IMPACT OF FREIGHT CONSOLIDATION ON LOGISTICS COST AND EMISSIONS

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Summary: This research explores the impact of longer delivery lead times on last mile delivery costs and emissions for an Omnichannel retailer. Results from this study suggest that longer lead times provide opportunities to improve truck utilization by improving shipment consolidation. At the same time, increasing route time in the delivery zone also improves utilization and reduces the overall number of trips in high density areas.

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KEY INSIGHTS

1. **We propose a methodology that reduces delivery frequency by utilizing longer lead times. This could lead to a 19% reduction in trips.**
2. **For high delivery density zones, increasing time available for in-zone deliveries could result in fewer trips up to 26%.**
3. **We applied our approach to one of the largest retailer that operates in more than 20 regions in Mexico. Our methodology shows annual savings up to $2.14 Million and 5.76 thousand metric tons of CO_2 emissions.**

Introduction

The transportation sector is one of the two principal contributors of greenhouse gas emissions (GHG), which are expected to double by 2050. Growing consumer demand for home deliveries with high service levels and no add-on costs is quickly becoming the standard. As a result, retailers are transforming their supply chains to meet these requirements through innovation in transportation. However fast delivery is a double-edged sword – it is expensive for companies to sustain and generates greenhouse gases from fuel combustion, which is harmful for the planet. Previous MIT studies have shown that customers may be willing to wait for their deliveries if the environmental impact of fast delivery is presented to them.

Our research considers the impact of freight consolidation on CO_2 equivalent emissions and logistics costs for omnichannel home delivery. We analyze data from a large omnichannel retailer in Mexico, derive insights on current operational metrics, apply heuristic methods to minimize trips and validate our hypothesis by means of experiments run on specific scenarios. We find that increased delivery lead times can lead to better route utilization, fewer trips to deliver customer shipments and therefore cost saving opportunities and lower emissions.

One of the effects of increased lead time that we focus on is improving the utilization of last mile routes with higher package density. We will also briefly dive into the impact on inventory positioning in the logistics network and quantify savings from modifying warehouse transfer policies as a consequence of having a few additional days to complete customer deliveries. This study will provide the following managerial recommendations:

- Changes to the current operating model to improve shipment consolidation on a route.
- Given the additional delivery lead time, the impact of modifying delivery frequency and delivery zones.
- The impact of increasing the time duration of a route to improve consolidation.

Methodology:

We analyze home delivery data from 2018 across all distribution centers. We first calculate the baseline metrics to understand current state and constraints. We then get the geocodes for delivery addresses and map them to a street network for clustering analysis. Further, we study the impact of increasing consolidation given longer delivery lead times. We use the number of truck moves (trips) as a proxy of fuel reduction and estimate the cost and emissions savings base on the trip reduction.

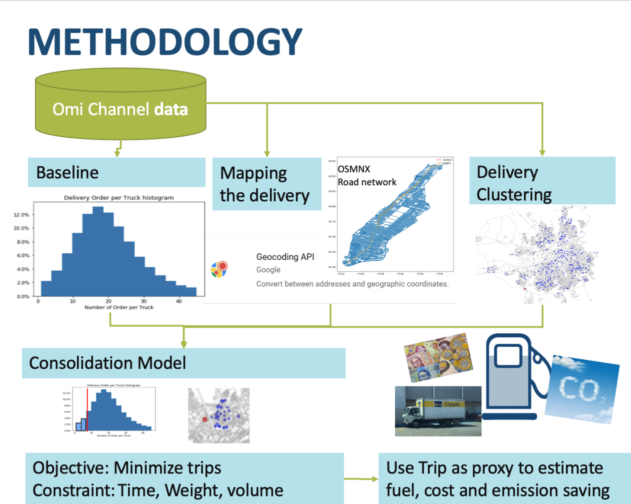

Figure 1. Methodology of our analysis to identify consolidation opportunities

Current Operation Model

This session presents the existing operating model and constraints that we gathered during a field trip to the company's distribution centers in March. Our sponsor company has a network of 20 regional distribution centers (DCs) in Mexico. These DCs fulfill orders to a network of stores as well as directly to customers for omnichannel orders. They run fulfillment operations 6 days a week (Monday to Saturday), starting with store fulfillment in the morning for 3 hours followed by home deliveries later in the day for up to 5 hours. Coppel runs its own fleet of vehicles for all deliveries to stores as well as furniture deliveries to customers.

Observations from Data

Upon analyzing truck utilization, we found that 75% of total home delivery trips had less than 3 cubic meters of cargo and 80% of trips had less than 200 Kg in the truck. A Coppel vehicle can roughly hold 1.26 tons and 10 cubic meters of cargo. This means 75% of Coppel's delivery trips to customers are less than 40% utilized, which aligns with the observations from our site visit in March 2019.

However, when we look into the number of orders per truck, we observe that about 60% of trucks are delivering on average 15 - 20 orders a day. This suggests that Coppel's fleet is better utilized in terms of time compared to volume and weight i.e. Time is the constraint today.

Geocoding and Clustering Home Delivery

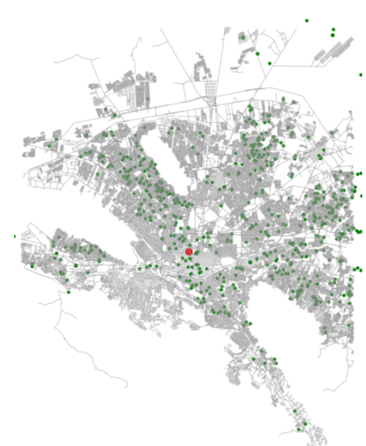

Figure 2. Plot of medium utilization truck (7-17 orders) in Monterrey, Nuevo Leon, Mexico

Using geocodes of addresses in the delivery data (via Google API), we plotted them onto Open Street Map in Python. Figure 2. is a map of areas serviced by trucks with medium utilization in Monterrey, Nuevo Leon, Mexico.

By looking at delivery data for six distribution centers and comparing high, medium and low-density zones based on orders / trip (i.e. High >=18 orders, Medium between 7 and 17 order, Low <= 6 orders), we are able to make recommendations on the delivery frequency and identify zones which could benefit from longer route times.

Results and Recommendations

After analyzing the data provided, we found that delivery time is currently the binding constraint. Making operational changes to improve delivery density by increasing route consolidation is key for cost and emissions reduction.

We recommend a three-pronged consolidation strategy for Coppel to achieve this goal.

Level 1: Remove the current operational inefficiency:

Currently, ~ 6% of truck moves are not bound by any constraint (volume, weight or time) and yet they depart with fewer than 6 orders in the truck. These orders could be shared by other neighboring routes or be delayed to the next day assuming the customer is willing to waiting.

Level 2: Utilize the longer delivery lead times to enable less frequent and therefore higher density routes. This approach is extremely effective for low delivery density cities. We identify 8 such cities within Coppel's network. This approach could result in 25% fewer trips in each city with the reduction as high as 73% in one city. Both level 1 and level 2 consolidation could be enabled by customer's willingness to wait.

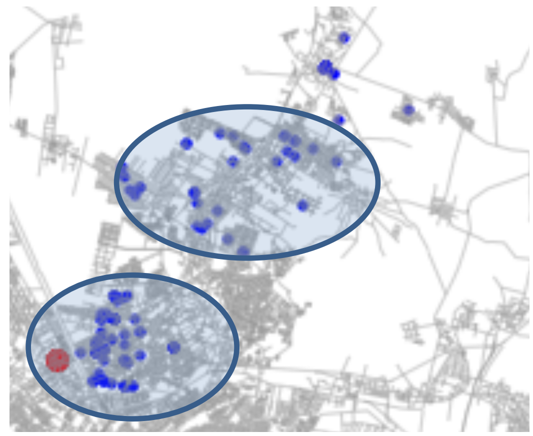

Figure 3. Longer time for in-zone delivery enable consolidation

Level 3:

High-density zones present the biggest opportunity for trip reduction and therefore savings by extending the current constraint on routes – time. By adding one hour to the total route time, which will be spent in-zone making deliveries, each truck will be able to deliver more orders and could also cover a larger area, thereby improving the overall route and vehicle utilization by about 32%.

Conclusion

In conclusion, Coppel's current home delivery operation has fairly low utilization by volume and/or weight. One of the key limiting factors is the total route time per truck and the service level promised to the customer of next-day delivery. One of the main insights of our project shows that If the customer would be willing to wait for their home deliveries and some recommendations regarding the operation on the routes were implemented, the company would reduce its delivery costs by up to 32% because of the reduction in the numbers of trips performed. This would equate to saving 2.14 Million Liters of fuel or 5.76 thousand Metric tons of CO_2 emission (IPCC 2006) or $2.14 million in fuel savings based on March 2019 Mexico Diesel prices.