Expansion	The possibility of expansion of the retail store as pick-up point	[67]-[69], [71]
Size of Offline Demand	The average daily traditional demand at the retail store	[65], [66], [69]
Responsiveness to Customers	Responsiveness towards customers' demand which affects the waiting time of the customers	[30]
Inventory Carrying Capacity	The total inventory carrying capacity of the retail store	[19], [29], [71]
Ease of Accessibility	The ease of access of the retail store to the customers which includes parking convenience, vehicle traffic density, store visibility, distance to main road, etc.	[65]-[67], [72]-[73]
Proximity to Demand	The average distance that the customers are covering to come to that retail store	[65], [69], [72], [74]
Percentage Elderly	The percentage of elderly population among the potential customers of the retail store	[65], [69]
Educational Level	The average educational level of the potential customers of the retail store	[65]
Population Density	The density of population in the neighborhood of the retail store	[65], [67], [69], [71]
Purchasing Power	The purchasing power of the residents in the neighborhood of the retail store	[65], [67], [71]
Number of Checkout Counters	The total number of available checkout counters at the retail store	[64], [71]-[72]
Assortments of Products	The number of assortments of products of the retail firm being sold at the retail store	[65], [69]
Magnet	The presence of crowd points which include organizations like hospitals, markets, hotels, cultural and educational organizations, government and business organizations, vehicle maintenance and relaxation factors etc. near the retail stores	[66]-[67]

The second objective is to maximize the overall performance scores of the retail stores selected for expansion which ensures that retail stores best suited as pickup points are selected for expansion represented in (20).

Thus, the final bi-objective optimization model is as follows:

(P1) Minimize: $f_1 = \sum_i A_i \left[E_i^f + \left(M_i - C_i^l \right) E_i^v + C^{penalty} \left(C_i^u - M_i \right) \right] + \sum_i P_i X_i^{pac} + \sum_i d_{il} A_i T + \sum_i \sum_j O_{ij} G_{ij} \beta_j D_j$

Maximize:

$f_2 = \sum_i u_i A_i$ Subject to, (3), (9)-(18)

$$\gamma_i A_i \geq \gamma_k^T \eta_{ik} \quad \forall i,k \tag{21}$$

$$\delta_i A_i \geq \delta_k^T \eta_{ik} \quad \forall i \tag{22}$$

$$G_{ij}, A_i = \{0,1\} \quad \forall i,j \tag{23}$$

$$X_i^{pac}, X_k^{Total}, M_i \geq 0 \text{ and integer} \quad \forall i,k \tag{24}$$

Constraints (21) and (22) ensure that the selected retail stores must satisfy the minimum threshold level corresponding to each retail zone for accessibility and attractiveness scores of the pickup points respectively. Constraints (23) and (24) impose the binary, non-negativity, and integer restrictions on the decision variables.

Since, problem (P1) is a bi-objective optimization problem, the two objectives may be conflicting in nature. In such a case, decision makers look for Pareto optimal solution set of the problem. In contrast, the solution of a single objective problem can be determined within reasonable time. Due to this, the problem discussed in this paper is converted into a single objective model using weighted goal programming approach. The bi-objective problem is solved using goal programming approach as it helps in achieving a trade-off between the conflicting objectives based on decision makers' preferences. Other methods such as weighted sum method, ε-constraint method, lexicographic method, etc. do not suit the current requirements of the decision makers. In weighted sum method, all the objectives should be of same type which is not the case in this problem. In the ε-constraint method, one primary objective is selected to be optimized from among the set of multiple objectives and rest of the objectives are treated as constraints. In the current study, the decision makers want to optimize both the objectives simultaneously with minimum compromise. Thus, in our case, goal programming methodology is the best suitable.

IV. Goal Programming Formulation:

Goal programming is a powerful, flexible and widely used multi-objective optimization methodology [75]. The aim of goal programming approach is to minimize the deviation of the level of achievement of an objective from its aspired level [76]. Initially, goal programming model was given by [77] to solve single objective linear problems; later it gained popularity as an effective approach to solve multi-objective linear problems [78]. It became popular because the model is simple and easy to apply [79]. The primary objective in goal programming methodology is to reach as closely as possible to the aspiration values set by the decision makers for conflicting goals to derive the best possible compromised solution [75]. The formulation of a standard goal programming model, minimizing the deviational variables associated with every objective function $f_i(x)$, is given below [80]:

(P2) Minimize: $$Z = g\left(\upsilon_i^+, \upsilon_i^-; i = 1, 2, ..., m\right) \quad (25)$$

subject to

$$f_i(x) + \upsilon_i^- - \upsilon_i^+ = \phi_i \quad \forall i = 1,2,...,m \tag{26}$$

$$x \in S \tag{27}$$

$$\upsilon_i^+, \upsilon_i^- \geq 0 \qquad \forall i = 1,2,...,m \tag{28}$$

Here, $g(.)$ denotes the achievement function which is a function of both the positive (υ_i^+) and negative (υ_i^-) deviations in the objective function values from the aspiration level represented by ϕ_i [78]. S denotes the set of feasible solutions for the multi-objective problem and m represents the number of goals (objective functions) in the problem. The deviational variables used to formulate the achievement function depends upon the type of goal. Different scenarios are represented in Table VI given below. The achievement function of the goal programming problem can be represented in different forms as a result of several variants of goal programming problem. Some of these variants include Weighted goal programming, Lexicographic goal programming, Chebyshev goal programming, fuzzy goal programming, and so on [81]-[83]. From among these, we have used the weighted goal programming variant of the goal programming problem.

TABLE VI : DIFFERENT SCENARIOS OF GOALS IN GOAL PROGRAMMING PROBLEMS

TYPE	SCENARIO	UNWANTED DEVIATIONAL VARIABLE
$f_i(x) \leq \phi_i$	Less is better	υ_i^+
$f_i(x) \geq \phi_i$	More is better	υ_i^-
$f_i(x) = \phi_i$	Exact is better	υ_i^+, υ_i^-

In weighted goal programming problem, the weighted sum of the deviations is considered as the achievement function. These weights are provided by the decision makers involved in the decision-making process. The achievement function for a weighted goal programming problem can be represented as given below in equation (29):

$$g\left(\upsilon_i^+, \upsilon_i^-; i = 1,2,...,m\right) = \sum_{i=1}^{m} \left(\omega_i \upsilon_i^+ + \rho_i \upsilon_i^-\right) \tag{29}$$

where, ω_i and ρ_i are the weights for positive and negative deviations respectively such that [84]:

$$\sum_{i=1}^{m} \omega_i + \sum_{i=1}^{m} \rho_i = 1 \tag{30}$$

$$\omega_i * \rho_i = 0 \qquad \forall i = 1,2,...,m \tag{31}$$

Thus, the weighted goal programming formulation corresponding to problem (P2) can be written as problem (P3) given below: (P3) Minimize: $Z = g\left(\upsilon_i^+, \upsilon_i^-; i = 1,2,...,m\right) = \sum_{i=1}^{m}\left(\omega_i \upsilon_i^+ + \rho_i \upsilon_i^-\right)$ (32)

subject to

$f_i(x) + \upsilon_i^- - \upsilon_i^+ = \phi_i \quad \forall i = 1,2,...,m$ (33); $x \in S$ (34) ; $\upsilon_i^+, \upsilon_i^- \geq 0 \quad \forall i = 1,2,...,m$ (35)

Often the objectives in multi-objective models are conflicting in nature. Thus, the decision makers try to find a compromised solution which is most satisfying from the set of feasible solutions through weighted goal programming approach. As proposed by [85], the solution achieved by solving (P3) is a properly efficient solution of (P2).

Sometimes, when the deviations are measured in different units it becomes necessary to scale them to handle the problem of incommensurability. In that case, the achievement function of the weighted goal programming problem after normalization of deviational variables can be written as given below:

$$g\left(\upsilon_i^+, \upsilon_i^-; i = 1,2,...,m\right) = \sum_{i=1}^{m}\left(\frac{\omega_i \upsilon_i^+}{\theta_i} + \frac{\rho_i \upsilon_i^-}{\theta_i}\right) \tag{36}$$

where, θ_i is the normalization factor with respect to the i^{th} goal $\left(i = 1,2,...,m\right)$. These normalization factors can be generated using a number of normalization techniques available. Thus, in this paper we have used the following steps to solve the mathematical model formulated in the above section:

Step 1: Solve the mathematical model considering one objective at a time to obtain the aspiration values for each of the objectives as given below:

(P4) (P5)

Minimize f_1 and Maximize f_2

subject to $X \in A$ subject to $X \in A$

where X is the set of decision variables of problem P3 and A is the feasible set of that problem. Let f_1^* and f_2^* be the optimal solutions of problems P6 and P7 respectively. These values are treated as the target values for the two objectives.

Step 2: Using the aspiration levels determined in the above steps and introducing deviational variables in the problem with weights ω_1 and ω_2; such that $\omega_1 + \omega_2 = 1$ and $\omega_1 * \omega_2 = 0$, problem (P1) is transformed into a goal programming problem (P6) as follows:

(P6) Minimize: $Z = \omega_1 \upsilon_1^+ + \omega_2 \upsilon_2^-$ (37)

subject to

$\frac{f_1}{f_1^*} + \upsilon_1^- - \upsilon_1^+ = 1$ (38); $\frac{f_2}{f_2^*} + \upsilon_2^- - \upsilon_2^+ = 1$ (39); $\upsilon_1^+, \upsilon_1^-, \upsilon_2^+, \upsilon_2^- \geq 0$ (40); $X \in A$ (41)

The next section presents the numerical illustration of the case of the Indian multi-channel firm for model validation.

V. Results

The bi-objective problem is first solved as two single objective problems keeping the other objective as a constraint in Lingo 11.0 (based on the above discussed data) to obtain the aspiration levels of both the objectives. When the model is solved for the first objective, that is the cost minimization objective, the model yielded a cost of INR 5,86,512 and the total utility value of 2.8620 with expansion budget utilization of INR 4,84,095 and incurred penalty cost is INR 5,460. The retail stores selected for expansion as a pickup point in each zone are encircled in Fig. 3 in Appendix. The expanded capacity of selected retail stores is given in Table VII. On the other hand, when the model is solved for maximization of utilization objective, that is the second objective, it leads to a different result. The total utility value obtained in this case is 4.6637 which is achieved at the total cost of INR 7,99,155. The retail stores selected for expansion in this case are encircled in Fig. 4 in Appendix. INR 6,99,860 has been utilized for expansion out of the total expansion budget bearing a penalty cost of INR 13,160. Table VIII gives the expanded capacities of selected retail stores. The results clearly show a conflict in the two objectives. Thus, weighted goal programming approach has been utilized in this paper to achieve the best possible solution.

TABLE VII: Expanded Capacities of Selected Retail Stores Corresponding to First Objective

S. No.	Retail Store	Retail Zone	Retail Store Location	Current Capacity	Expanded Capacity
1	RS1	1	Great India Place, Noida	160	218
2	RS4	2	Janak Palace, Janakpuri	140	218
3	RS6	3	Ambience Mall, Gurugram	170	221
4	RS8	3	Galleria Market, Gurugram	140	179
5	RS11	4	City Square Mall, Rajouri Garden	140	206
6	RS12	5	Select City Walk, Saket	140	214
7	RS16	6	MGF Mall, Gurugram	130	181
8	RS19	7	Model Town	120	170

TABLE VIII :Expanded Capacities of Selected Retail Stores Corresponding to Second Objective

S. No.	Retail Store	Retail Zone	Retail Store Location	Current Capacity	Expanded Capacity
1	RS1	1	Great India Place, Noida	160	184
2	RS2	1	Mall of India, Noida	170	204
3	RS4	2	Janak Palace, Janakpuri	140	170
4	RS5	2	Sector 5, Dwarka	110	158
5	RS6	3	Ambience Mall, Gurugram	170	221
6	RS7	3	M G Road, Gurugram	140	179
7	RS9	4	Unity One Mall, Rohini	140	161
8	RS10	4	Rajouri Garden	140	189
9	RS14	5	Khan Market	130	204
10	RS15	6	DLF Promenade, Vasant Kunj	180	206
11	RS16	6	MGF Mall, Gurugram	130	156
12	RS19	7	Model Town	120	170

TABLE IX :Expanded Capacities of Selected Retail Stores with Equal Weights for Objectives

S. No.	Retail Store	Retail Zone	Retail Store Location	Current Capacity	Expanded Capacity
1	RS2	1	Mall of India, Noida	17~~6~~0	228
2	RS4	2	Janak Palace, Janakpuri	14~~6~~0	194
3	RS5	2	Sector 5, Dwarka	110	134
4	RS6	3	Ambience Mall, Gurugram	170	221
5	RS8	4	Galleria Market, Gurugram	140	179
6	RS10	4	Rajouri Garden	140	206
7	RS14	5	Khan Market	130	204
8	RS15	5	DLF Promenade, Vasant Kunj	180	206
9	RS16	6	MGF Mall, Gurugram	130	156
10	RS19	7	Model Town	120	170

To obtain the compromised solution using weighted goal programming, the objective function values obtained by solving the single objective models are taken as the aspiration values for both the objectives respectively. For solving the model, the decision makers of ABC firm are asked to provide the weights of both the objectives. Initially, they wanted to attain a compromised solution by giving equal importance to both the objectives. Thus, by inputting the value of $\omega_1 = \omega_2 = 0.5$, the model was solved by developing a Lingo code (Lingo 11) for (P5). The compromised solution obtained yields a cost of INR 6,75,042 and overall utility value of 3.8047. The retail stores selected for expansion are encircled in Fig. 5 in Appendix and their expanded capacities are listed in Table IX. The total budget utilization for expansion in this case is INR 5,78,095 with penalty cost of INR 9,240. It can be clearly seen from the results obtained that the model has successfully achieved a trade-off between the two objectives.

A. Discussions

The results obtained by solving the single objective models show that both the objectives conflict in nature and it is imperative for the firm to determine the best possible compromised solution. For this purpose, the decision makers at the ABC firm decided to solve the model by giving equal importance to both the objective functions. To further elucidate the applicability of the model developed and results obtained, the baseline model, without considering the retail zones was solved. It was observed that, upon solving the model for the first objective, that is cost minimization, only four retail stores: RS3, RS4, RS11 and RS16 were selected for expansion. The minimum cost obtained was INR 3,65,821. On the other hand, when the model was solved for utility maximization, eleven retail stores were selected for expansion while achieving a utility value of 4.9585. However, no retail store was selected from zone 5. Therefore, to increase the reachability of the pickup points, it is pertinent to categorize the retail stores into different zones.

Further, the results obtained by solving the weighted goal programming model of model (P1) successfully achieved a trade-off between the two objectives. The results obtained demonstrate that the most efficient compromised solution has been obtained with approximately 83% budget utilization. Due to under-utilization of the allocated budget, the decision makers at ABC firm wanted to understand the changes in the compromised solution when the expansion budget is decreased. Also, they wanted to understand whether or not the increase in expansion budget will lead to a better utility value. Thus, for enhancing ABC firm's decision making and helping the decision makers in selecting the best possible combination of retail stores to be expanded as pickup points we conducted variational analysis. Upon further discussion with the decision makers of the firm, it was concluded that the value of β_i, that is the percentage BOPS demand at i^{th} retail store varies between 10% to 30%. Thus, to strengthen the results obtained, a variational demand analysis is conducted by varying the values of β_i between 10% to 30% for each retail store to understand the effect of

BOPS demand on the optimal design of the problem. Hence, the analysis conducted in this study is to observe the changes in the results obtained if the weights of importance of both the objectives are changed and how the model will react to changes in the expansion budget and percentage of BOPS demand. Conducting variational analysis helps in determining the answers to various 'what if' questions which leads to better, more informed decision making. The insights obtained from such analysis often provides implications which are more useful than the numerical results obtained by solving the model [86].

Therefore, for this purpose, first the analysis of aspiration values determined by changing budget values has been done. Then, along with different budget values, to understand the relationship between demand and the decision variables, the values of β_i are varied between 10% to 30%. Finally, the weights of both the objective functions are varied to see their implications on budget utilization and achievement of aspiration of both the objectives. The discussions based on the results obtained in both scenarios are presented in the following sections.

1) Effect of change of budget value on the aspiration values of the two objectives.

The results obtained by solving the model highly depends upon the allocated budget for expansion. Thus, to derive better insights and to enhance decision making, the model is solved for different budget values. Discussions are held with the decision makers of the firm and it was decided to solve the model keeping the budget value for expansion of retail stores at INR 9,00,000, INR 8,00,000, INR 6,00,000, and INR 5,00,000 apart from the original budget value of INR 7,00,000. The results obtained are presented to the decision makers so that they can understand whether or not they will be able to achieve a better solution by increasing the expansion budget slightly and to understand the effects of decreasing the budget. The aspiration values for both the objectives corresponding to each of the budget values derived by solving the single objective models is given in Table X. As can be seen from the results obtained, the aspiration value for cost objective function is indifferent to the changes in the expansion budget. But upon decreasing the expansion budget value beyond INR 4,83,485, we found that the single objective model of cost minimization was infeasible. Therefore, it can be said that to set up pickup points for BOPS, ABC firm should have a minimum budget value of INR 4,83,485. Also observing the aspiration values for the second objective, that is utility maximization, (given in Table X), we can conclude that increasing the expansion budget beyond INR 7,00,000 has marginal effect on the aspiration level. Whereas, decreasing the expansion budget has significantly higher effect on the aspiration values of the second objective function. Therefore, if ABC firm slightly decreases its expansion budget beyond INR 7,00,000; the firm is compromising on its second objective significantly. Thus, the inference drawn is that contrary to the perception that increasing the budget is proportional to increase in the total utility score, the analysis shows that budget value of INR 7,00,000 is the most suitable for generating a desirable result.

TABLE X: TARGET VALUES OF OBJECTIVES CORRESPONDING TO VARYING EXPANSION BUDGET VALUE

S. No.	Expansion Budget Value	Aspiration Value for Minimization of Cost Objective	Aspiration Value for Maximization of Utility Objective
1	900000	586512	5.4512
2	800000	586512	5.0928
3	700000	586512	4.6637
4	600000	586512	3.8785
5	500000	586512	3.0092

2) Effect of change of percentage of BOPS demand on the results obtained.

To understand the effect of change of percentage of BOPS demand on the results obtained, we have varied the value of β_i, that is the percentage BOPS demand at i^{th} retail store, between 10% to 30% while keeping the budget fixed at INR 7,00,000. The results obtained are documented in Table XI below. Table XI demonstrates that with the increase in BOPS demand, the aspiration value for utility objective decreases. This is because in order to maximize the value of utility objective, the model selects maximum possible retail stores within the budget allocated. Clearly, to satisfy the increase in demand under budget restriction and demand satisfaction constraints, the model is compelled to select the retail stores with less utility value within the zone. As a result, the aspiration values of the utility objective decrease with increase in demand. On the other hand, the aspiration values of the cost objective increase as the demand increases. The model, however, is infeasible for $\beta_i = 30\%$ as with a high increase in demand, budget restriction and/or the capacity constraints are violated. Upon further analysis, it is understood that the model remains feasible with increase in the budget allocated for expansion, which clearly indicates that infeasibility is due to the capacity constraint. If the demand increases beyond 28%, the current retail stores will not be able to handle the pickup demand. In that case the firm will have to set up dedicated pickup points for picking up the BOPS type of orders in the zones where demand is beyond 28%. Therefore, it can be concluded that for the current case, BOPS demand up to 28% can be handled by the available retail stores. If the demand increases beyond 28%, the firm will have to determine other locations for setting up a pickup point or a pickup point cum retail store based on the requirement.

TABLE XI: RESULTS OBTAINED BY VARYING PERCENTAGE OF BOPS DEMAND BETWEEN 10% TO 30%

VALUE OF β_i	ASPIRATION VALUE FOR MINIMIZATION OF COST OBJECTIVE	ASPIRATION VALUE FOR MAXIMIZATION OF UTILITY OBJECTIVE	MINIMUM COST ACHIEVED	MAXIMUM UTILITY ACHIEVED	BUDGET UTILIZED	PENALTY FOR UNDER-UTILIZATION OF RESOURCES	NUMBER OF RETAIL STORES SELECTED
10%	434078	4.8908	434078	2.4940	372305	6660	7
15%	478801	4.7089	531873	3.0678	449600	6360	8
20%	580107	4.6366	664010	3.6925	559420	7980	10
25%	769097	4.1018	820163	4.1018	699495	7860	11
30%	Infeasible	-	-	-	-	-	-

3) Effect of change of budget value and weights of importance on budget utilization and achievement of aspiration.

Further, to understand the achievement of aspiration and budget utilization with respect to each expansion budget value for different sets of weights, the weighted goal programming model is solved keeping the weights of both the objectives between [0,1] such that $\omega_1 + \omega_2 = 1$. The weighted goal programming models for all the 5 expansion budget values and their corresponding aspiration values are given in Table X. To improve the decision making, percentage utilization of the allocated budget for expansion for each combination of weights and budget value is also done. It was observed that the lower the budget value, the higher the utilization. But decreasing the budget value beyond INR 7,00,000 leads to significant decrease in the aspiration level of the second objective function. Therefore, decreasing the allocated budget beyond INR 7,00,000 may not be suitable for ABC firm and increasing the budget allocation for expansion will lead to lower budget utilization. Therefore, it can be concluded from the analysis that the current budget value of INR 7,00,000 is most appropriate for expanding some of the ABC firm's retail stores as pickup points for BOPS orders. Further analysis of the percentage variation from the achievement values for both the objectives the weights of importance, it was observed that in most of the cases, giving preference to cost objective function over the second objective leads to the achievement of aspirations. But higher expansion budget value leads to exorbitant percentage increase in the cost value from the aspiration level. Similarly, the utility value achieved is highly sensitive to the priority weights of the two objective functions. These insights can be used for the firm to decide which efficient solution best suits their requirements.

VI. Managerial and Theoretical Implications

This paper attempts to fill the gap in the existing literature on the adoption of OCR and the reconfiguration of SC network. The model developed in this study will help the retail firms in emerging economies who want to venture into OCR. This research will help the decision makers in such firms in strategic implementation of BOPS fulfilment options for their customers for gaining organizational benefits and competitive advantages. It helps the firms to optimally utilize their available resources for bringing innovation in their existing operations which, in turn, leads to operational efficiency. Following are the managerial and theoretical implications that can be drawn from the current study:

A. Managerial Implications

The study aims to provide the decision makers of multi-channel firms with an understanding of the issues at the strategic and operational levels so that they can effectively offer the BOPS option to their customers as a part of their omni-channel initiative. The following managerial implications can be drawn from this study:

- From the practical perspective of BOPS adoption, the study highlights the importance of retail stores' appropriateness to function as pickup points. More and more retailers are trying to implement BOPS. But managers should understand that selecting retail stores for expansion as pickup points solely on the basis of cost will not be beneficial. They should realize that certain factors like the accessibility of the retail store and its attractiveness play an important role in selection. Therefore, it becomes imperative for managers to carefully look at nuanced role of such characteristics of firm's retail stores in creating value of omni-channel initiatives like BOPS which require substantial capital investments.

- When deciding which retail stores should be expanded, the retailers may be tempted to expand all of their retail stores in anticipation of gaining profits. However, adopting this all-inclusive strategy may lead to conflicts between demand, unavailability of product for walk-in customers, reduced workforce efficiency, and so on and it incurs a large amount of capital investment. Therefore, it is clear that if retailers adopt a selective strategy, that is, expanding some of its retail stores as pickup points, it will lead to cost saving. Strategic selection of such retail stores will also help the firm in avoiding the above-mentioned problems. Our bi-objective optimization model assists the retail firms in deciding which retail stores should be expanded considering various factors like demand, available capacity, expansion cost, etc. Apart from selection, the model also helps the managers in deciding the expanded capacities of those retail stores.
- Capacity expansion is an important strategic decision while setting up pickup points at the retail stores. The managers need to decide the expanded capacities of the selected retail stores. The model helps the managers in deciding the expanded capacities of the retail stores selected as pickup points to handle the pickup operations. In the current scenario, the capacity of the retail store is expanded to increase the functionality of the retail store. It is the one of the major investments that the decision makers of the firm have to make for handling pickup operations. This study helps the managers to determine capacities based on the total demand at the retail store. A number of researchers have explored upon the capacity expansion but very few have addressed the issue of capacity expansion for increasing the scope of operations at the retail store. The current model helps the managers to select the most suitable expanded capacities to offer an additional fulfilment option to their customers.
- As highlighted by Kibo Commerce, there was a surge in BOPS type of orders during the pandemic [24]. A similar trend was seen in the Indian apparel retail industry. Due to the presence of a huge variety of fabrics and common fraud in online delivery of the apparel, customers want to personally touch and feel the clothes before making a final purchase. Because BOPS provides this option to the customers, BOPS became a

preferred retail strategy for many firms during the pandemic [87]. Thus, the retail firms adopted an all-inclusive policy of functioning all their retail stores as pickup points for offering BOPS. As there was no traditional offline demand at that moment and customers were opting for online channel or BOPS channel to limit their human interactions, firms were able to handle BOPS demand at the retail stores. But now when the worst of the pandemic is behind us, customers want to continue using these OCR options. This has presented a challenge for retail firms who have adopted BOPS as a measure to endure their sales during the pandemic [87]. Now since markets are re-opening, people have once again started visiting the retail stores, and it has become difficult for retailers to manage both types of traffic at their retail stores. Thus, the current research helps the managers in such firms in selecting the retail stores for expansion as pickup points to handle both traditional and BOPS types of demand. It helps them in deciding the expanded capacities of the selected stores and how they can manage the BOPS type of demand of non-selected stores.

B. Theoretical Implications

From the theoretical perspective, this paper provides a tool for multi-channel retail firms who want to launch a BOPS fulfilment option as a part of their OCR strategy. Based on the above study, the following theoretical implications can be drawn:

1) Strategic and operational decision making:

The optimization model developed in this paper helps the retail firm in simultaneously making the strategic decision of which retail stores to be selected for expansion and the operational decision of allocating BOPS demand of other retail stores to the selected stores. This can significantly benefit the retail firm's performance as it leads to effective utilization of resources, higher demand satisfaction, and better customer satisfaction. Selecting the retail stores to be expanded as pickup points is a crucial decision in launching BOPS as highlighted by [33]. Therefore, this research contributes to the literature in this context.

2) *Resource-based view:*

The idea of utilizing firm's existing retail stores for fulfilling BOPS orders can be supported by the theory of resource-based view and dynamic capabilities. In dynamic capabilities theory under resource-based view, 'the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments' is considered [88]. These changes can include combining, transforming or renewing the firm's existing resources into new competencies as the market evolves to gain competitive advantage [89]. In this paper, the existing resources of the firm are optimally utilized to help the firm in launching a BOPS fulfilment option and thus gaining competitive advantage.

3) *Development of facility location selection model:*

Facility location selection is a well-researched and developed field in SC literature [37]. Researchers have developed models for capacitated facility location [38], facility location selection for waste collection [39], facility location selection for relocation [40], facility location selection for closed loop SC [41], facility location selection from the perspective of triple bottom line [42], and so on. But to the best of our knowledge very few researchers have studied the facility location problem for functionality expansion. The model proposed in this study is a step in this direction. The model contributes to the SC literature for facility location selection through which the existing facilities of any firm can be selected for expansion to increase the scope of operations of that facility. Apart from selection, the model also helps in determining the expanded capacities of the selected facilities. The model is validated with the help of a case study of OCR, but the robustness of the model is such that it can be easily generalized and modified for any other scenario.

4) *Configuration of model as a bi-objective programming formulation:*

It has been stated by a number of researchers that the adoption of omni-channel strategy requires huge investments [4]. Restructuring the SC to be in-line with the modified fulfilment option is essential [23]. Retail store selection done through this model is an effective and efficient one which satisfies the demands of both the offline and BOPS customers through retail stores in the best possible manner. By optimally expanding its retail stores based not just on the cost but also on the customers' preferences in terms of performance scores of the retail stores, a firm has higher chances of succeeding and gaining competitive edge. Therefore, the proposed facility selection model is configured as a bi-objective programming formulation which minimizes the cost and maximizes the performance scores (utility). The ultimate aim of this bi-objective optimization model is to help the firm in adopting BOPS in such a way that the demands of both the channels are satisfied effectively.

5) *Real-life validation:*

The model presented in this research is validated with the help of the real-life implementation of an Indian multi-channel retail firm. This helps in understanding the unique functionalities of the model and how it can be applied to various other case studies. Moreover, considering the case of an Indian firm makes the paper unique as no such study in emerging economies has been done to this date by researchers.

VII. Conclusion

The study depicts the strategic implementation of OCR by multi-channel retail firms in emerging economies. The paper is focused on the first step of restructuring the SCs for providing BOPS fulfilment option to customers, that is, the expansion of firm's existing retail stores as pickup points. The uniqueness of the study can be highlighted by the fact that: (i) the study provides a framework for adopting OCR by multi-channel retail firms in emerging economies, (ii) it helps the retail firms in selecting the retail stores for expansion as pickup points based on demand, budgetary restrictions, retail stores' performances, and so on, and (iii) it helps in deciding the expanded capacities of the selected retail stores. This has been realized through configuration of the facility selection model as a bi-objective optimization model with the two objectives of cost minimization and performance (measured in terms of utility based on multiple criteria) maximization. Weighted goal programming approach is utilized for solving the bi-objective model and obtaining a trade-off between the conflicting objectives. The proposed model is validated with the help of a case of an Indian multi-channel retail firm from apparel sector. The firm wants to select at least 7 retail stores for expansion as pickup points from the shortlisted 19 stores divided into 7 retail zones. The retail stores are shortlisted on the basis of a number of criteria like operational cost, expansion cost, availability of workforce, online and offline demands, accessibility, attractiveness, population characteristics, and so on. Based on the data provided by the firm and their importance rating for both the objectives, the model is solved in Lingo 11.0 using weighted goal programming approach. As a result, 10 retail stores are expanded as pickup points by the retail firm. The positive outcomes of the model developed in this paper are: (i) the consideration of two objectives leads to better decision making as the retail stores are examined not just on the basis of cost but also considering customers' preferences in terms of performance scores, (ii) the model helps in taking the strategic decisions of selection of retail stores for expansion and deciding the expanded capacity of the selected retail stores along with the operational decision of allocating the BOPS demand of un-selected retail stores to the selected ones simultaneously which leads to better decision making, (iii) managerial insights are drawn related to these decisions that can help firms implement the BOPS fulfilment option of OCR.

A. Limitations and Future Scope

The study is developed under certain limitations which are discussed here along with suggestions for further research. Firstly, the performance scores of retail stores based on different criteria are calculated through focus group discussions among the decision makers. Instead of this qualitative approach of finding the scores, a more advanced quantitative approach like Multi-Criteria Decision Making (MCDM) can be used to determine the performance scores of the retail stores under consideration. Moreover, these scores should be calculated based on customers' opinion. Therefore, a survey should be done to determine the performance scores. Secondly, the uncertainties in the decision-making environment have not been considered in the development of the bi-objective mathematical model. To provide more flexibility, techniques like Fuzzy goal programming or intuitive goal programming, for example, could be used. Thirdly, within the Indian context, the model has been developed for a particular multi-channel retail firm. However, this model can be easily generalized for other retail firms venturing into OCR. Very few firms have adopted OCR in emerging economies to this point, so this model can serve as a starting point for implementation of BOPS fulfilment option for retailers. Also, the study only focuses on the selection and expansion of retail stores to function as pickup points; it does not describe how the SCs will have to be modified for this purpose. This can be done in future research as it would involve other complexities such as managing inventories and logistical flows across channels, overlapping demands and different lead times. Considering these limitations, in the future, a more comprehensive model can be developed for the current case. Some of the assumptions of the model can be relaxed to build a more exhaustive model. In future studies, the model can be modified to incorporate the case of unmet demand and the case where pickup demand is converted into online demand due to an unavailability of pickup points near the customer location. Moreover, the model can also be modified and validated for launching BOPS in Tier 2 and Tier 3 cities in countries like India. Also, in future, the selection and expansion of retail stores as pickup point can be done considering sustainable attributes. Moreover, studies can focus on risk evaluation of adopting BOPS fulfilment option by multi-channel retailers in emerging economies which is a good work in the future. Apart from this, the adoption of other omni-channel fulfilment strategies can be explored upon in the future. The model can be expanded to incorporate such fulfilment strategies.

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APPENDIX

TABLE XII

FINAL CRITERIA FOR EVALUATION OF RETAIL STORES

Notation	Key Criteria	Includes	Priority Weights
KC1	Cost	C1, C2, C3, C4	0.1851
KC2	Expansion Possibility	C6, C7, C9, C16	0.1711
KC3	Accessibility	C10, C11	0.3708
KC4	Attractiveness	C8, C17, C18	0.2175
KC5	Population Characteristics	C5, C12, C13, C14, C15	0.0555

TABLE XIII

FINAL UTILITY SCORES OF THE RETAIL STORES IN EACH ZONE

Retail Store	Zone	Utility Scores	Retail Store	Zone	Utility Scores

RS1	1	0.4860	RS11	4	0.3173
RS2	1	0.5140	RS12	5	0.3324
RS3	2	0.3731	RS13	5	0.3292
RS4	2	0.3084	RS14	5	0.3384
RS5	2	0.3186	RS15	6	0.5706
RS6	3	0.3945	RS16	6	0.4294
RS7	3	0.3163	RS17	7	0.3644
RS8	3	0.2892	RS18	7	0.3308
RS9	4	0.3459	RS19	7	0.3048
RS10	4	0.3368			

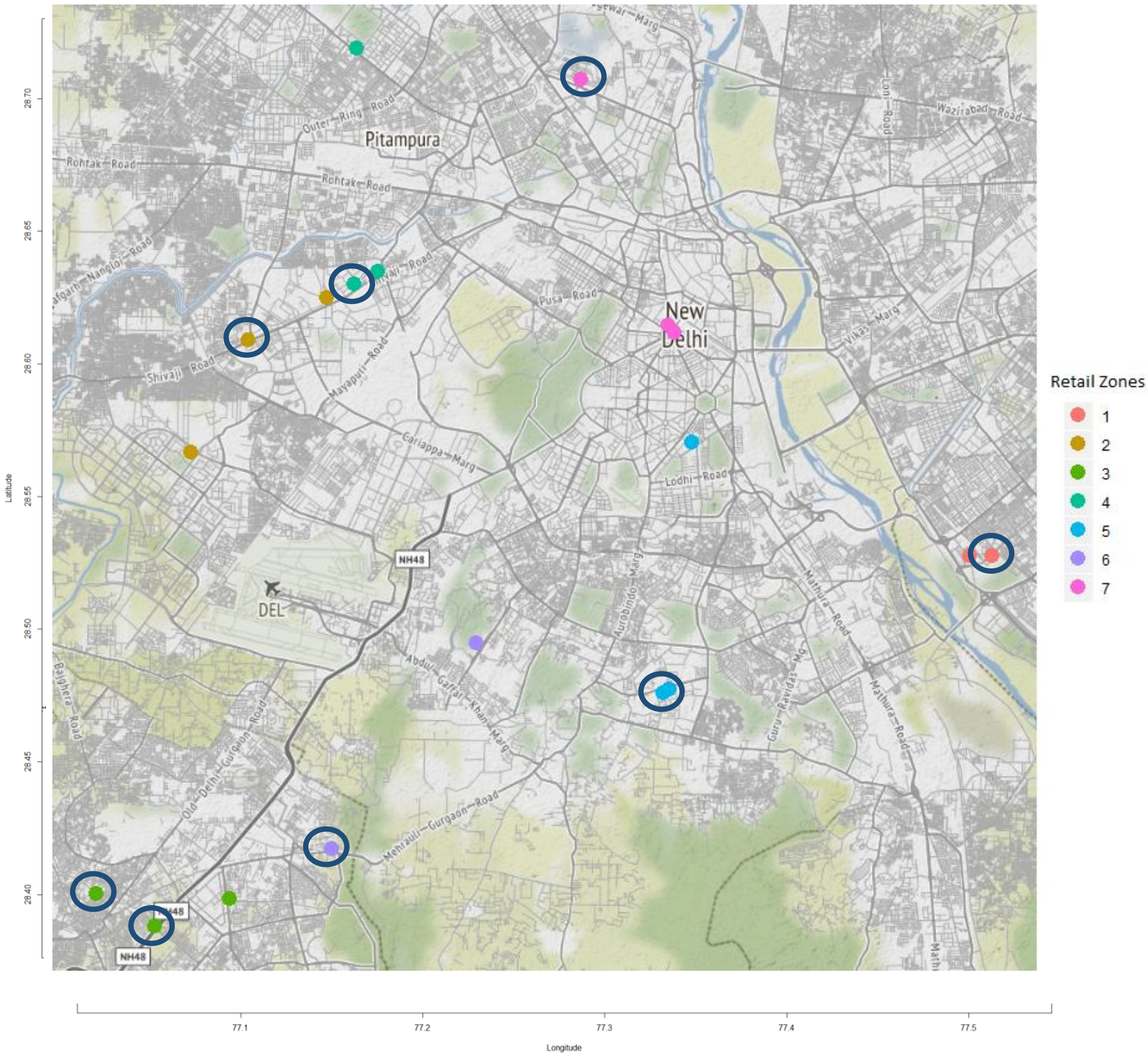

Fig. 3. Retail Stores Selected for Expansion Corresponding to First Objective

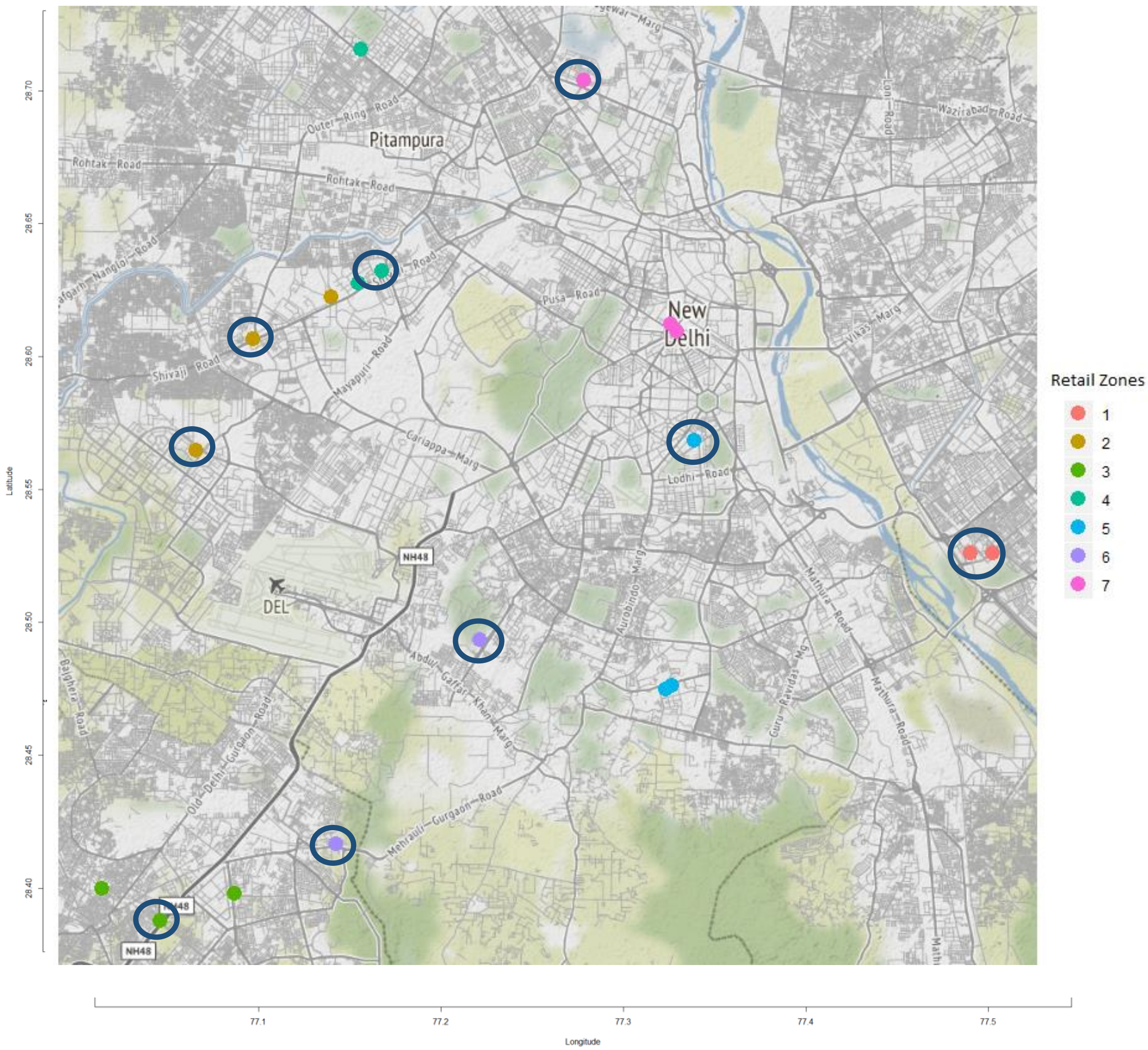

Fig. 4. Retail Stores Selected for Expansion Corresponding to Second Objective

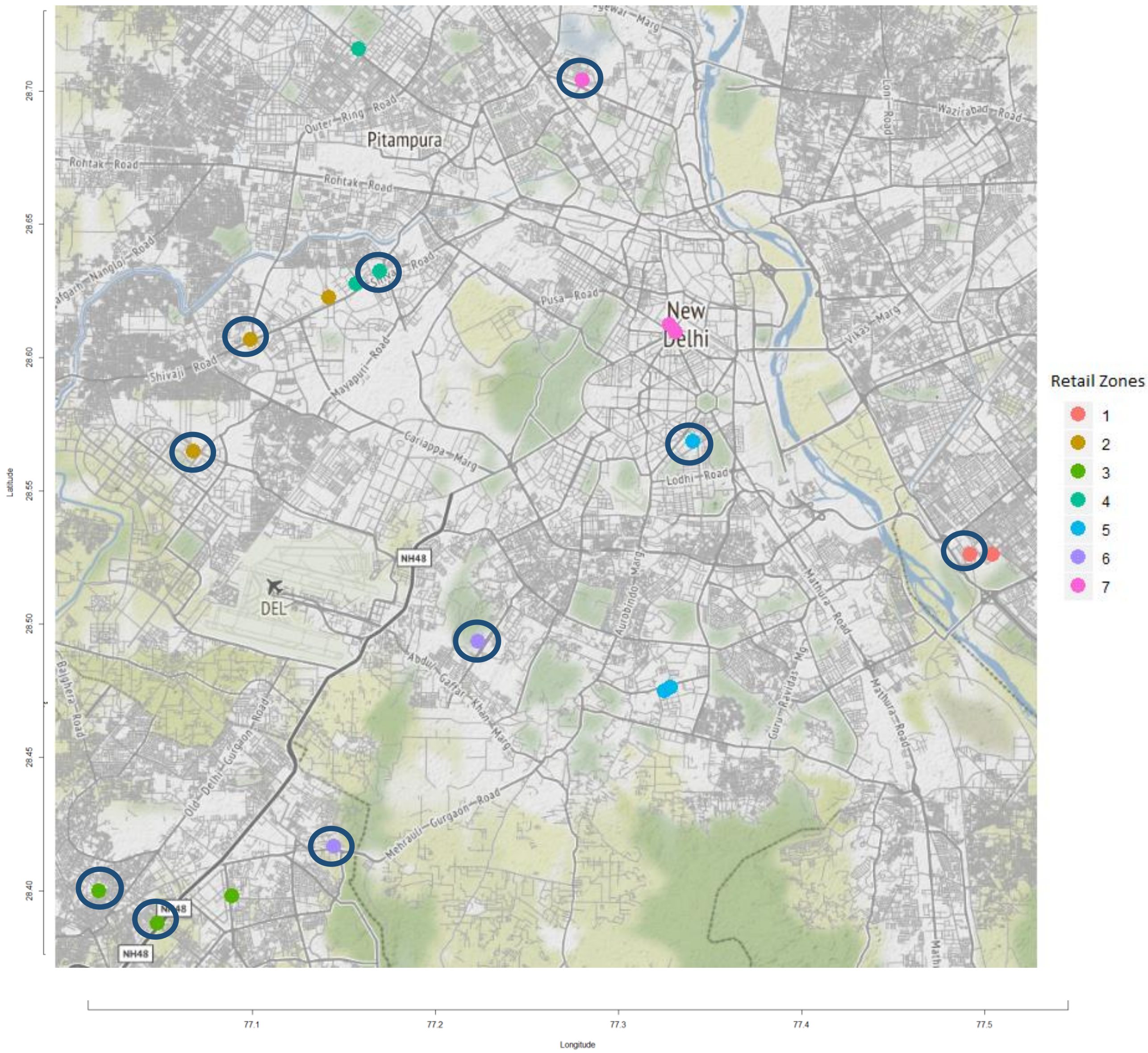

Fig. 5. Retail Stores Selected for Expansion with Equal Weights for Objectives