E-commerce Business-to-Business (e-B2B) Distribution Strategy and Network Design for Nanostores

by

Austin Iglesias Saragih
B.S. Industrial Engineering, Purdue University (2014)

and

Syed Tanveer Ahmed
B.Tech. Electrical Engineering, Indian Institute of Technology Bhubaneswar (2015)

SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE IN SUPPLY CHAIN MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2021

Signature of Author: ______________________________
Department of Supply Chain Management
May 14, 2021

Signature of Author: ______________________________
Department of Supply Chain Management
May 14, 2021

Certified by: ______________________________
Dr. Christopher Mejía Argueta
Research Scientist, Center for Transportation and Logistics
Director, Food and Retail Operations Lab
Capstone Advisor

Accepted by: ______________________________
Prof. Yossi Sheffi
Director, Center for Transportation and Logistics
Elisha Gray II Professor of Engineering Systems
Professor, Civil and Environmental Engineering

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ABSTRACT

With 50 million nanostores globally, nanoretailing is the most important retail channel in developing countries. In India, these stores are called kiranas, and they are the backbone of India's retail market. Unfortunately, the distribution to this massive retail segment is fragmented. Current fragmented channels of exclusive distributors, wholesalers, and stockists are costing kiranas more than 50% of their potential margins and impacting their business viability. A non-exclusive e-commerce business-to-business (e-B2B) distribution strategy can serve as a promising solution to reduce fragmentation, cost-to-serve, and increase potential margins in the industry. This research formulated a non-exclusive e-B2B distribution strategy at the lowest cost-to-serve and identified the essential urban network design factors for e-commerce platforms to consider. We extended the Two-Echelon Capacitated Location-Routing Problem (2E-CLRP) with the augmented route-cost estimation to consider wallet share, market penetration, frequency, drop size, and urban circuity factors. We also computed the Road Network Circuity Factor (RCF) values of several Indian cities. Our results indicate that, through e-B2B distribution, companies can achieve most of their cost savings and profitability when they reach certain threshold of wallet share and market penetration. Furthermore, geographical circuity constraints and increasing frequency of deliveries do not significantly increase logistics costs. In summary, we recommend that companies reach their threshold of wallet share and penetration to reduce costs optimally. Key initiatives to reach this target include sharing cost savings back to the nanostores, develop free shipping options and loyalty programs, increasing delivery frequency, and expanding to new service regions. Moreover, companies should not be afraid to increase their delivery frequency or open service in promising regions as these factors only slightly increase cost to serve. Although this project focuses on India, our findings are also applicable to other developing countries. A non-exclusive e-B2B distributor improves adaptability and affordability of nanostore supply chain operations and provides ample opportunities to for further research.

Capstone Advisor: Dr. Christopher Mejía Argueta
Title: Research Scientist, Center for Transportation and Logistics

ACKNOWLEDGMENTS

We are immensely grateful to our advisor Dr. Christopher Mejía Argueta, for his mentorship and support as our advisor and incredible expertise in nanostores and retail supply chain. Thank you for guiding us, teaching us to be great supply chain researchers, and for being approachable and amiable. We truly appreciate him and look forward to continue having him as our mentor professionally and personally.

Austin Iglesias Saragih, specifically would like to thank his parents: Roselyn Maria Sinaga and Freddy Rikson Saragih. Thank you for your supporting me to achieve this dream. Without their dedication and prayers, he would not be here today. This dream, which has been 21 years in the making, has finally come true. He would also like to thank my sisters: Stephani Putri Fajar, Patricia Utami Saragih, and Angelyn Olivia Karlina Saragih. Ad Majorem Dei Gloriam (AMDG).

Syed Tanveer Ahmed would like to thank God, the Almighty for his blessings throughout his journey and my family for their love and support. My mom, Sheereen Banu and dad, Syed Fiaz Ahmed have been pillars of support throughout my life and their sacrifices and constant motivation has led him to where he is today. He would like to thank his sister, Tasneem and brother-in-law, Mohammed Muzaffar for their support. Finally, his young nephews, Muhammed Uzair and Muhammed Umar for their sweet innocent love and keeping him in good spirits throughout his Micro Masters and MIT journey in these challenging times.

We would also like to thank our sponsoring company and its advisor for providing us with high-quality and granular data and guiding us on our project. We would like to thank Dr. Daniel Merchán and Dr. Matthias Winkenbach for providing access to their research and giving a few ideas in the preliminary stage of this capstone project.

Finally, we would like to thank the SCM program and CTL team for their hard work and dedication to all members of the SCM class of 2021. This has been a wonderful experience for us.

Austin Iglesias Saragih and Syed Tanveer Ahmed

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

Today, almost 90% of India's consumer packaged goods (CPG) manufacturers operate in fragmented channels. These channels consist of approximately a million individual distributors and wholesalers whose goods reach the kirana stores, serving millions of Indian consumers (Bhise, 2019). A kirana is a small, family-owned retail store. It is usually referred to as a nanostore, mom-and-pop store, or the traditional channel (Fransoo et al., 2017). This substantial retail market is facilitated through a long business-to-business (B2B) retail supply chain between the CPG manufacturers and the end consumers through multiple intermediaries (Kumar, 2019).

In India, at least 14 million kiranas exist and operate every day, and their characteristics and issues are very distinctive. Their small size makes distribution a logistics challenge. Other challenges include small distribution drop sizes, limited available cash, and minimal shelf space - especially in urban areas. Furthermore, Kin (2018) argued that kirana supply chain networks are highly fragmented due to different goals between manufacturers and kirana owners, which increases the cost to serve of this channel. An independent, online, and multi-brand distributor would fill the gap to address this issue and help to gain further efficiency in the fiercely competitive retail landscape and last-mile delivery environment.

India is a high-tech market with several companies leading business-to-consumer (B2C) e-commerce platforms. However, only a few have entered the CPG wholesale business to disrupt the decades-old exclusive distributor-led traditional fulfillment channels and improve the B2B retail value chain for brands and consumers. These e-commerce companies would directly serve the kiranas better, provided that it has a robust distribution strategy and comprehensive supply chain network model.

This research aims to formulate a non-exclusive e-commerce B2B (e-B2B) distribution strategy at the lowest cost-to-serve, at the highest service levels, and identify essential urban network design factors. Using geolocations of each kirana and the projected 5-year demand, delivery frequencies, projected market penetration[1], and wallet share[2], this study provides a comprehensive urban network supply chain strategy that entails the value proposition and the network model for e-commerce B2B distribution.

1.2 Motivation

Globally, billions of consumers buy their staples from up to 50 million nanostores worldwide. In developed countries, modern channel retailers are very dominant due to the larger purchasing power of the customers and the ability to provide cheaper products due to logistics efficiencies reach via door-to-door distribution strategies. However, the opposite is true in most developing countries. The traditional channels retailers can serve lower-income consumers through closer proximity, credit line offers, and the format of the kirana (Fransoo et al., 2017).

Kiranas are not only the backbone of India's everyday CPGs but also dairy products, fruits, and vegetables, including rice and pulses. The Indian Retail Industry Analysis by IBEF (Kamath, 2020) calculated that they comprise 80% of India's $ 1.1 trillion retail market. Typically, a kirana serves the needs of approximately 500 families in the neighborhood. With an average space of 300 ft^2 and

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[1] Percentage of stores (i.e., kiranas) subscribing to the e-B2B service provided by the e-commerce platform
[2] Percentage of goods in the store (i.e., kirana) distributed by the e-commerce platform

US$3,000 in inventory at any given time, a kirana offers roughly 2,500 SKUs, which vary in response to the socioeconomic composition of the neighborhood's and customers' preferences.

The most challenging problem of kiranas has been the considerably high cost to serve, which adversely affects their survival (Castañon-Choque, 2018). Limited capital, space, and technology prevent them from adequately stocking to fulfill demands, which leads to overstocking without a clear business strategy and less product availability. Moreover, most of the CPG manufacturers do not offer frequent visits to deliver their goods directly. As a result, store owners have no choice but to close their stores every few days to visit the closest wholesale market to buy their consumer's demands (Kamath, 2020). This condition results in loss of business, time, and money.

Moreover, kiranas' high fragmentation causes substantial distribution inefficiencies, especially in congested megacities. A solution is required to serve them efficiently, given the unique features of their commercial channels and logistics strategies, technological challenges, and others (Sponsor Company, 2020). However, tackling the logistics complexities of serving millions of kirana stores is a challenge that many face, yet few master. (Fransoo et al., 2017).

These two challenges emerged in designing a non-exclusive e-B2B distribution solution for these kiranas. Therefore, this capstone project addresses the challenges by cutting the fragments of distributors, reducing the cost to serve, and serving rapid replenishment to the kiranas. Kirana owners can benefit from the faster service to provide a better experience to their consumers. They can also benefit from a cheaper cost-to-serve to increase their wallet share. Brands can also increase their gross merchandise volume (GMV), and consequently, their margins. Finally, entering the B2B business will boost growth and foster forward-looking logistics approaches to serve kiranas.

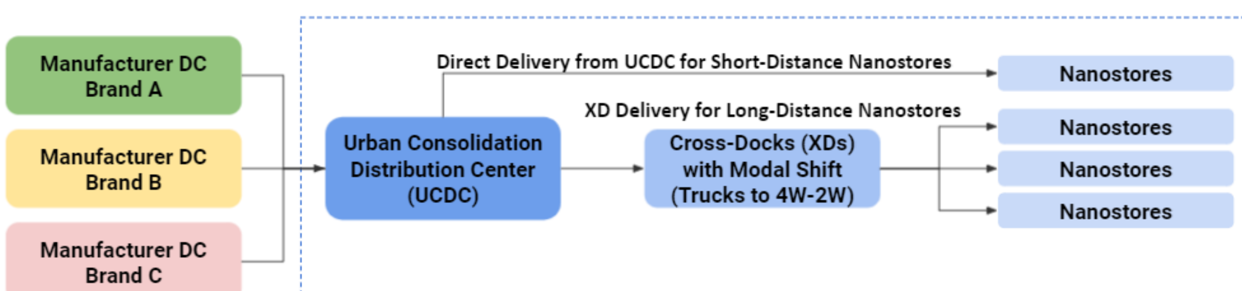
1.3 Research Problem

Our research questions are the following:

- What should be the e-B2B distribution strategy (see Figure 1.1) to serve kiranas at optimal cost subject to service levels?
- What factors of urban network design should be considered to implement the distribution strategy at different stages?

Figure 1.1

Scope of e-B2B Distribution Strategy and Network Design



To answer the first question, we develop a recommendation framework for e-commerce platforms. This framework becomes a guiding principle for companies to design their distribution from brand manufacturers to the kiranas. On distribution strategy, Spoor (2016) and Kin (2018) offer a variety of options: direct delivery to kiranas, delivery through cross-dock points or and urban consolidation centers (UCC), or a combination of both.

To answer the second question, a large-scale network design solution is developed to highlight the tradeoffs between penetration, wallet share, frequency, and urban circuity characteristics in achieving the objective for the platform. Sensitivity analysis of the network model is provided. Finally, we describe the key factors to be considered at different stages.

1.4 Methodology

Given a geographical region of kirana stores (i.e., demand points), whose aggregate demand distribution is known daily, a distribution network design model was built for the kirana stores via an e-commerce platform's distribution centers and cross-dock points. We use the following procedure to address the aforementioned research questions:

1. Cluster and segment the kiranas based on their characteristics.
2. Identify the drivers of logistics cost-to-serve, e.g., the frequency of kirana's orders, wallet share of kirana's orders fulfilled by the platform, the number of kiranas onboarded, the capacity of kiranas, types of vehicle, and so on.
3. Calculate road circuity values.
4. Compute the cost-to-serve objective function of the network.
5. Define the constraints and identify the tradeoffs in the optimization function.
6. Optimize the objective function subject to constraints with the continuous approximation method using Gurobi Software.
7. Perform sensitivity analyses over different urban geography settings of the optimization function with respect to parameters to discuss key observations.
8. Formulate short- and long-term recommendations and effort-impact matrix guidelines based on the network model results and the network's most critical parameters.

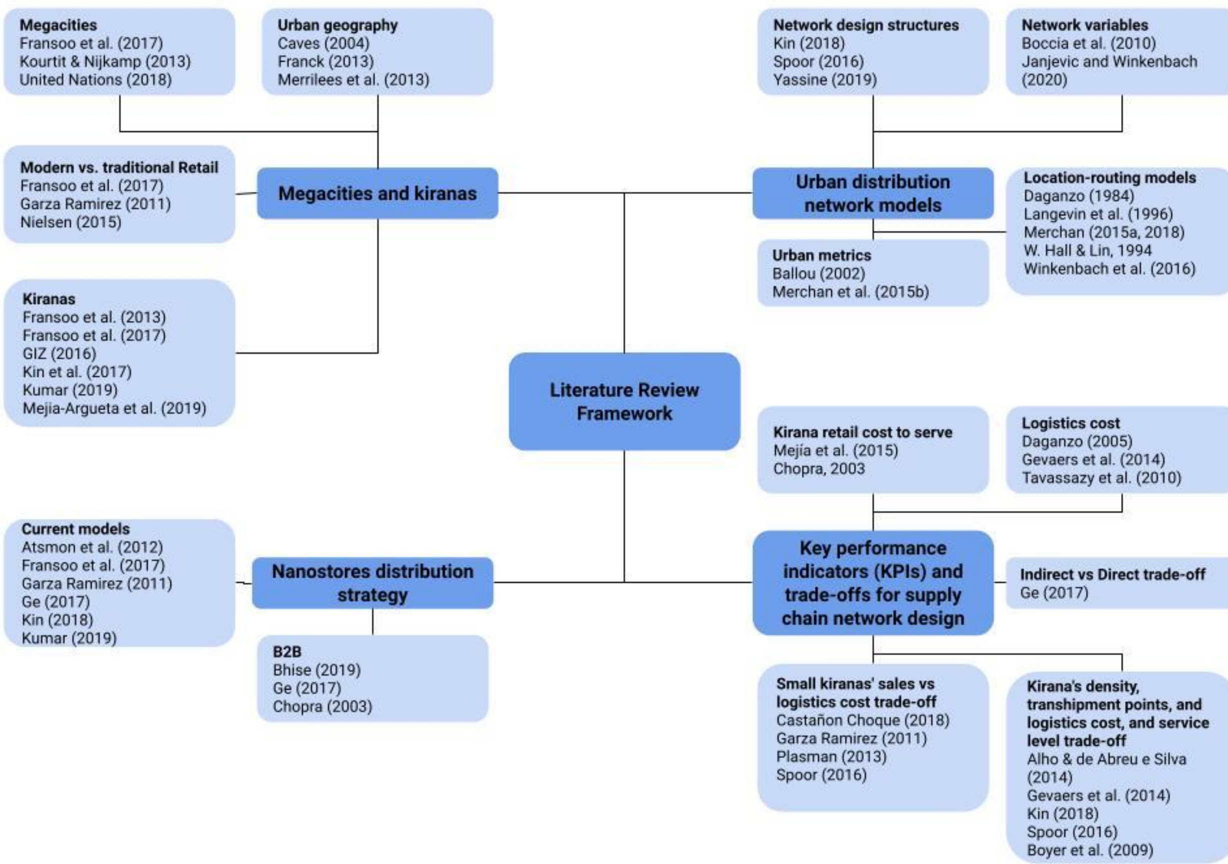
1.5 Summary

Kiranas are an integral part of the retail atmosphere. Unfortunately, current fragmented traditional distribution channels are costing the kiranas' their potential margins. Therefore, a non-exclusive e-B2B distribution strategy becomes a promising solution, and with an appropriate network design model, the strategy can generate a lower cost structure. To achieve this, we formulate a two-echelon location-routing problem (2E-CLRP) suitable for the large-scale distribution network design to minimize cost-to-serve to kiranas. Network model results show that companies should focus their resources on attaining the threshold of wallet share and penetration (see Chapter 4 and 5). In this project, the threshold for wallet share and penetration is 10%. Moreover, opening new areas or improving services should not deter companies as increasing frequency and network circuity do not substantially increase costs. The next chapter will review the works of literature pertinent to the project.

2 LITERATURE REVIEW

This chapter surveys the literature on kiranas, distribution strategies to serve them, current distribution network models, and key performance indicators (KPIs) to measure their performance (see Figure 2.1). The literature review is conducted to identify relevant works to our research goal: to build Business-to-Business (B2B) distribution strategies to serve kiranas at optimal cost and service levels; and urban distribution network models in addition to that. First, we discuss the current and future status of megacities and kiranas. Next, we review the existing distribution strategies, urban supply chain network models, KPIs, cost-to-serve approaches, and tradeoffs. The gaps in the literature and the specific contributions from our research are then presented.

Figure 2.1.
Literature Review Structure



2.1 Megacities and Kiranas

A megacity is a vast city, typically with a population of more than 10 million inhabitants. It is expected that the number of megacities will continue to grow, from 33 to 43 by 2030 (United Nations, 2018). The World Cities report from the United Nations finds that big cities "create wealth, generate employment and drive human progress" for entire nations. India is expected to have seven megacities by 2030 and remain the second most populated country globally.

The rise of megacities is due to three significant factors: 1) Demographic transition, due to both population increase and smaller household sizes; 2) Rural-urban migration as the economy depends less on agriculture and more on services; and 3) Geographic spread of urban areas by increasing the urban sprawl (Kourtit & Nijkamp, 2013). This increase will be most dramatic on the least-urbanized continents: Asia, Africa, Latin America, and the Caribbean. Surveys and projections indicate that developing countries will mainly drive all urban growth over the next 25 years. The emerging market economies in these developing countries will be characterized by high economic growth, the emergence of a sizeable middle class with different consumption patterns, and urbanization (Fransoo et al., 2017).

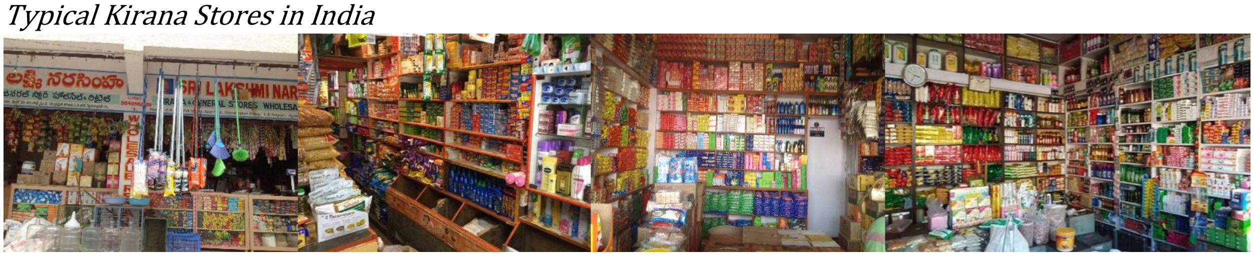
One can use urban morphology to classify urban regions which entail different logistical challenges. The 'core city' is the largest or most important city of a metropolitan area and is surrounded by smaller satellite cities, towns, and suburbs (Caves, 2004). 'Satellite cities' are smaller municipalities adjacent to a major city which is the core of a metropolitan area (Merrilees et al., 2013). A 'metropolitan area' or metro is a region consisting of a densely populated urban core and its less-populated surrounding territories. A 'conurbation' is a region comprising several metropolises, cities, large towns, and other urban areas that have merged to form one continuous urban or industrially developed area (Caves, 2004). 'Twin cities' are a particular case of two cities or urban centers founded in close geographic proximity (Franck, 2013).

Retailing in megacities depends on the presence of many retail outlets to serve the increasing populations. Retail outlets that sell consumer packaged goods (CPG) are diverse but broadly can be classified into two types. One type is stores belonging to the modern retail chains (e.g., Walmart, Carrefour). Modern retail stores include hypermarkets, supermarkets (of varying sizes), and smaller convenience stores or mini-markets (e.g., 7-Eleven), and these are owned by large companies (Garza Ramirez, 2011; Fransoo et al., 2017). The other type is traditional retail, which comprises independent retailers. Traditional store formats can include mom-and-pop stores, kiosks, street vendors, and open markets, but the unique feature is the sole proprietorship. They are neither part of a larger company nor a franchise. These stores are known by different names in academia, including 'traditional channels', 'unorganized', 'mom & pop stores', 'neighborhood markets', 'nanostores' or 'high-frequency stores'. These stores have different local names in different countries: kirana (India), hanout (Morocco), changarro (Mexico), tienda de barrio (Colombia), bodega (Peru and United States), warung or toko (Indonesia), and sari-sari (Southeast Asia) (Nielsen, 2015; Fransoo et al., 2017).

Since the context of this research is India, the local term 'kirana' is used. Kiranas (depicted in Figure 2.2) are defined as independently owned retail stores that are generally small in size ($< 20m^2$). They mainly operate with cash, have a small width of the product assortment, mostly lack a storage room, have a low degree of technological penetration in order placement, and have no logistics support with limited optimization possibilities (Fransoo et al., 2013). Kiranas form the backbone of the Indian economy, being an essential part of the country's retail industry.

Figure 2.2.

Typical Kirana Stores in India



Modern retail typically expands as countries become urbanized, gross domestic product (GDP) rises, and trade liberalizes. However, various factors account for the continued presence of kiranas in emerging market economies (Kin et al., 2017; Mejia-Argueta et al., 2019). The first one is high population density, i.e., lack of sufficient space for modern retail outlets that usually occupy larger areas. Economic inequality is another factor, as evidenced in the higher presence of kiranas in economically impoverished areas. The last two are the social role played by kiranas and the presence of an informal economy. Kirana stores occupy a 90% market share, representing a force of around 14 million kiranas that are the bedrock of India's everyday CPG supply. The Indian consumer retail market is expected to grow at a compound annual growth rate (CAGR) to reach $1.6 trillion in 2025 from nearly $900 billion in 2019 (Kumar, 2019).

Hence, kiranas remain essential for manufacturers to reach sales in major emerging markets, at least in the near future. Fransoo et al. (2017) and Mejia-Argueta et al. (2019) predict that kiranas will continue to flourish, but the form of retailing would change considerably. Some of the changes include cashless transactions, the use of e-commerce platforms, and the merging of virtual and physical inventory.

As cities get more extensive and denser, the impact on urban freight transport (UFT) is significant. Logistics facilities become further located from the urban core areas, where most jobs, residents, and businesses are present. Also, the high fragmentation of kirana stores causes substantial distribution inefficiencies, especially in congested megacities. Recent trends indicate that UFT will become more complex and expensive. In India, an estimated 60% of daily deliveries in urban areas are linked to independent retail (GIZ, 2016). With most consumption taking place in urban areas, a frequent and reliable UFT system and a well-coordinated logistics, warehousing strategy are needed.

2.2 Kirana Distribution Strategy

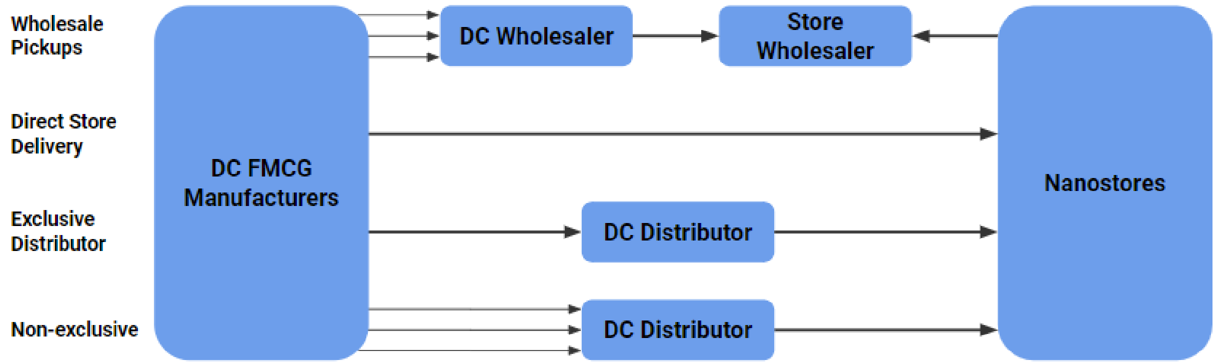
Several decades of rapid economic growth have transformed the purchasing power parity of emerging market economies. The current retail landscape for the CPG industry in emerging-market megacities is highly fragmented. Traditional channel is a significant revenue and cash-flow source for CPG manufacturers. Multinational and local CPG suppliers inevitably and primarily rely on tens of thousands of kiranas in megacities to access millions of consumers with increasing purchasing power parity (i.e., middle class). For example, in India, Unilever deploys thousands of salespeople to distribute directly to more than 1.5 million kiranas (Atsmon et al., 2012).

To compare distribution in traditional and modern retail, modern retailers depend on a supply chain network of distribution centers (DCs), cross-docks and logistics service providers. Goods are shipped in comparatively large volumes from manufacturer locations to the retailer's DCs and, subsequently, to the retail stores in a consolidated way, often using full truckload (FTL). In the case of family-owned small retail, such optimization possibilities are lacking. Manufacturers have different strategies to supply the kiranas. Fransoo et al. (2017) distinguished five different supply strategies: Onboard sales, Pre-sales + direct store delivery, Pre-sales + distributor, Distributor, and Wholesaler to serve kiranas and identified advantages and disadvantages for each. The small volumes ordered by kiranas and the lack of storage space cause significant logistical differences. Therefore, the CPG manufacturers mainly supply kiranas via indirect models such as wholesalers.

The indirect supply, which is the cheapest option, offers a comparatively low degree of control and visibility because of wholesalers. However, large manufacturers typically exert more control, visibility over the sales and delivery process by either conducting the processes themselves or outsourcing to exclusive distributors (see Figure 2.3). A typical distributor led process with deliveries uses the pre-sales scheme that looks as follows: a salesperson visits a store to get the order; in case of sales (not every visit leads to sales), goods are (usually) delivered the next day after which the payment is collected (Garza Ramirez, 2011; Fransoo et al., 2017).

Figure 2.3.

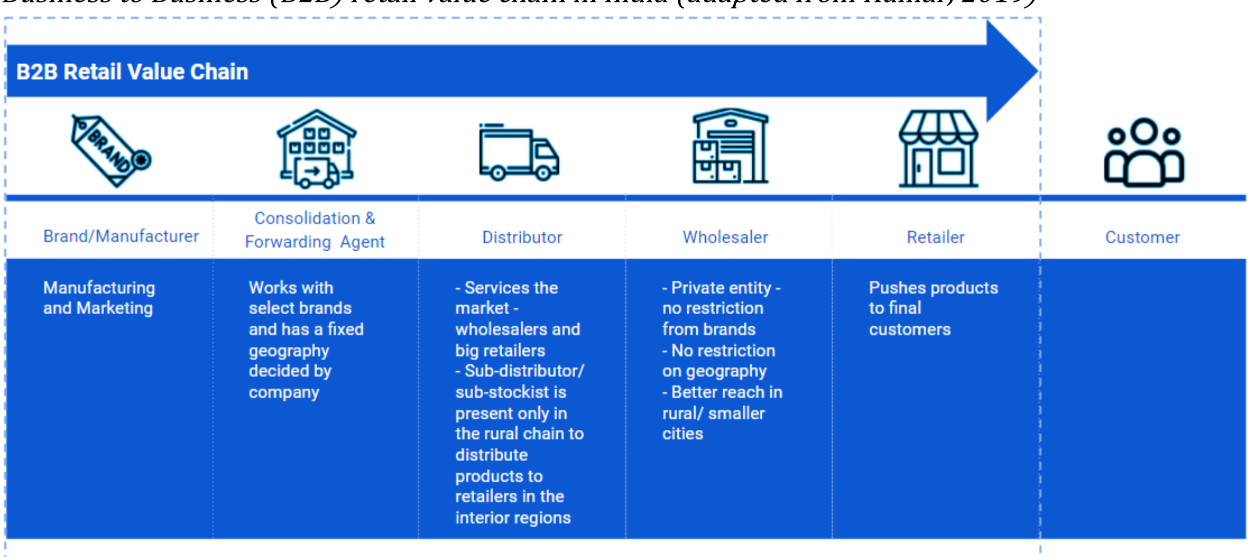
Strategies to Supply Kiranas (adapted from Kin, 2018)



A crucial topic is the efficiency of last-mile deliveries. Supply of kiranas concerns large volumes collectively, but final deliveries are highly fragmented. The characteristics of kiranas (i.e., small size with limited or no storage room) make shipments small. If a store owner has little cash available, fewer products can be purchased by that store (Fransoo et al., 2017). Altogether, the exclusive supply of kiranas is characterized by an inherent lack of bundling with multiple suppliers delivering to a single store. Bundling products of several manufacturers are essentially what non-exclusive distributors and wholesalers do. Currently, it seems that CPG manufacturers only stop using exclusive distributors as modern retail becomes dominant, or if the manufacturers look for expanding the market in a relatively unknown channel, geography, or if they want to continue exploiting the expanded market profitably (Ge, 2017).

Figure 2.4.

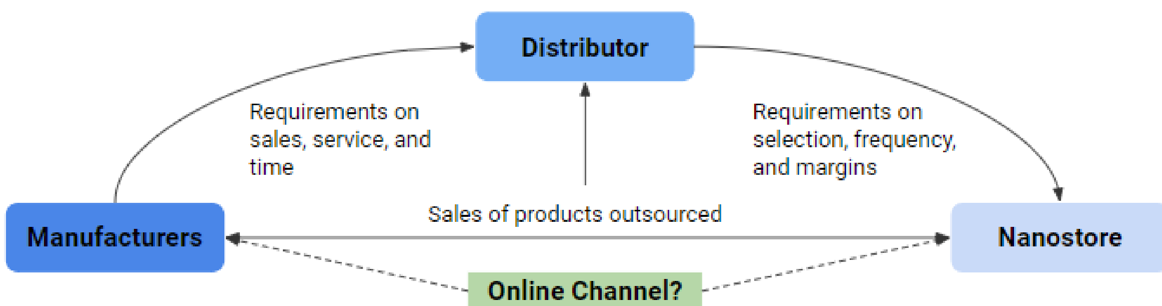
Business to Business (B2B) retail value chain in India (adapted from Kumar, 2019)



The Indian B2B retail value chain has four to five layers of intermediaries starting from a forwarding agent, a distributor, a sub-distributor, a wholesaler, and a retailer. Thus, a brand/manufacturer needs to go through to get to the end consumer (see Figure 2.4). This traditional supply chain system causes multiple bottlenecks that lead to longer timeliness, losses in CPG manufacturer's efficiency, issues with quality, and most importantly, reduction in retailer's margin. Traditional distribution's *modus operandi* has been to overstock retailers with weekly/fortnightly replenishments (Bhise, 2019).

An e-B2B distributor can fill various nanostore distribution processes (see Figure 2.5): Starting from handling delivery logistics, warehousing needs, getting the proper inventory from the right set of manufacturers to taking orders online, and get them fulfilled to the kirana. The other advantages of e-B2B would be easy demand generation (i.e., kiranas may order through a website or app), credit options to kirana stores, and doorstep delivery, which will substantially improve the business prospects for the retailer. Ge (2017) predicts that kiranas have great potential to adapt to new retail environments in the coming decades, and they may even prosper in future omnichannel operations.

Figure 2.5.
e-B2B Channel for distribution (taken from Kin, 2018)



Three current e-B2B models are: 1) 'Asset Light - Technology Led' marketplace, which relies on pure tech-led demand generation and just-in-time inventory; 2) 'Inventory based - Technology Led' players, who maintain their inventory, but rely on tech-led demand; 3) 'Inventory based - Assisted' players, who keep the inventory in their warehouses and promote the feet-on-street assisted-demand generation, i.e., they have their sales force who visit the kiranas for taking orders, in addition to having an app (Kumar, 2019). All these models are evolving and have yet to prove their viability. A non-exclusive e-B2B distributor can fit in any of these three models. According to Kumar's (2019) classification, this research focuses on an inventory-based e-B2B distribution platform.

The next step is to understand the potential urban distribution network models that an e-B2B non-exclusive distributor can adopt. Distribution is a crucial driver of the overall profitability of a firm because it directly impacts both the supply chain cost and the customer experience. A high-performance distribution can be used to achieve various supply chain objectives ranging from low cost to high responsiveness (Chopra, 2003).

2.3 Urban Distribution Network Models

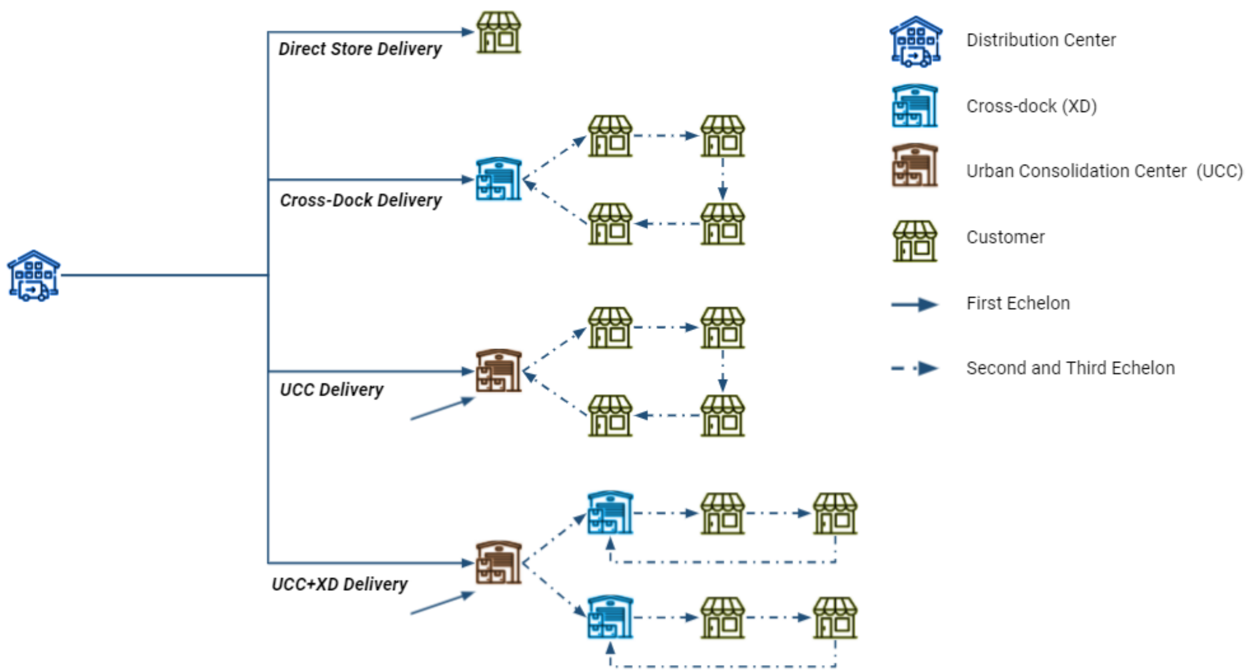
Frameworks that position supply chain network designs in urban environments are growing in the world. They are essential for studying the pros and cons of different distribution structures. Spoor

(2016) presents four different last-mile delivery network structures of the supply chain for distributors to supply kiranas (see Figure 2.6):

1. Direct Delivery: Typically, dispatched vans to distribute directly to kiranas
2. Cross-dock Delivery (XD): A large vehicle travels to a cross-docking facility where the parcels are unloaded and then sorted into smaller vehicles (e.g., motorbikes, vans)
3. Urban Consolidation Center (UCC): A cross-docking facility with consolidation from other CPG companies' distribution center, typically exist in CPG's distributors, logistics service providers (LSPs) or third-party logistics (3PLs).
4. UCC+XD: A combination of UCC and XD

Figure 2.6.

Four Network Delivery Structures (adapted from Spoor, 2016)

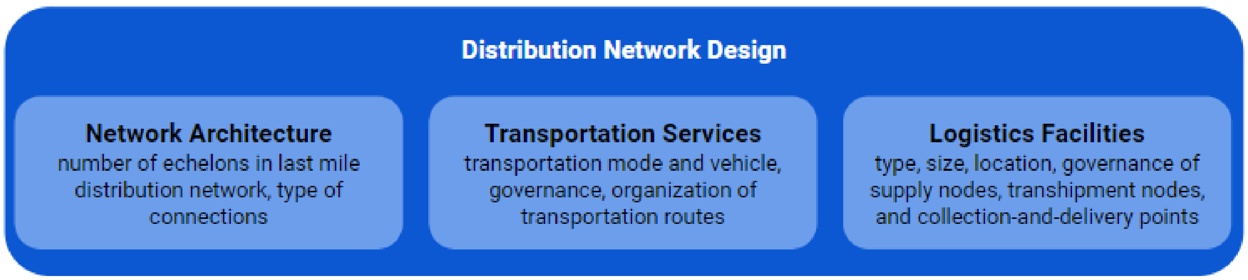


Cross-dock delivery (XD), urban consolidation center (UCC), and the combination of them are considered multi-echelon urban delivery networks because there exist two (or more) tiers or echelons of transportation. These networks allow for consolidation and increased vehicle utilization. These facilities are also known as (city) hubs, transshipment points, transfer points, or terminals. The use of cross-docks and UCCs makes CPG manufacturers incur facility costs and additional handling costs, but it reduces transport costs due to modal shift to smaller vehicles and reducing the impact of congestion from logistics sprawl (Kin, 2018; Yassine, 2019). UCC, in essence, is an additional transshipment point, but rather than being operated by a single company, it provides a collaborative system for multiple stakeholders (Kin, 2018). However, UCC is also the main barrier as it necessitates collaboration and data sharing with potential competitors and their suppliers and customers.

Boccia et al. (2010) argued that urban logistics networks require three levels of decision: strategic, tactical, and operational. The strategic decisions are long-term related decisions that include considering the count, types, and location of the supply and transshipment distribution facilities. In the medium term, the tactical decisions comprise defining the types and number of vehicles required at each facility. Lastly, in the short term, the optimized vehicle routes are determined for day-to-day operations. Kirana distribution strategies should lean on long-and-medium term planning to ensure business sustainability.

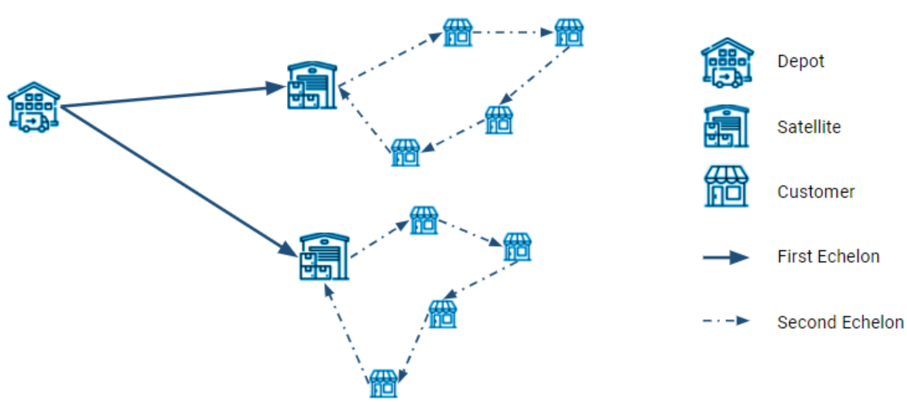
To classify relevant network design variables, Janjevic and Winkenbach (2020) denoted three critical components in a conceptual framework for distribution network design: i) network architecture, ii) transportation services, and iii) logistics facilities (see Figure 2.7). These components are used to develop the distribution network design. Available variables at each component will be the baseline variables for our proposed network model.

Figure 2.7.
Distribution Network Design Framework (taken from Janjevic & Winkenbach, 2020)



The most applicable network model for the project is a two-echelon capacitated location-routing problem (2E-CLRP) by Winkenbach et al. (2016), Merchán (2015a), and Merchán et al. (2018), which seeks to minimize cost for last-mile delivery networks (see Figure 2.8). The authors present case studies in two different cities served by a postal service company in France. Sensitivity analysis and scenarios were performed to show the tradeoffs between various network choices. The study concluded that service levels and population density directly impact the distribution network design considerations.

Figure 2.8.
2E-CLRP Network Model



Due to the enormous size of combining two NP-hard problems, the augmented route-cost estimation (ARCE) formula is introduced to approximate the routing cost component and reduce complexity while maintaining a high-quality solution. This model will be used as a base formulation to implement the kirana distribution strategy in our study. However, our approach will focus mainly on the strategic and tactical location-allocation approach. Merchán (2015a) extended Winkenbach's model to add cross-dock points and congestion factors; he also tested the model in a case study from a Latin-American country. The study showed that specific cross-dock platforms could also increase delivery and cost efficiency in places of high congestion. Lastly, Daganzo (1984) and Langevin et al. (1996) also introduced one-to-many distribution approximation models, which fit the needs of our project network model and justify the foundations of our approach.

Despite vehicle routing is operational and short-term, it is a very complex problem to be solved mathematically. The continuous approximation will help enable the solution to be robust yet comprehensible to solve network problems (Hall & Lin, 1994). In this research, we will not focus on the vehicle routing problem as it is an operational problem that can be approximated. The inherent complexity of multi-echelon LRP for large-scale problem instances in the context of real-world urban geographies would render the optimization models virtually intractable if they depended on explicit routing algorithms (Winkenbach et al., 2016). We instead focus on the high-level strategic and tactical location-routing problems to compute needs, set expected capacities, and estimate various logistic metrics.

In the next section, we will discuss the various factors influencing the choice of the distribution network and their relative strengths and weaknesses. Determining key performance indicators (KPIs) along with the tradeoffs will help identify distribution networks that are best suited for a variety of customer and product characteristics.

2.4 KPIs and Tradeoffs for Supply Chain Network Design

This project found two major KPIs for kiranas distribution strategy and network design: cost-to-serve (mostly on logistics cost) and service levels. First, cost-to-serve and logistics cost components will be thoroughly discussed. Second, we examine the tradeoffs to logistics cost based on multiple features of kiranas and their assortment. Finally, we discuss the service level expectations of kiranas and its tradeoff to cost-to-serve.

On cost-to-serve, Mejía et al. (2015) introduced a cost-to-serve methodology in three phases to sort kiranas depending on their profit and cost-to-serve. This study enabled us to understand each segment of the cost, its drivers, and to determine its profit margin. By knowing and classifying its cost depending on the commercial, logistics nature of all elements, the tradeoffs and the impact of kiranas' distribution strategy and network design can be measured granularly and comprehensively. As we run different scenarios and network designs, the inventory, transportation, handling, and information costs are affected (Chopra, 2003).

Cost-to-serve is an impactful KPI for our project. Castañon-Choque (2018) analyzed the cost-to-serve for a distribution company in Mexico and the impact that kiranas going bankrupt would have on their logistics costs and operations. Her work considered commercial variable costs (e.g., credit and order management), commercial fixed costs (e.g., leasing, maintenance, promoters, and salesforce payroll), logistics variable costs (e.g., transportation, warehousing, inventory), and logistics fixed costs (e.g., leasing outsourcing). Transportation cost was simplified by using one-to-many continuous approximation. The authors indirectly discuss the variety of goods being distributed, but more as a cost driver than a source of analysis.

On logistics cost, Daganzo (2005) classified four main cost components: transportation, handling, rent, and inventory. Also, Gevaers et al. (2014) developed a last-mile cost model for business to consumer (B2C) without considering inventory and handling at supply and transshipment points. For B2B, the previous approaches will be similar except for a higher first-time hit rate and larger drop size.

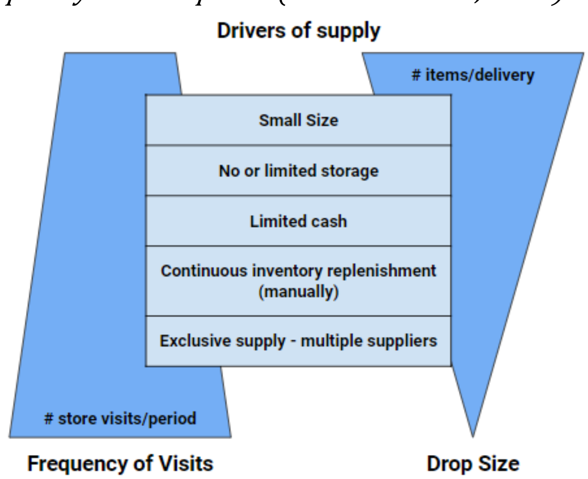
Tavassazy et al. (2010) defined the distribution costs as a function of inventory, handling, and transportation costs. Inventory costs are modeled as a function of replenishment frequency, order size, and transport time. Handling costs involve the transshipment points of unloading, picking, and loading to the final delivery vehicle. The transport costs are modeled as a function of the distance, shipment size, frequency, density, speed, and reliability of the mode used.

Furthermore, there is a tradeoff for serving kiranas with small drop sizes as it will increase sales and transportation costs. Kirana characteristics and their assortment (i.e., wallet share) will determine the replenishment frequency, that is, the number of times in a given period the kirana is served. The latter impacts the drop size per delivery, calculated as the total volume demand in a given period. This quantity is divided by the replenishment frequency during that period, impacting transportation cost (Garza Ramirez, 2011). In addition, small drop size is inversely proportional to the number of store visits (see Figure 2.9) due to small size, limited storage at kiranas, their limited cash on hand, manual replenishment that requires multiple deliveries from various suppliers.

An increased replenishment frequency can reduce out-of-stock events and thereby increase sales (Spoor, 2016). Also, upper limits on drop size due to cash constraints can impact frequency (Plasman, 2013). Plasman (2013) also considered that stores with small drop sizes will increase the transportation cost extensively and that with high density, it would not be economically feasible to serve them. Castañon-Choque (2018) reported that the new and usually smaller stores might cost more despite the increased transportation cost. However, it is better to have them instead of losing them to competitors, provided that they have a reasonable survival rate.

Figure 2.9.

Relationship Between Frequency and Drop Size (taken from Kin, 2018)



Other studies have analyzed the tradeoffs of serving kiranas. Ge (2017) presented tradeoffs between logistics costs and growth of demand for a distributor to choose between indirect and direct delivery channels to serve kiranas. Direct delivery allows faster growth but has higher logistics costs. However, the author also shows the need to define the most efficient pathway to serve kiranas.

Another tradeoff exists between kiranas' distance, routes, and density, whether we should build transshipment points, service levels, and logistics costs. For a short distance, direct is always the best; for long-distance, XD/UCC distribution is better (Spoor, 2016). The last-mile transportation cost also varies depending on the properties of the receiving kiranas per geographic area. The number of kiranas in each area will determine the stop density and, therefore, inter-customer travel distance (Alho & de Abreu e Silva, 2014). Other cost variables that influence logistics cost are the (average) stop time per kirana, the (average) distance from the depot to the first stop, the distance between the stops and the average speed. (Gevaers et al., 2014). Last-mile delivery routes can be restricted on two measures, by the vehicle's capacity or the available shift time of the driver (Boyer et al., 2009).

In summary, there exist multiple tradeoffs that affect logistics cost: sales of kiranas with small drop sizes, indirect vs. direct channels, and building transshipment points based on density, routes, and distance. Moreover, Kin (2018) identified some of the preferences of kiranas for store deliveries, which depend on distribution strategy and network model: delivery at the store, delivery lead times, delivery within a specific time window, real-time delivery information, products of different brands bundling for delivery and possibility of express delivery. Fulfilling these service level requirements will also impact the logistics cost due to the fragmentation caused by a lack of consolidation of routes and shipments. A non-exclusive e-B2B distributor will be well placed to satisfy these preferences of kiranas.

2.5 Gaps and Contributions

The literature review revealed some gaps in the research on kiranas: 1) Studies of non-exclusive e-B2B distributors for delivery to kiranas in emerging market economies. 2) Careful analysis of various tradeoffs to create high-performance distribution strategies to serve kiranas. 3) Quantitative models proving the cost and service effectiveness of new distribution models. 4) Network strategy roadmaps propose a flexible distribution scheme that considers the retail evolution and changes in consumption patterns in an integrated way over an extended period.

After analyzing the current state of the art and understanding the practical challenges faced in kirana distribution by distributors and manufacturers, the capstone project will:

1) Formulate an e-B2B distribution strategy on the short-, medium- and long-term.

2) Develop a network model which minimizes the cost-to-serve to implement the e-B2B distribution strategy.

3) Analyze tradeoffs between multiple scenarios and drivers of cost-to-serve, efficiency, and service level (e.g., the frequency of kirana orders, wallet share of kirana orders fulfilled by the platform, delivery frequency, and geographical circuity values).

4) Formulate a short list of recommendations and effort-impact matrix guidelines based on network model and qualitative findings, including the most critical parameters of the kirana distribution network strategy.

3 DATA AND METHODOLOGY

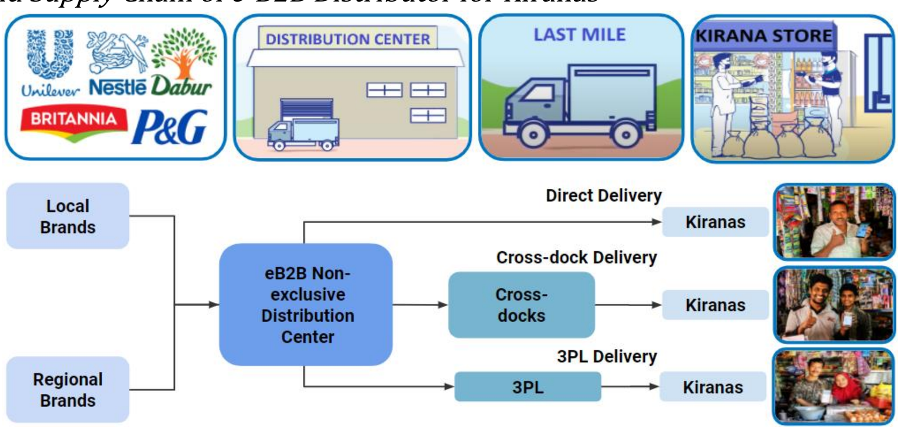
This chapter describes the methodology used to formulate a non-exclusive e-commerce business-to-business (e-B2B) distribution strategy to serve kiranas (i.e., mom-and-pop stores) at optimal cost and build a quantitative network model to determine the short-, medium-, and long-term network expansion strategy. First, we developed a model to optimize the total logistics cost. Next, we developed tradeoffs between cost-to-serve and negotiated service levels. We further analyzed the tradeoffs among multiple business scenarios by changing the frequency, wallet share, number of kiranas onboarded, kiranas, urban setting, and fleet capacity and compute the cost-to-serve and service levels. Finally, we formulated business recommendations and derived actionable managerial insights based on the study.

3.1 Business Overview

The company serves as an e-B2B distributor for kiranas in Indian megacities (see Figure 3.1). Local and regional brands supply the consumer-packaged-goods (CPG) to the distribution center (DC) through consolidation and forwarding agents (C&FA) and distributors. At the DC, the goods are inbounded and put away in storage locations.

Figure 3.1.

The End-to-end Supply Chain of e-B2B Distributor for Kiranas

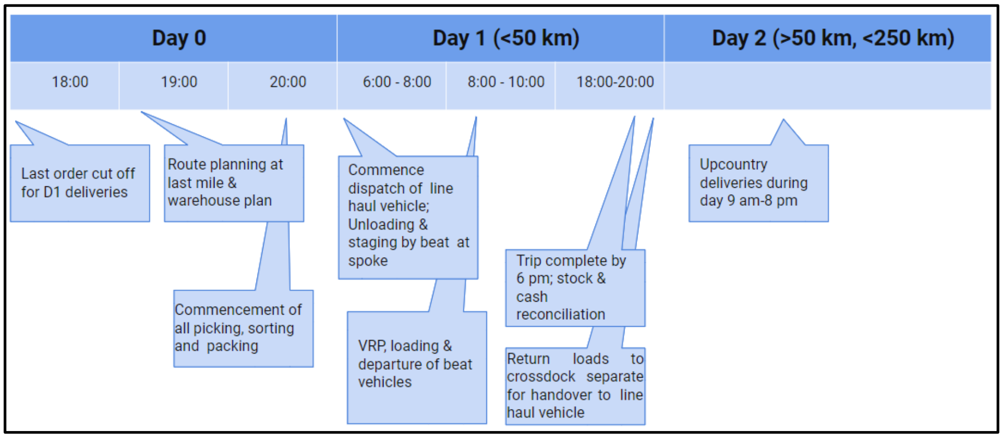


As the kiranas put the orders throughout the day, the DC will pick, sort, pack, and dispatch the packages and goods. Once dispatched, the parcels go through three types of delivery: direct, cross-dock, and 3PL direct. Whereas direct delivery is typically used for short-distance kiranas, cross-dock delivery is suited for longer-distance kiranas. Finally, third-party logistics delivery is allocated for kiranas in lower-demand tier-2 cities or non-densely populated areas.

Operationally, when kiranas order before 18:00 hours, they expect a next-day delivery (D1) for those located <50 km from the distribution center and two-day (D2) for those located further or in tier-2 cities (see Figure 3.2). Route and warehouse planning and handling activities are executed at night. On the next day, most line haul and last-mile activities commenced. The line haul trucks run in the morning and arrive at the cross-dock points. There, the trucks are unloaded, and the parcels are then assigned to the last-mile beat vehicles. Afterward, these vehicles deliver throughout the day.

Figure 3.2.

Operations Clock of Kirana Distribution



To further understand the kiranas, it is essential to know how they are segmented. Kiranas are generally categorized into five segments: large, specialized, medium main street, medium residential, and small (see Figure 3.3). For our project, the company focuses on the specialized and medium kiranas as its target market. Currently, large kiranas are already well-served with the state-of-the-art distributions; the rest of the kiranas are not. Moreover, small kiranas' drop sizes are too insignificant to match the cost-to-serve (Plasman et al., 2013; Castañon-Choque, 2018). Thus, the target market segment possesses high potential in volume, economies of scale, and serviceability. It also encompasses more than half of the retail market share (4.5-5.5 million kiranas).

Figure 3.3.

Kirana Market Segments and The Company's Target Market (Sponsor Company, 2020)

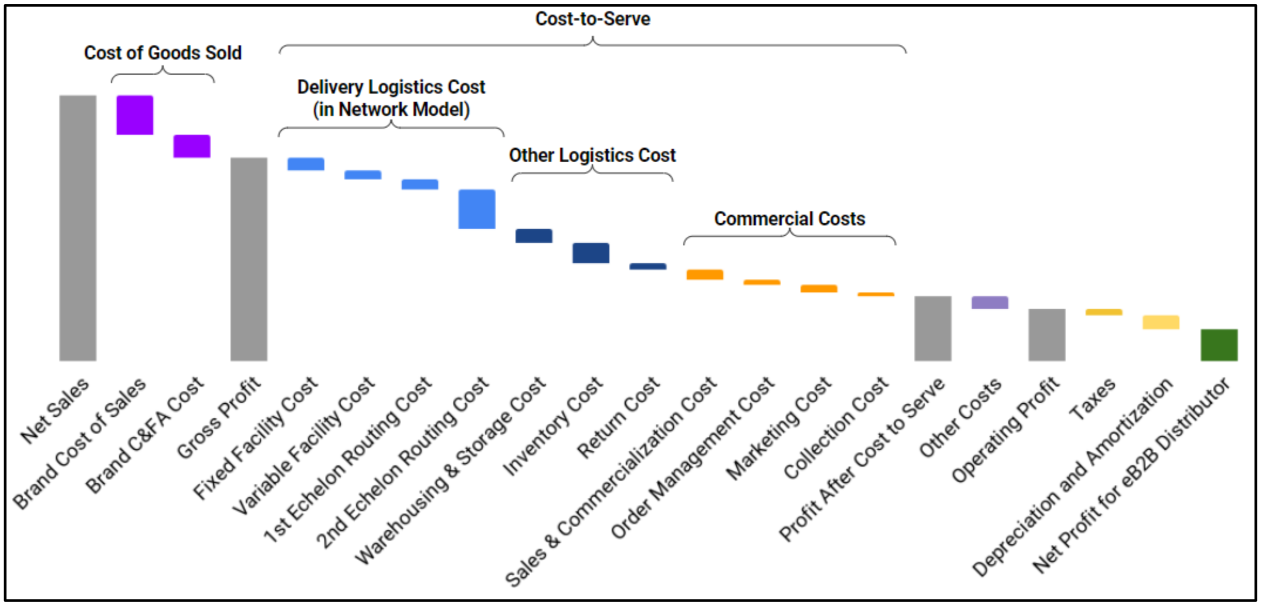
Type	Size (sq. ft.)	Overview	Est # Stores	Market Share	SKUs/ Kirana	
Large Store	1,000-3,000	Customers pick products from racks; premium assortment	~30K	~5%	~2K	
Specialized Store	300-800	Over-indexed on a category with deeper assortment; incl. chemists	~1M	5-10%	0.3-0.5K	Target Market
Medium Store (Main Street)	100-300	Anchor shops in main markets (all categories incl. staples)	3.5-4M	50-55%	0.5-1K	Target Market
Medium Store (Residential)	100-300	Feeder shops for localities (all categories, limited staples)	3.5-4M	50-55%	0.3-0.5K	Target Market
Small Kirana	50-100	Neighborhood store evenly-indexed across categories	4.5-5M	30-35%	0.1-0.3K	

3.2 Distribution Strategy Key Performance Indicators (KPIs) and Tradeoffs

The first KPI is cost-to-serve (see Figure 3.4). Minimizing cost-to-serve is crucial in e-B2B distribution strategy, and the components are within the company's control. The most significant component of cost-to-serve is delivery logistics cost, which will be optimized using our distribution network model. The company will utilize numbers derived its internal analyses for the cost of goods sold, other logistics costs, commercial costs, other costs, taxes, depreciation, and amortization. With this framework, we will compute the net profit and total cost-to-serve (TCTS) for the e-B2B distributor and use it as a strategic and measurement tool to serve kiranas.

Figure 3.4.

Cost to Serve Waterfall (Adapted from Mejía-Argueta, 2015)



Today, current fragmented channels of exclusive distributors are costing kiranas more than 50% of their potential margins and impacts their business viability (Bhise, 2019). The rest of the margins are taken by consolidation and forwarding agents (C&FA), distributors, wholesalers, stockists, and sub-distributors (Kumar, 2019). C&FAs take around 10% of the margins. Direct distributors typically take the other 40% of the margins. If wholesalers also participate in the supply chain, they will take 10% of the margins, and the distributors will take 30%. In regions beyond dense urban clusters, additional intermediaries (i.e., stockists and sub-distributors) take even more margins from kiranas.

The second KPI to be considered to devise an effective e-B2B distribution strategy is the level of service. Kiranas generally expect the delivery lead time to be 1-2 days after ordering. Furthermore, they also prefer as many drop frequencies as possible per month and the smallest drop size to reduce inventory and storage at the physical stores. As increasing drop frequencies will increase cost-to-serve, an optimal balance is required. Meeting kiranas' expectations and service levels is essential to increase sales and retain/grow loyalty (Kin, 2018). At the same time, the level of service should not be a reason for high cost-to-serve and low profitability.

Given these conflicting KPIs, we identified the four main tradeoffs that should drive e-B2B distribution strategy:

1. **Frequency vs. Cost-to-serve:** We quantify the impact of drop frequencies on cost-to-serve. Currently, we hypothesize that the increase in the drop frequencies and the reduction of lead time will increase the cost-to-serve. Our goal is to find a suitable pairing to couple both strategies profitably.

2. **Market Penetration vs. Cost-to-serve:** We quantify the progression of cost-to-serve as the aggregate volume increases. This measurement is crucial for the following reasons: 1) We can identify the optimal target volume where we can reach profitability and low cost-to-serve; 2) We can calculate the burn rate required to grow market penetration to reach business' profitability. Our current hypothesis is that as volume grows, the cost-to-serve forms a

logarithmically decreasing function. With this tradeoff, we can formulate a strategic roadmap in the short-, medium-, and long-term for the company.

3. Wallet share vs. Cost-to-serve: Similar to volume, we would like to find the optimal level of drop size to reach profitability and low cost-to-serve. With this tradeoff, we can quantify the number of brands needed to be onboarded and consolidated as a non-exclusive distributor, the proper wallet share per kirana to reach optimal cost savings. Both wallet share and frequency impacts drop size (see Section 3.3 and Eq. 3.12)

4. Urban morphology of the Indian market (e.g., core city, conurbation, twin-cities, and satellite cities) vs. cost-to-serve: Megacities have various urban morphologies that may have an impact on cost-to-serve, which will be beneficial for the company to estimate the need of logistic capacity, needs and the associated costs. With this tradeoff, the company can form an individualized distribution strategy pertinent to the urban settings of the cities and urban districts where the kiranas are located.

3.3 Data Overview

The following datasets and assumptions are used in the network model proposed in this study. The sponsoring company of this project provides the datasets.

1. Demand and Market: Demand and market datasets are assumed to be static and deterministic. They consist of number of stores, frequency of deliveries, wallet share, and penetration. The data is an average forecast considered as orders per day over a 60-month time horizon (i.e., five years) and 10 cities (list of cities see Table 3.1) with individual data points at a month level for each city. The demand in orders per day is derived using the entire set of kiranas present, penetration percentage, average order size, and frequency. Also, the drop size is considered to calculate the service time, setup time, and vehicle utilization. The equations are in the following:

$$\boldsymbol{Daily\ Orders = Total\ Set\ of\ Kiranas \times\ Penetration\ Percentage\ \times Monthly\ Frequency\ of\ Visits}$$

$$\boldsymbol{Drop\ Size\ = \frac{Average\ Monthly\ Sales\ of\ a\ Kirana\ \times\ Wallet\ Share}{Monthly\ Frequency\ of\ Visits}}$$

   This drop size definition and equation will be an essential component in the network model (see Eq. 3.12).

2. City Segment: The problem considers dense urban districts with intense logistics flows. The city segment data contains zip codes, latitude, longitude, percentage of stores of the city per zip code, number of stores, area, and store density. Table 3.1 summarizes the information on city segments.

Table 3.1.

City Segment Summary

City / Region	Pincodes	Number of Sample Stores From Sponsoring Company	Average Pincode Area (Km^2)	Average Pincode Stores Density (Stores/Km^2)
NCR	134	150,259	26	47
Bangalore	95	62,758	13	59
Hyderabad	80	57,216	12	73
Chennai	108	64,210	15	47
Mumbai	92	135,962	22	79
Pune	51	40,000	16	58
Ahmedabad	40	40,000	16	68
Surat	18	30,000	40	43
Rajkot	12	10,000	32	28
Vadodara	39	12,000	13	25

3. Maximum Service Time: The model assumes a maximum daily service time. This is the total time available for last-mile delivery to kiranas. We set this to eight hours based on a regular working journey for delivery representatives of the sponsor company.

4. Cross-dock Centers: The cross-dock data contains the longitude and latitude of the potential cross-dock locations. Some of the city segments are assumed to have a cross-dock facility. This assumption is made based on the company's expansion strategy to select well-located, cost-effective city segments to serve kiranas. The capacity, fixed cost, and operating cost of cross-dock are considered in the model (see Table 3.2).

5. Vehicles: Different speed ranges and capacities are assumed per vehicle type. Vehicle fixed cost of rental per day and operating cost per hour are considered (see Table 3.2).

Table 3.2.

Cost Component and Capacity Summary for Cross-dock Facilities and Vehicles

Cost Component	Amount (Rupees)
Wage Per Hour	80
Truck Operating Cost Per Vehicle Per Hour	100
Truck Fixed Cost Per Vehicle Per Day	600
Van Operating Cost Per Vehicle Per Hour	50
Van Fixed Cost Per Vehicle Per Day	300
Operating Cost Per Cross-dock Per Day	30
Fixed Cost Per Cross-dock Per Day	3,000

Capacity	Kgs
Van Vehicle Capacity	150
Truck Vehicle Capacity	1,000
Cross-dock Capacity	1,000

3.4 Network Model

The Two-Echelon Capacitated Location-Routing Model (2E-CLRP) introduced in this section was inspired by the formulation proposed by Winkenbach et al. (2016) and Merchán (2015a), and Merchán et al. (2018) to explore the impact of transshipment networks to serve critical city districts, given their unique demand patterns and urban conditions. For the sake of scope, this model will not be a multi-criteria model. We aim to build a mono-criterion approach to set a baseline of this approach. Different tradeoffs due to changing frequency, wallet size, drop size will be analyzed in scenario analysis. Figure 3.5 provides a schematic representation of the problem.

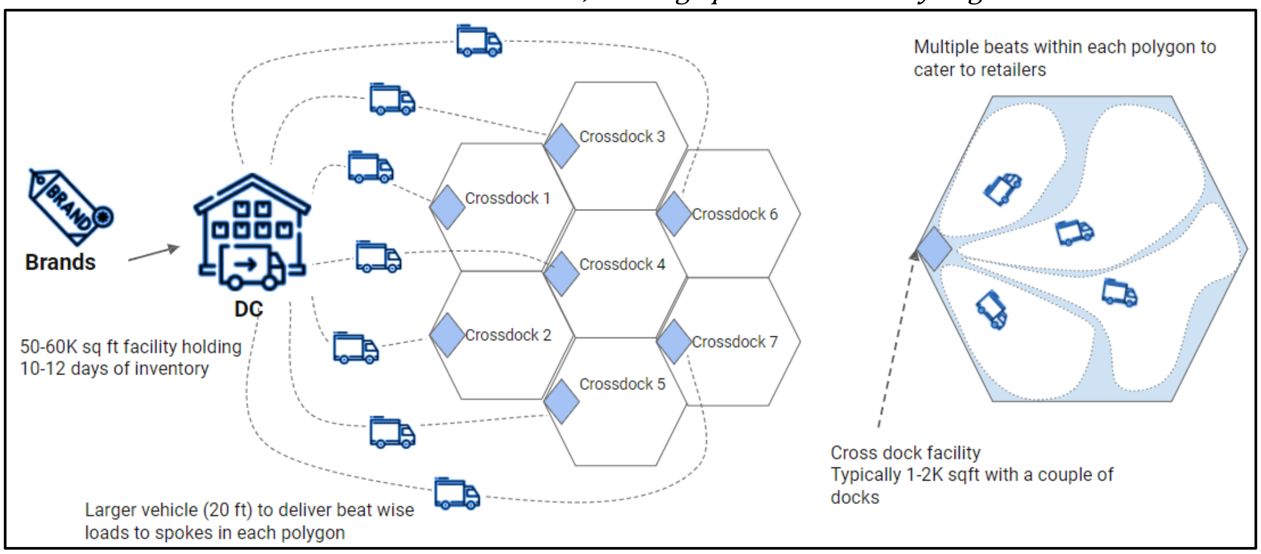
The cross-dock network configuration can be described as:

- Three layers or two-echelons are considered: DC, cross-dock, and kirana city segments.
- DCs and cross-docks are connected using dedicated routes, while cross-docks and kiranas are connected via tours.
- Location decisions are only made for cross-docks. Locations of DCs are fixed.

DC locations as a variable will be considered in the extension of this formulation.

Figure 3.5.

Schematic Illustration of Cross-dock Networks, Serving Specific Urban City Segments



We consider three sets: $i \in I$ that refer to cross-dock (XD) points, $j \in J$ that refer to city segments, $v \in V$ that refer to vehicles. Tables 3.3 - 3.8 summarize the notation used for model components, parameters, and model variables.

Table 3.3.

Objective Function Components

C	Total delivery cost per day
C^F	Facilities fixed cost per day
C^U	First-echelon (1E) transportation cost per day
C^V	Second-echelon (2E) transportation cost per day
C^G	Capacity utilization cost per day

Table 3.4.

General Model Parameters

δ_s	Customer density in city segment s
A_s	Area of city segment s
d_s	Average customer demand in segment s
w	Wage per hour for delivery executive
F_i^C	Fixed cost of enabling a cross-dock (XD) at location i per day
T	Maximum service time (MST)

Table 3.5.

First-echelon Parameters and Endogenous Variables

r_i^0	L1-norm distance from DC, denoted by 0, to XD at location i
a^0	1E line-haul vehicle speed – set to 30 km/s
k^0	Area accessibility factor (L2 norm r_i^0) or circuity factor (L1 norm r_i^0)
$c^{O,U}$	1E vehicle operating cost per hour
$c^{F,U}$	1E vehicle fixed cost per day
N	Number of active XDs
θ^a	Administrative setup time per trip at DC
θ^d	Operational setup time per trip at DC

Table 3.6.

Second-echelon (2E) Parameters and Endogenous Variables

$r_{i,s}$	L1-norm distance from XD at location i to the centroid of segment s
a_v	2E speed (within city segment) for vehicle type v – set to 30 km/s
k_v'	2E road circuity factor for vehicle type v
k	Tour factor for 2E routing - set at 1.15 according to Winkenbach et al. (2016)
${c_v}^{O,V}$	2E vehicle type v operating cost per hour
${c_v}^{F,V}$	2E vehicle type v fixed cost per day
$f_{i,s,v}$	Average total distribution cost to serve segment s from XD at i using vehicle type v
$m_{i,s,v}$	The average number of 2E tours per vehicle type v starting from XD at location i
$n_{i,s,v}$	The average number of customers served per vehicle type v per tour from XD i
$b_{i,s,v}$	The average number of full-load tours a vehicle type v can complete within the maximum service time starting from XD located in i to city segment s
$j_{s,v}^V$	The capacity of 2E vehicle type v in terms of the average number of stores that can be served
$q_{i,s,v}$	Number of type v vehicles needed to serve segment s from XD at location i
$t_{s,v}^R$	Average time per tour of vehicle type v in segment s
t_v^l	Average operational setup time per tour per container using vehicle type v
t_v^s	Average service time at each customer per container using vehicle type v
t_v^p	Average parking time at each customer using vehicle type v
M	An arbitrarily large number for linking constraints
D	Number of days in a month

Table 3.7.
Physical Capacity Parameters

p_v^V	Space requirement for 2E vehicle type v at an XD
p^U	Space requirement for 1E vehicle at an XD
c_i^S	Cost of unit of space at XD located in i
S_i	Physical space capacity at XD located in i

Table 3.8. Drop Size, Wallet Share, Frequency and Penetration Parameters
Drop Size, Wallet Share, Frequency and Penetration Parameters

α_s	Average drop size (in containers) of the city segment s
λ_s	Customer penetration (%) of city segment s
μ_v	Capacity of 2E vehicle type v in terms of number of items that can be fitted
β_s	Wallet share (%) of city segment s
ω_s	Average monthly frequency of visits of city segment s

Two sets of decision binary variables are defined:

$$X_i = \begin{cases} 1, \text{if location i accommodates an XD} \\ 0, otherwise \end{cases}$$

$$Y_{i,s,v} = \begin{cases} 1 \text{ if XD located in i serves city segment s using vehicle type v} \\ 0 \ otherwise \end{cases}$$

The objective function accounts for the total daily distribution cost and includes the following components: The fixed cost of enabling a cross-dock (XD) point (3.1); the transportation cost between the distribution and XDs, or 1E distribution cost, (3.2) that depends on the number of active XDs (3.3.); the transportation cost between the cross-dock points and the city segments, or 2E distribution cost (3.4), and the cost of physical capacity utilization at each cross-dock location (3.13).

$$C^F = \sum_i F_i^C X_i \quad (3.1)$$

$$C^U = \sum_i X_i \left[2 \frac{k^o r_i{}^o}{a^o} (w + c^{O,U})\right] + N(c^{F,U} + w\,\theta^d + w\,\theta^a) \quad (3.2)$$

$$N = \sum_i X_i \quad (3.3)$$

$$C^V = \sum_i \sum_s \sum_v Y_{i,s,v} f_{i,s,v} \quad (3.4)$$

$$f_{i,s,v} = q_{i,s,v}\, m_{i,s,v} \left[n_{i,s,v}\, t_v^l \alpha_s w + n_{i,s,v}\, t_v^s \alpha_s w + n_{i,s,v}\, t_v^p (w + c_v{}^{O,V}) + 2 \frac{k_v{}' r_{i,s}}{a_v} (w + c_v{}^{O,V}) + n_{i,s,v} \left(\frac{k_v{}' k}{a_v \sqrt{\delta_s \lambda_s}}\right) (w + c_v{}^{O,V})\right] + q_{i,s,v}\, c_v{}^{F,V} \quad (3.5)$$

$$t_{s,v}^R = j_{s,v}^V \left(\left(\frac{k_v{}' k}{a_v \sqrt{\delta_s \lambda_s}}\right) + t_v^s + t_v^l + t_v^p\right) \quad (3.6)$$

$$b_{i,s,v} = \frac{T}{t_{s,v}^R + 2 \frac{k_v{}' r_{i,s}}{a_v}} \quad (3.7)$$

$$n_{i,s,v} = j_{s,v}^V min[1, b_{i,s,v}] \quad (3.8)$$

$$m_{i,s,v} = max[1, b_{i,s,v}] \tag{3.9}$$

$$q_{i,s,v} = \frac{\delta_s A_s \lambda_s \omega_s}{j^V_{s,v} b_{i,s,v} D} \tag{3.10}$$

$$j^V_{s,v} = \frac{\mu_v}{\alpha_s} \tag{3.11}$$

$$\alpha_s = \frac{d_s \beta_s}{\omega_s} \tag{3.12}$$

$$C^G = \sum_i c^S_i \{[\sum_s \sum_v Y_{i,s,v}(q_{i,s,v} p^V_v)] + p^U\} \tag{3.13}$$

Equations 3.5-3.13 describe the estimated routing cost considering drop size, wallet share, frequency of visits, and penetration, further extending the Augmented Route Cost Estimation (ARCE) method proposed by Winkenbach et al. (2016) and Merchán et al. (2018). Constraints (3.5) compute the average total distribution cost to serve each city segment *s* from the cross-dock point *i* using vehicle type *v*. Constraints (3.6) calculate $t^R_{s,v}$, the average tour time needed to serve a segment s using a specific vehicle type v. This value is used to calculate $\delta_{i,s,v}$, the number of full load tour a vehicle departing from cross-dock at i can complete within the maximum service time (MST) from constraints (3.7). Then, $n_{i,s,v}$ is obtained, which is the average number of customers served per tour from constraints (3.8), $m_{i,s,v}$, which is the average number of tours needed from constraints (3.9), and $q_{i,s,v}$, which is the average number of vehicles needed from constraints (3.10), number of stores, penetration, frequency, vehicle size, number of tours, and number of days in a month. This set of constraints now consider the frequency of deliveries, customer penetration, the number of kiranas served, full load tours per vehicle, and their capacity in the number of kiranas served. Constraints (3.11) computes the capacity of 2E vehicles in the number of kiranas that can be served, depending on the capacity in the number of items and the average drop size. Finally, the average drop size is computed based on the individual demand, the frequency of visits, and the wallet share per kirana is obtained in constraints for each city segment *s* (3.12).

The mixed-integer linear programming model can be formulated as follows:

$$Min\ C = C^F + C^U + C^V + C^G$$

Subject to

$$\sum_i \sum_v Y_{i,s,v} = 1 \qquad \forall s \tag{3.14}$$

$$\sum_v \sum_s Y_{i,s,v} \leq M\, X_i \qquad \forall i \tag{3.15}$$

$$\sum_s \sum_v Y_{i,s,v} q_{i,s,v} p^V_v \leq (S_i - p^U)\, X_i \qquad \forall i \tag{3.16}$$

$$\sum_i X_i \geq X^L \tag{3.17}$$

$$Y_{i,s,v}, X_i \in \{0,1\} \tag{3.18}$$

Constraints (3.14) ensure that all city segments are served and constraints (3.15) restrict allocation to segments and vehicles to active cross-docks. Constraints (3.16) restrict space availability in each cross-dock and constraints (3.17) determine the minimum number of active cross-docks to be used, if needed. Constraints (3.18) denote the domain of the variables.

3.5 Urban Morphology Impact – Road Network Circuity Factor (RCF) Calculation

In order to calculate the impact of the urban morphology, we measured the Road-Network Circuity Factor (RCF) of each of the cities from each category. We use the calculation presented by Merchán et al. (2015b):

$$RCF = \frac{1}{m}\sum_{i}^{m}\frac{d_j^R}{d_j^{L1}}$$

In the equation presented above, m indicates the number of samples of distances between zip codes taken for a particular city. The real distance d_j^R was computed using Google Maps API by computing the one-way direction, driving distance between the zip codes of the Indian city analyzed. On the other hand, d_j^{L1} was computed by calculating the L1-norm distance between zip codes of the Indian city analyzed. Finally, the RCF values are computed for every city in this study.

In summary, we presented the high-level business and data overview of the project. Then, we identified the key trade-offs that are essential in the e-B2B distribution strategy. On the network design model, we presented a 2E-CLRP model with cost approximation, which is scalable and extended to consider drop size, wallet share, penetration, delivery frequency, and RCF values of each city. Finally, we discussed on scenario analysis and planning and measuring the RCF values. In the next chapter, we presented the results from the methodology.

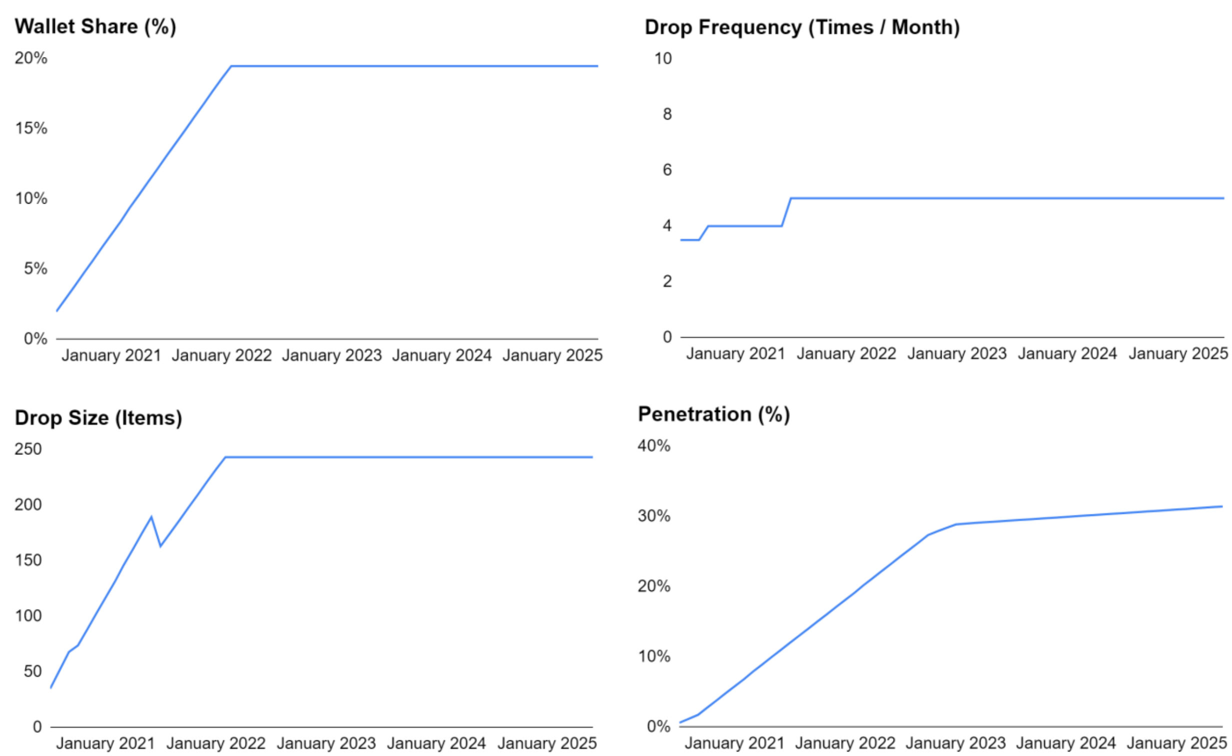
4 RESULTS AND ANALYSIS

In this section, we first describe the company overview of the project. Then, we calculate Road Network Circuity Factor (RCF) values to quantify the impact of urban morphology in our continuous approximation model. The network design results are generated using our 2E-CLRP formulation to answer our research questions. Full computational results are presented. Finally, sensitivity analyses of each key variables are presented.

4.1 Company Overview

The sponsoring company is a leading B2C e-commerce platform in India. The company is currently planning to foray into the e-B2B option for their CPG market segment. In this new business, kiranas can order their bulk merchandise online and have it delivered the next day. The company provides five years of data of their wallet share, drop size, drop frequency, market penetration. The actual data is from July to December 2020, and the forecast data is from January 2021 to June 2025 (see Figure 4.1). The data explains the company's growth aspirations across different business parameters. Its source is derived from business planning forecasts required to build a PnL (Profit and Loss) perspective of the potential e-B2B distribution business.

Figure 4.1.
Wallet Share, Drop Size, Drop Frequency, and Penetration July 2020-June 2025



The company's strategy is to offer lower prices than distributors, provide one week credit, and a next day delivery option to kiranas. The strategy on wallet share is to start at a small percentage and improve it steadily by adding more product offerings or SKU's. The company expects a steady rise in wallet share over the years, with an eventual final target at around 20%. The expectation on frequency is to match the current best offline distribution capabilities of weekly delivery (4 times a month) and scale it to around twice a week over the planning horizon. The drop size is expected to grow as wallet share increases. However, it could have some troughs as frequency increases. Finally, the market penetration that the e-B2B platform could achieve is expected to increase linearly, with an eventual target of around 40%. The end targets of these variables may not necessarily result in best-in-class cost structures. The estimation is done purely from a business planning perspective, and the variables can change in the future depending on business strategy. The ultimate goal is to identify the right inflection points for the business to consider to optimize their logistics costs.

4.2 Urban Morphology and Road Network Circuity Factors Results

The project uses four types of geographical scopes in Table 4.1. These urban settings collectively represent most cities in India and most developing countries, and we can consider them as urban archetypes from a high-level perspective.

Table 4.1.
Urban Morphology Settings

Urban Morphology Type	Population	Sample Kiranas from Sponsoring Company (Approx.)	Capstone Project Scenarios
Megalopolis	30 million	100,000	NCR, Mumbai
Megacity	12 million	40,000	Hyderabad, Bangalore, Chennai
Twin Cities	21 million	70,000	Mumbai, Pune
Distributed Cities	16.5 million	55,000	Ahmedabad, Surat, Rajkot, Vadodara

We calculated the Road Network Circuity Factor (RCF) of our city scenarios (see Figure 4.2). The results align with the country-level analysis done by Ballou (2002), where the RCF of India has an average of 1.31 and a standard deviation of 0.21. The numbers are noticeably lower than RCF values of Latin American and Non-Indian Asian cities by Merchán et al. (2015b) (Ranging from 1.47 to 1.99), suggesting that Indian cities have fewer grid-like roads than these cities. We subsequently use these results in the scenario analysis section. Figure 4.3 illustrates how different urban settings look like on a spatial instrument, like a map. Clearly, city arrangements differ from each other and, therefore, their logistics strategies.

Figure 4.2.
Road Network Circuity Factor (RCF) of City Scenarios

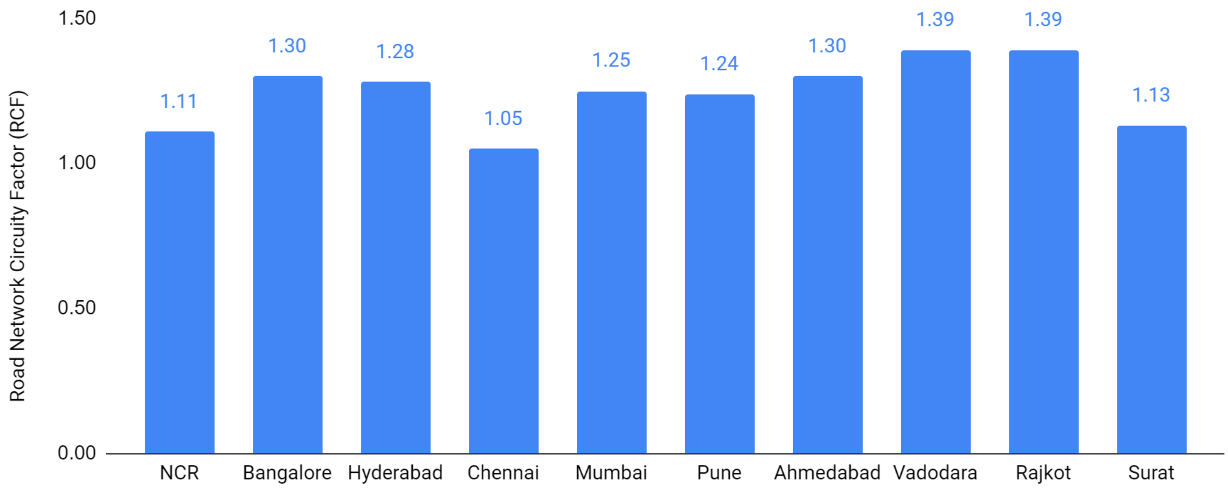
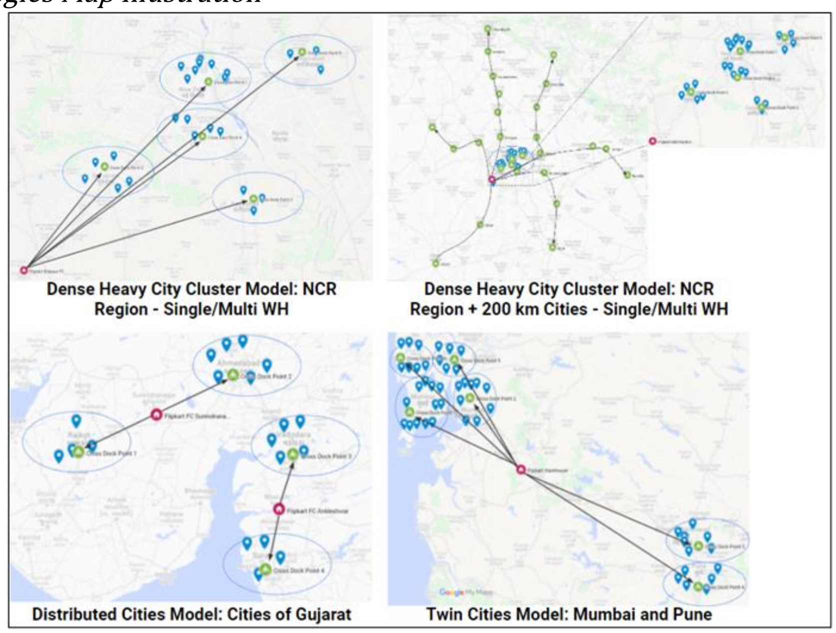


Figure 4.3.
Urban Morphologies Map Illustration



4.3 Model Implementation and Results

The 2E-CLRP is coded in PYTHON 3.9 and solved using GUROBI 9.1. We made the experimental runs in a personal Core i7 computer with 2.60 GHz Processor and 16.0 GB RAM. We generate the results for a single geographic area for a baseline scenario for the sake of space. Figures 4.4 and 4.5 illustrate the network design model and solution.

Figure 4.4.
All Kirana Stores and Their Demand Volumes are Aggregated into City Segments

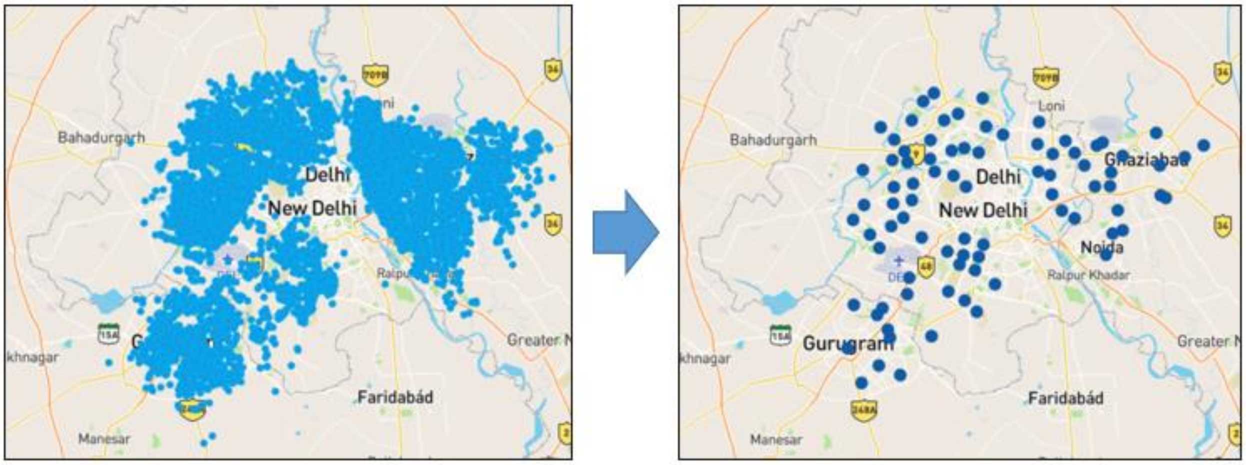
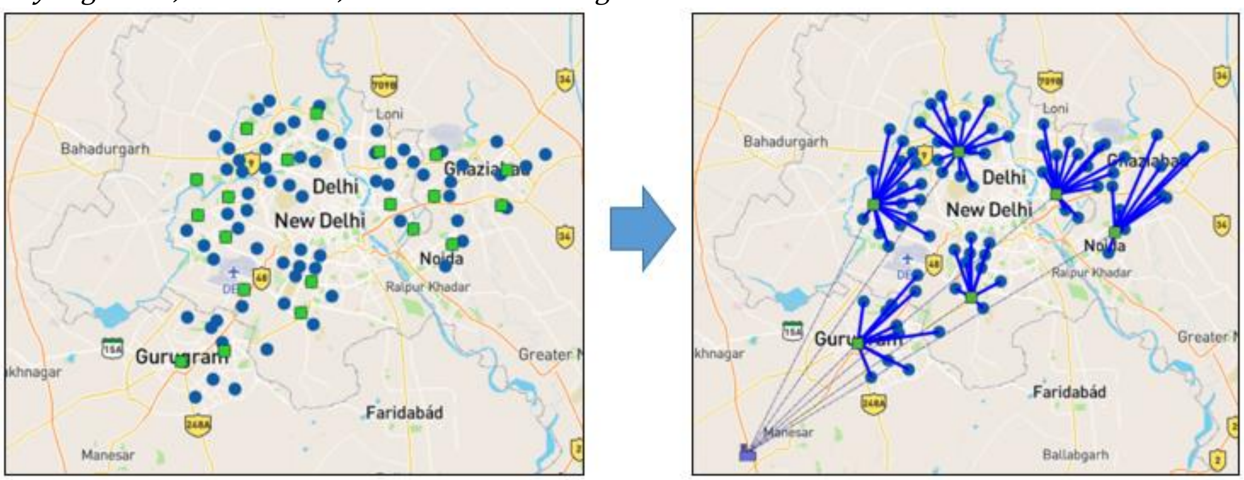


Figure 4.5.
City segments, Cross-docks, and a Network Design Model to Minimize Costs



Using the 5-year data provided by the sponsoring company, the network design model computes the logistics costs. The cost-to-serve percentages are computed by dividing logistics cost with total sales. Full results are provided on Table Appendix 1.1. From Figure 4.6 shown below, the cost-to-serve percentage over the 5-year time horizon reduced significantly in the first few months, moderately in the following few months, and plateaued for the rest of the months. The summary of the results is given on Table 4.2 below.

Figure 4.6.
Cost-to-serve Percentage Over Time Horizon

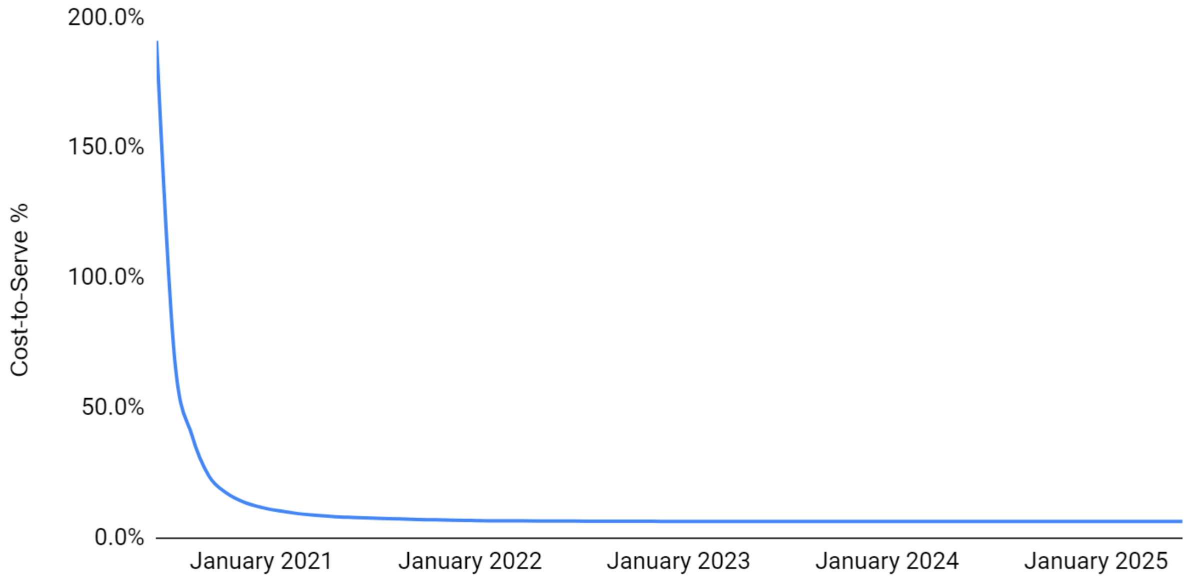


Table 4.2.
Summary of Cost-to-Serve Over Key Variables in NCR

Time Period	Mode of Frequency	Wallet Share	Penetration	Range of Cost-to-Serve
July 2020 to October 2020	3.5	< 5%	< 5%	23.8-191.0%
November 2020 to March 2021	4	5-10%	5-10%	8.9-17.7%
April 2021 to February 2022	5	10-20%	10-20%	6.7-8.4%
March 2022 to June 2025	5	> 20%	> 20%	6.4-6.7%

To further elaborate the results, the cost to serve percentage eventually reaches a minimum value and remains steady even after increasing wallet share or market penetration. Initially, a significant cost reduction is achieved by moving from less than 5% to around 10% wallet share and penetration. Afterward, adding more wallet share and penetration does not significantly reduce the cost-to-serve percentage as they reach the end of second echelon routing economies of scale. In practice, cost-to-serve will respond to changes in fixed and operating cost structure or the average selling price (ASP).

4.4 Sensitivity Analysis of Wallet Share, Frequency, and Market Penetration

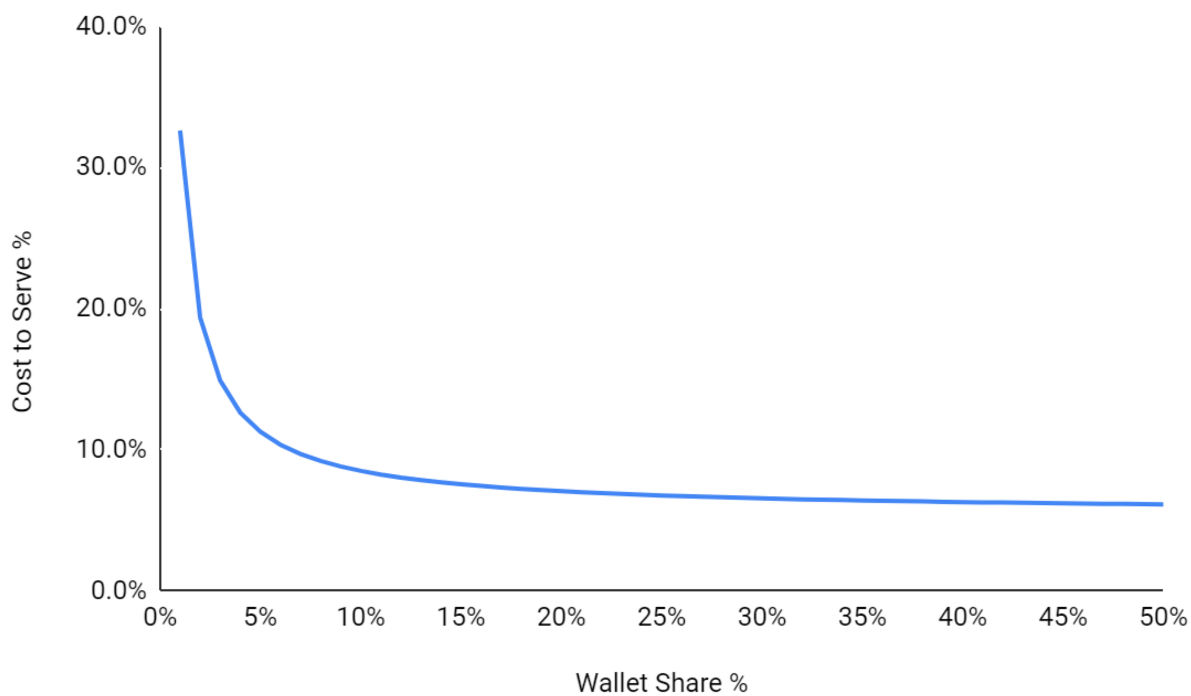
We compute the following sensitivity analysis of wallet share, frequency, and penetration towards the cost. The sensitivity of drop size is not analyzed as it is dependent on wallet share and frequency (see Section 3.3 and Eq. 3.12).

4.4.1 Wallet Share

From Figure 4.7, we found a huge cost reduction from 0.5% to 5% wallet share. Then, there exist a moderate cost reduction from 5% to 10% wallet share. Afterwards, the cost-to-serve percentage plateaued, which indicates that the cost savings after attaining a 10%-wallet share are insignificant. It reaches a drop size that maximizes the vehicle utilization that could be achieved in this distribution network.

Figure 4.7.

Sensitivity Analysis of Cost-to-serve percentage over Wallet Share percentage



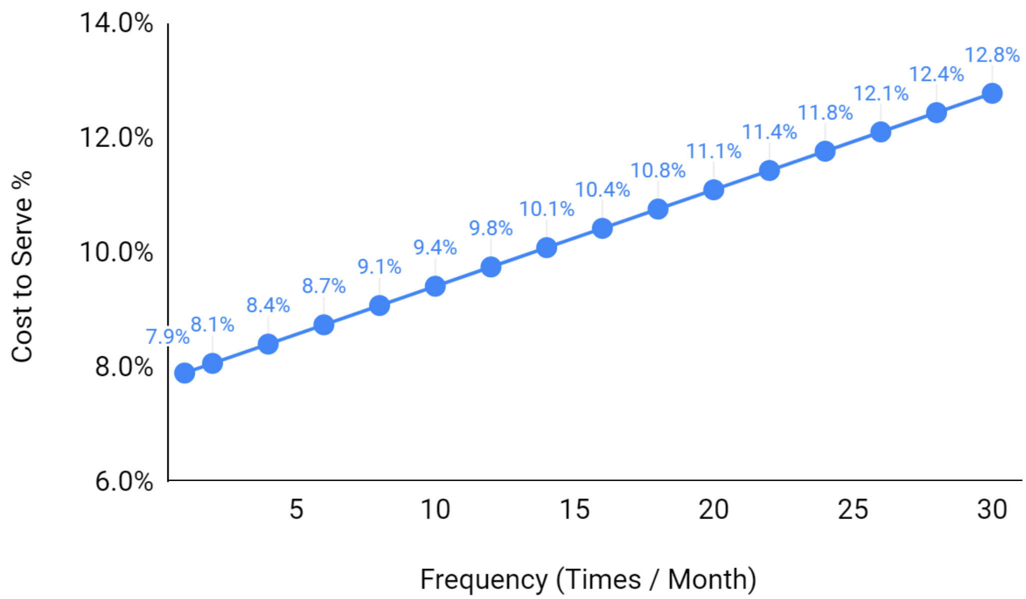
As cost-to-serve reaches steady state, further increase of wallet share will necessitate additional vehicles to fulfil the demand, leading to proportional cost increase and cost-to-serve to remain constant. To look for additional cost opportunities, the company must evaluate different vehicular types. Whereas e-commerce B2C distribution depends purely on customer density, e-B2B distribution depends on store density and drop size per store. Increasing drop size per node with higher wallet share will not give proportional cost benefits beyond a certain level as the vehicular utilization requirements are completely utilized.

4.4.2 Frequency

From Figure 4.8, we found that as we add a monthly delivery frequency, the cost to serve linearly increases by 0.17%. This chart assumes that other variables are not changed. In reality, wallet share and penetration increase as delivery frequency increases. Despite the expected linear increase when fixing other variables, we aim to compute the percentage of increase and the lower bound that ended being 0.17% and 7.9% as reported in the Figure 4.8 below. In practice, changing frequency will lead to changes in wallet share and market penetration.

Figure 4.8.

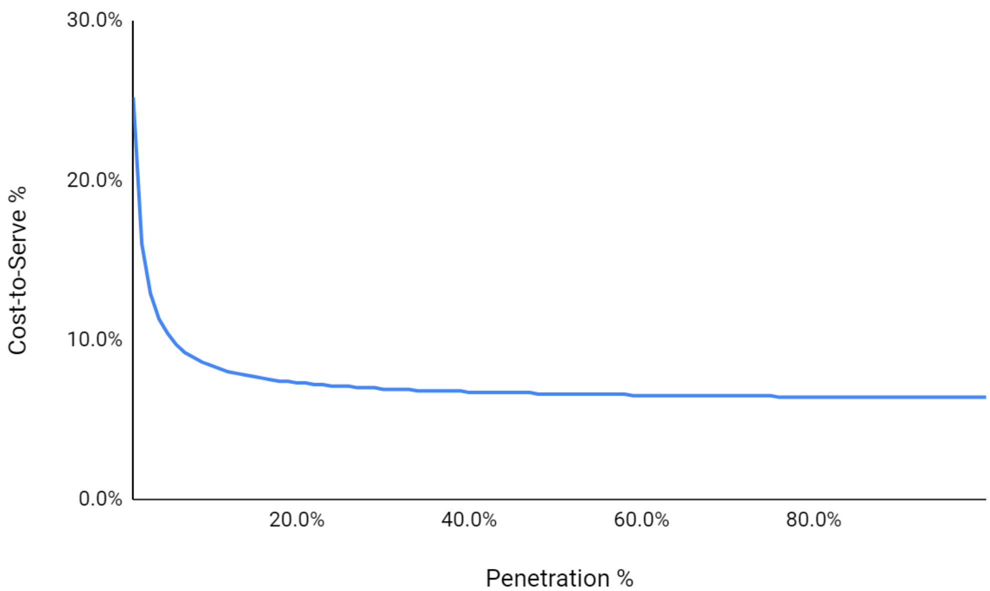
Sensitivity Analysis of Cost-to-serve percentage over Monthly Delivery Frequency



4.4.3 Market penetration

The sensitivity analysis of penetration is the similar to wallet share. From Figure 4.9, we found a considerable cost reduction that 0.5% to 5% penetration. We also found a moderate cost reduction from 5% to 10% penetration, and the cost-to-serve percentage plateaued afterwards. The chart also indicates that the cost savings after 10% market penetration are negligible. At certain density it is no longer profitable to add more stores because more stores will add more vehicle. The only way we can change is if we increase vehicle operating time or vehicle size. In terms of operating time there could be legal and labor constraints. In terms of vehicle size, there exist constraints by the urban environment and parking space. For example, we cannot use large trucks to directly serve kiranas.

Figure 4.9.
Sensitivity Analysis of Cost-to-serve Percentage over Penetration Percentage



Market penetration also has a limiting impact on cost to serve after a certain level. Second echelon routing depends on two key variables, the travel distance between kiranas and the time spent at each kirana location. With higher penetration, the network reduces the travel distance, but the interaction time at kirana location is independent of density. Finally, the number of vehicles also depend on penetration (see Eq. 3.11). This explains the plateauing of cost to serve after a certain threshold of market penetration.

4.5 Sensitivity Analysis of Urban Morphologies

We are using the Road Network Circuity Factors (RCF) from Section 4.2 and compute the cost-to-serve percentages over different RCFs for the cities. From Table 4.3 and Figure 4.10, there is a very slight increase of cost-to-serve % as RCF values increase. This might be due to the fact that we are not computing the differences in urban features at a granular level (e.g., per square kilometer). The results end up showing RCF values that range between 1.05 to 1.39, whereas in cases with more granular information grows, the values grow to 1.38 to 1.99 in diverse cities according to Merchán et al. (2015b). This will require further research in the future.

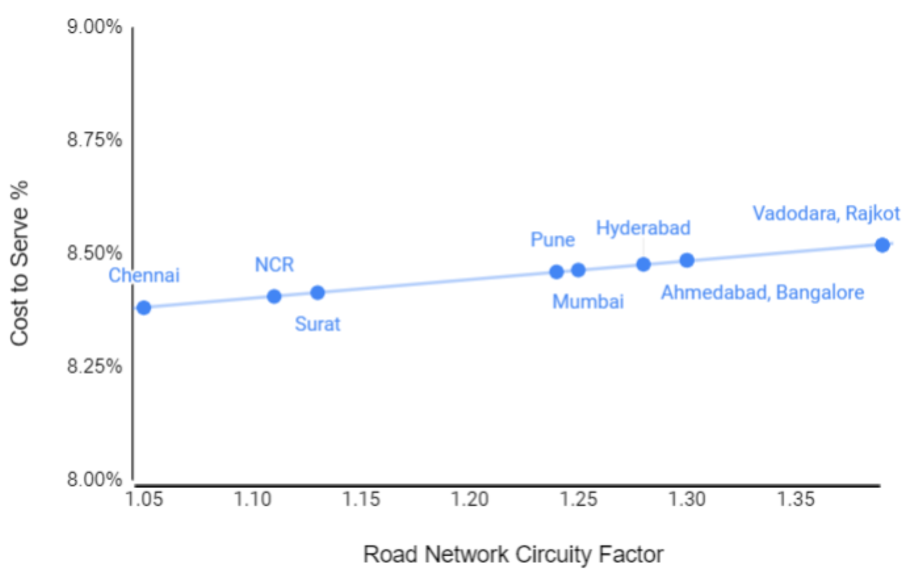
Table 4.3.

Cost-to-Serve Over Road Network Circuity Factors of Different Cities/Regions

City / Region	Road Network Circuity Factor	Cost to Serve %
NCR	1.11	8.41%
Bangalore	1.30	8.49%
Hyderabad	1.28	8.48%
Chennai	1.05	8.38%
Mumbai	1.25	8.46%
Pune	1.24	8.46%
Ahmedabad	1.30	8.49%
Vadodara	1.39	8.52%
Rajkot	1.39	8.52%
Surat	1.13	8.41%

Figure 4.10.

Sensitivity Analysis of Cost-to-serve Percentage over Road Network Circuity Factor (RCF)



From Figure 4.10, the cities with higher RCF values are incurring higher distribution costs. For example, Pune and Mumbai (twin cities) have higher cost-to-serve percentages due higher RCF values than NCR (megalopolis). Higher RCF values means higher effective road distance. This reduces vehicle productivity and thereby increases cost.

5 DISCUSSION

From the previous chapter, we found that the key differentiator of a non-exclusive e-B2B distribution is the routing cost, which could be optimized using higher wallet share (which increases drop sizes) and a more robust market penetration. We further discuss in the following sub-sections.

5.1 Trade-offs

There exists a significant reduction in cost-to-serve percentages as we increase wallet share and market penetration to a certain threshold. The reduction is driven by the increase of economies of scale (drop size of each stop) and grow revenue, given the increased likelihood of a successful visit to a kirana to sell more in frequent visits (see Table Appendix 1.1). Wallet share increases drop sizes; this in turn reduces cost-to-serve. In the case of the sponsor company data and parameters, as the wallet share and penetration reach 10%, the cost to serve percentages plateau afterwards, which means the cost savings are almost null after 10%. Therefore, most of the savings can be attained by reaching 10% of wallet share and penetration to achieve optimal cost savings. Beyond the threshold, companies can continue to gain wallet share and penetration with very minimal cost savings; but increasing their logistics complexity to manage a larger number of product families, SKUs and also stores to be served. This is not considered by the costs of our model and further analysis are needed at an operational level. Finally, changing data and parameters will change the threshold.

Moreover, from a high-level perspective, increasing delivery frequency reduces drop sizes and increases cost-to-serve percentages. However, the increase is linear and does not provide big savings. This trade-off heavily favors wallet share because this also impacts sales by taking advantage of one visit to deliver a larger quantity of goods to the kirana owners. Finally, the impact of urban morphologies shows to be small towards cost-to-serve at a level of analysis per urban district (every 5-10 km^2), and this should not be a point of consideration compared to wallet share and penetration at a strategic-tactical level. The impact of drop size towards cost-to-serve also affirms the findings by Kin (2018), given that as we increase the drop size by reducing the frequency or increasing wallet share, the cost-to-serve decreases.

5.2 Insights and Practical Implications

Based on the sensitivity analysis in Section 4.4, Section 4.5, and the tradeoffs discussion in Section 5.1, five key insights can be rendered:

1. Fragmentation can be reduced with an e-B2B distribution by increasing the drop size through reducing frequency or increasing wallet share.
2. Wallet share, penetration, frequency, and Road Network Circuity Factor (RCF) values are the key factors of urban network design.
3. Reaching wallet share and penetration threshold should be the key focus for companies looking to reduce cost-to-serve and fragmentation in supplying nanostores.
4. Companies should not be afraid to increase the delivery frequency or open service at different regions as these factors only slightly increase cost-to-serve.
5. By extending the Two-echelon location-routing problem (2E-CLRP) to consider drop size, wallet share, penetration, and frequency, this network design model can be reliably used to design transsshipment networks for nanostores and minimize logistics cost-to-serve. This model is scalable, modifiable, and applicable to use for nanostores distribution network design.

5.3 Management Recommendations

Our recommendations to e-commerce platforms seeking to become leaders of non-exclusive, e-B2B distribution are compiled below.

5.3.1 Key Distribution Strategy Framework on Different Phases

We developed a threshold framework (see Table 5.1) and recommended companies need to spend marketing and operations resources to reach 10% market penetration and wallet share threshold to reduce cost-to-serve significantly. Reaching targets of wallet share and market penetration at 20% and beyond should be considered medium and low priority, respectively; or they should be recommended for more advanced stages of maturity in the non-exclusive distribution, e-B2B environment. These thresholds can change depending on the companies' data and operating strategy.

Table 5.1.

Distribution Strategy Action Framework with Expected Savings and Priority

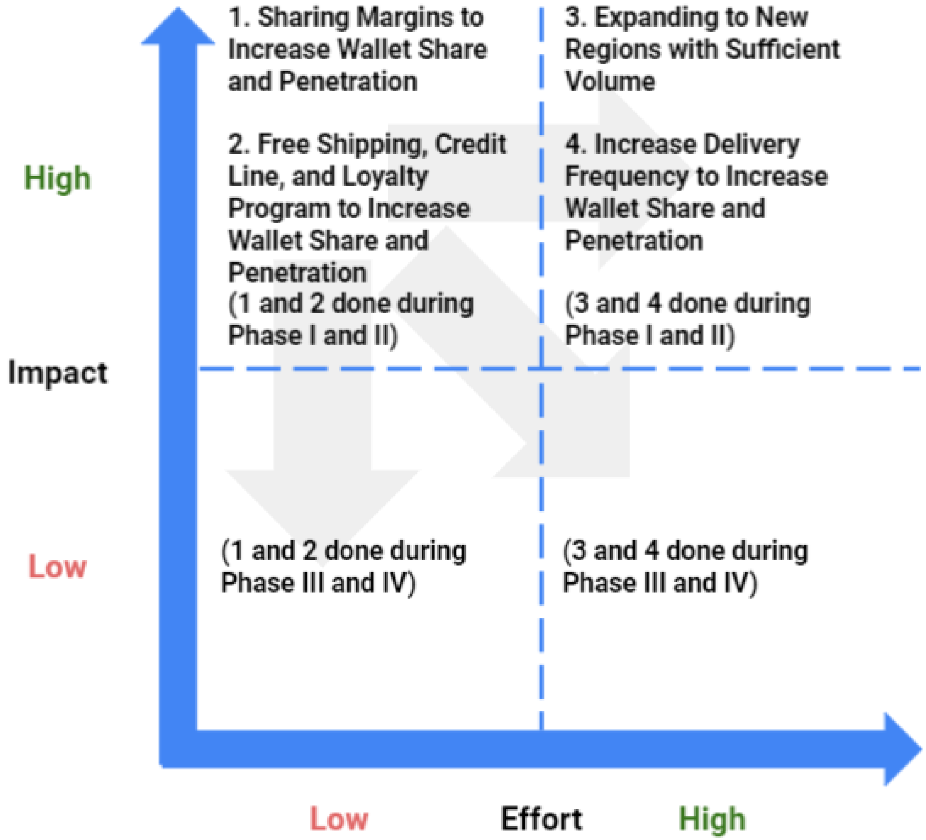
Phase	Wallet Share (WS)	Penetration	Action	Cost Savings	Priority
I	< 5%	< 5%	Reach 5% on WS and Penetration	> 80%	Very High
II	5-10%	5-10%	Reach 10% on WS and Penetration	Up to 50%	High
III	10-20%	10-20%	Reach 20% on WS and Penetration	< 20%	Medium
IV	> 20%	> 20%	Go Beyond 20%	< 5%	Low

5.3.2 Key Initiatives in Distribution Strategy

At a strategic-tactical level, companies can distinguish themselves by expanding service at different regions or increase delivery frequency to attain the targets of wallet share and market penetration. This might be possible given that the cost savings from these two factors outweigh the increase of costs associated with circuity and frequency of deliveries. However, these efforts require substantial capital and operational expenses. Few actions that may grow market share and revenue without significant effort include giving some cost-to-serve savings back to the kiranas or implementing free shipping, line of credit extensions, and customized loyalty programs to attract more kiranas to join and increase wallet share of existing kiranas. Some disruptive ideas might include to optimize assortment optimization from the CPG manufacturer's and distributor's standpoints per neighborhood to boost market penetration, wallet share and indirectly, minimize stock-out events, and returns. These initiatives are summarized in Figure 5.1.

Figure 5.1.

Effort-Impact Matrix of Initiatives



6 CONCLUSION

Indian CPG firms are staring at a major disruption in their distribution models. Traditional distributors have seen their margins shrink over the years due to intense competition. It is challenging for CPG firms to replace distributors who churn. This could be the vacuum that emerging distribution models such as e-B2B distribution can fulfill. With traditional retail still accounting for 90% of the business, e-B2B players could drastically change how companies reach their customers, the retailers. With widespread mobile penetration and digital connectivity at very affordable prices, the emergence of e-B2B distribution is happening at the right moment.

From the brands perspective, regional and challenger brands are eager to partner with e-B2B players compared to marquee brands as marquee brands have well-established exclusive offline distribution channels. An e-B2B distribution makes the day-to-day lives of the kirana owners much simpler, as they can focus their time on selling rather than having to deal with hundreds of salespeople for orders, payments, new product listings, and inventory management. Even though this may seem disruptive, it is likely to emerge as the most efficient model in the coming years, where offline fragmentation will lead to disowning a large part of the traditional distribution network, and lead to partnering with regional and national e-B2B distribution players to enable the most effective and lowest cost-to-serve distribution model for CPG brands across all channels.

From this project, we presented a novel e-B2B distribution approach and a network model that reduces fragmentation and cost-to-serve in supplying kiranas. We found that companies should focus on wallet share and market penetration to generate significant cost savings. Increases in frequency and circuity do increase the costs. Nevertheless, the magnitude is less significant provided that no other investments or complexity are added to the distribution model. This means companies should not be afraid of these factors. We recommend the sponsoring company reach the threshold of 10% of wallet share and penetration to reduce costs swiftly. These findings are also applicable to other developing countries. Finally, the cost savings can be used by companies to invest in other regions, increasing the level of service, or sharing margins back to kiranas to improve their livelihood as their customers. As aforementioned in discussion, different companies can have different thresholds.

In this study, there exist a few limitations. First, in terms of granularity, the RCF values are limited by high-level zip code data. Second, this study assumes no complexities and cost implications of rapid growth in terms of wallet share and market penetration of nanostores. Moreover, the data provided by the sponsoring company are representative samples and averages which have yet to capture the heterogeneity of nanostores. For the sake of scope, we also assumed there exist no challenges in assortment, marketing, pricing, warehousing, and inventory. This requires further investigation to analyze other trade-offs at tactical and operational levels.

Finally, after tackling last-mile distribution strategy and network design, essential cost-to-serve elements such as inventory, marketing, promotion, and pricing strategies on e-B2B, non-exclusive distribution solutions to nanostores are exciting challenges that one can take on. Future research can be done by formulating pricing and inventory strategies together. Other challenges include developing dynamic or stochastic network design models over different periods. An empirical or analytical study to calculate the risks and complexities of the rapid growth of e-B2B distribution is also meaningful in this exciting field. In summary, the e-B2B distribution model posits promising benefits towards large developing economies (e.g., India) and the urban retail atmosphere that keeps growing and will prevail in those economies.

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APPENDIX

Table Appendix 1.1.

Cost-to-Serve over Frequency, Wallet Share, Penetration, and Drop Size in NCR

Month	Stores	Frequency (Times / Month)	Wallet Share (%)	Drop Size (Units)	Penetration (%)	Total Sakes (USD)	Logistics Cost (USD)	Cost-to-Serve %
Jul-20	854	3.5	1.90%	35	0.60%	4,159,399	264,866	191.00%
Aug-20	1,708	3.5	2.90%	51	1.10%	12,270,227	288,180	70.50%
Sep-20	2,562	3.5	3.80%	68	1.70%	24,332,484	320,230	39.50%
Oct-20	4,104	4	4.70%	74	2.70%	48,468,727	383,749	23.80%
Nov-20	5,646	4	5.60%	88	3.80%	79,738,432	457,824	17.20%
Dec-20	7,188	4	6.60%	103	4.80%	118,000,000	543,844	13.80%
Jan-21	8,730	4	7.50%	117	5.80%	164,000,000	643,341	11.80%
Feb-21	10,272	4	8.40%	132	6.80%	216,000,000	755,867	10.50%
Mar-21	11,814	4	9.30%	146	7.90%	276,000,000	881,070	9.60%
Apr-21	13,356	4	10.30%	161	8.90%	343,000,000	1,018,460	8.90%
May-21	14,898	4	11.20%	175	9.90%	417,000,000	1,168,813	8.40%
Jun-21	16,440	4	12.10%	189	10.90%	498,000,000	1,332,566	8.00%
Jul-21	17,982	5	13.10%	163	12.00%	587,000,000	1,535,849	7.90%
Aug-21	19,524	5	14.00%	175	13.00%	682,000,000	1,726,261	7.60%
Sep-21	21,066	5	14.90%	186	14.00%	785,000,000	1,928,918	7.40%
Oct-21	22,608	5	15.80%	198	15.00%	895,000,000	2,144,278	7.20%
Nov-21	24,150	5	16.80%	209	16.10%	1,010,000,000	2,372,598	7.00%
Dec-21	25,693	5	17.70%	221	17.10%	1,140,000,000	2,613,522	6.90%
Jan-22	27,235	5	18.60%	233	18.10%	1,270,000,000	2,867,635	6.80%
Feb-22	28,777	5	19.50%	243	19.20%	1,400,000,000	3,128,106	6.70%
Mar-22	30,319	5	19.50%	243	20.20%	1,480,000,000	3,278,023	6.70%
Apr-22	31,861	5	19.50%	243	21.20%	1,550,000,000	3,427,828	6.60%
May-22	33,403	5	19.50%	243	22.20%	1,630,000,000	3,577,625	6.60%
Jun-22	34,945	5	19.50%	243	23.30%	1,700,000,000	3,727,413	6.60%
Jul-22	36,487	5	19.50%	243	24.30%	1,780,000,000	3,877,118	6.50%
Aug-22	38,029	5	19.50%	243	25.30%	1,850,000,000	4,026,753	6.50%
Sep-22	39,571	5	19.50%	243	26.30%	1,930,000,000	4,176,382	6.50%
Oct-22	41,113	5	19.50%	243	27.40%	2,000,000,000	4,325,984	6.50%
Nov-22	41,917	5	19.50%	243	27.90%	2,040,000,000	4,403,961	6.50%
Dec-22	42,648	5	19.50%	243	28.40%	2,080,000,000	4,474,873	6.50%
Jan-23	43,380	5	19.50%	243	28.90%	2,110,000,000	4,545,784	6.50%
Feb-23	43,565	5	19.50%	243	29.00%	2,120,000,000	4,563,749	6.50%
Mar-23	43,696	5	19.50%	243	29.10%	2,130,000,000	4,576,484	6.50%
Apr-23	43,828	5	19.50%	243	29.20%	2,130,000,000	4,589,219	6.50%

Month	Stores	Frequency (Times / Month)	Wallet Share (%)	Drop Size (Units)	Penetration (%)	Total Sakes (USD)	Logistics Cost (USD)	Cost-to-Serve %
May-23	43,959	5	19.50%	243	29.30%	2,140,000,000	4,601,954	6.40%
Jun-23	44,091	5	19.50%	243	29.30%	2,150,000,000	4,614,689	6.40%
Jul-23	44,222	5	19.50%	243	29.40%	2,150,000,000	4,627,424	6.40%
Aug-23	44,353	5	19.50%	243	29.50%	2,160,000,000	4,640,160	6.40%
Sep-23	44,485	5	19.50%	243	29.60%	2,170,000,000	4,652,895	6.40%
Oct-23	44,616	5	19.50%	243	29.70%	2,170,000,000	4,665,629	6.40%
Nov-23	44,747	5	19.50%	243	29.80%	2,180,000,000	4,678,364	6.40%
Dec-23	44,879	5	19.50%	243	29.90%	2,190,000,000	4,691,099	6.40%
Jan-24	45,010	5	19.50%	243	30.00%	2,190,000,000	4,703,834	6.40%
Feb-24	45,141	5	19.50%	243	30.00%	2,200,000,000	4,716,569	6.40%
Mar-24	45,273	5	19.50%	243	30.10%	2,200,000,000	4,729,304	6.40%
Apr-24	45,404	5	19.50%	243	30.20%	2,210,000,000	4,742,038	6.40%
May-24	45,536	5	19.50%	243	30.30%	2,220,000,000	4,754,773	6.40%
Jun-24	45,667	5	19.50%	243	30.40%	2,220,000,000	4,767,508	6.40%
Jul-24	45,798	5	19.50%	243	30.50%	2,230,000,000	4,780,243	6.40%
Aug-24	45,930	5	19.50%	243	30.60%	2,240,000,000	4,792,977	6.40%
Sep-24	46,061	5	19.50%	243	30.70%	2,240,000,000	4,805,709	6.40%
Oct-24	46,192	5	19.50%	243	30.70%	2,250,000,000	4,818,433	6.40%
Nov-24	46,324	5	19.50%	243	30.80%	2,260,000,000	4,831,157	6.40%
Dec-24	46,455	5	19.50%	243	30.90%	2,260,000,000	4,843,882	6.40%
Jan-25	46,586	5	19.50%	243	31.00%	2,270,000,000	4,856,606	6.40%
Feb-25	46,718	5	19.50%	243	31.10%	2,270,000,000	4,869,330	6.40%
Mar-25	46,849	5	19.50%	243	31.20%	2,280,000,000	4,882,054	6.40%
Apr-25	46,981	5	19.50%	243	31.30%	2,290,000,000	4,894,778	6.40%
May-25	47,112	5	19.50%	243	31.40%	2,290,000,000	4,907,502	6.40%
Jun-25	47,243	5	19.50%	243	31.40%	2,300,000,000	4,920,226	6.40%