Increasing Fleet Utilization Through a Heuristic to Determine Backhaul Routes

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Topic Areas: Transportation, Distribution, Environment

Summary: In this capstone project, we developed a methodology to identify backhaul opportunities to add to an established routing network. Backhauls occur when a truck completes a delivery to a store and instead of driving empty back to the distribution center, the truck goes to a nearby vendor and picks up a delivery for the distribution center. Backhauls increase fleet utilization, reduce the cost of using third-party logistics providers, and reduce carbon emissions. A heuristic was developed that determines the closest vendor to the last store in each route and then matches the vendors with the forecasted demand to make sure there are enough pickups for the scheduled backhauls. The total trip time is then calculated using the total trip distance and the time to load the delivery. This total trip time was calculated to ensure that the route and backhaul could be completed in less than 14 hours per federal regulations. We performed a case study on the distribution network of Food Lion, which is a business unit of Ahold Delhaize. From our analysis of Food Lion, we were able to identify 18 backhaul solutions that would yield $320,000 in annual savings and reduce their carbon emissions by 166,800 lbs. Extrapolating these results to the entire company, Ahold Delhaize could save $1.6 million and reduce their carbon emissions by 830,000 lbs.

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KEY INSIGHTS

1. **We have developed a methodology to improve fleet utilization through backhauls by finding the closest supplier to the last store in a route**
2. **We applied our approach for a grocery retailer in the US. Our methodology shows annual savings of up to $1.6 M and carbon emissions reduction of 830,000 pounds.**
3. **To improve the number of backhaul solutions, routes should be planned with 3-4 stops and the solution is sensitive to changes in transportation costs.**

Introduction

Fleet optimization is a well-researched field in supply chain management, but many companies struggle with implementing an optimized solution. Improving fleet utilization is a challenge because of constraints on operations, limited capacity to identify and implement improvements, and a lack of sponsorship from management. In this capstone project, we developed a heuristic to identify feasible backhaul routes and calculate the cost savings from a highly utilized fleet. Backhauls are illustrated in Figure 1. We will also calculate the environmental impact of backhauls by calculating the reduction in CO_2 emissions. We will not only provide a new set of routes with backhauls for Ahold Delhaize but will also identify the steps to implement improvements. This capstone can also then be used for companies with similar networks to help drive improvements in their transportation utilization.

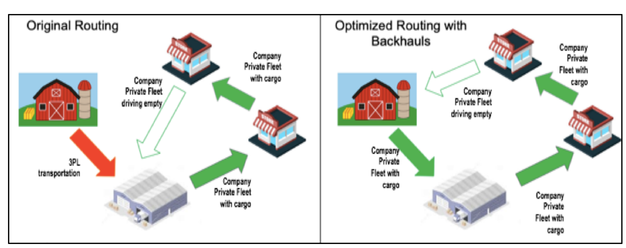

Figure 1: Backhauls reduce carbon emissions and operating costs

Our methodology is based on the analysis of the incoming and outgoing demand from the distribution centers, current truck routing, and locations of stores, vendors, and DC's. We then use this data to develop a backhaul heuristic to identify feasible backhauls based on their current routing. Ahold Delhaize consists of five operating entities, and for this capstone, we focused our analysis on Food Lion. We used Food Lion as a case study since all the data was readily available for this brand and the results could be extrapolated to the other brands. For Food Lion, we reviewed the existing inbound and outbound shipment data and data of empty backhauls that can be potentially utilized for inbound shipments. To identify the benefits, we performed a cost-benefit analysis of utilizing backhauls to conclude whether it is worthwhile for Ahold Delhaize to utilize their outbound network for inbound shipments. Our analysis showed significant benefits of using the backhauls and using that as a basis we designed a new transportation routing plan for the client. This improved network increases the utilization of the private fleet and enables the company to increase profits by reducing operating costs by $320,000 and reducing CO_2 emissions by 166,800 pounds. Extrapolating the results from the Food Lion analysis to the entire company, Ahold Delhaize could save up to $1.6 million annually and reduce CO_2 emissions by 830,000 pounds.

Methodology

Several assumptions were included in the development of this heuristic. To determine the total time of the route and backhaul, we calculated the distance from the store to the closest vendor and the distance from this vendor to the DC. We determined the additional miles to this route by adding these two distances (store to the vendor and then vendor to DC) and then subtracting the distance from the last store to the DC. This new distance was labeled as the additional mileage that we are adding to the route. To ensure that the additional mileage is feasible for each route, we added a constraint to limit the total constraint time to be below 14 hours. To calculate the amount of time that a driver can be on the road, we had to make an assumption on the average speed for a truck and the average pickup loading time at a vendor. Based on conversations with Ahold Delhaize, we are using 60 mph as our average speed and an average pickup time of two hours. These assumptions allow us to use the additional mileage to calculate the time of the new route with the backhaul attached. We also assumed that each pickup from each vendor is one full truckload. The methodology we developed is seen in Figure 2.

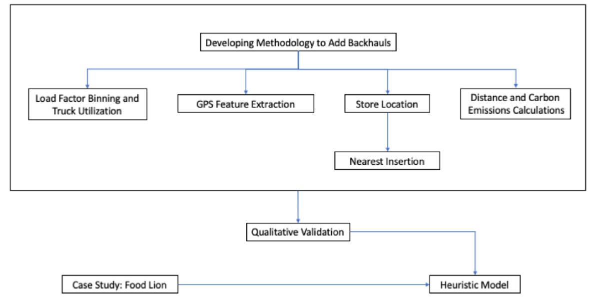

Figure 2: Methodology to develop a backhaul heuristic

To determine feasible backhauls, we adopted a four-step approach. The first step was to find the nearest vendor to the last store in the route. To calculate the closest vendor, we used the latitude and longitude of each vendor and each last store and then calculated the distance using the Great Circle distance formula

The second step was to calculate the new total distance for the route. This consisted of finding the additional miles that would be driven by adding this backhaul and then calculating the total time the driver would be driving in this route. The third step was to develop a list of the feasible backhauls based on these constraints. In the fourth and final step, if a vendor was included in more feasible solutions than the number of deliveries it had each week, then the routes with the shortest times were chosen. The shortest routes were chosen since they minimize the cost of driving from the store to the vendor since the truck is driving empty.

The constraints in this heuristic are based on limitations in running trucking operations. The Federal Motor Carrier Safety Administration (FMCSA) has mandated that it is legally required that truck drivers can be on the road for a maximum of 14 hours including stops and deliveries. This limitation is a critical constraint because otherwise the new routes that we propose would not be feasible to implement if the trip took more than 14 hours. The other main constraint is ensuring that the number of backhauls for each vendor matches the number of pickups. This constraint makes sure that even though a particular vendor might be closest to a large number of stores, we have a limited number of deliveries that can be used for backhauls. These constraints ensure that the routing solutions we propose are practical solutions that can be implemented.

If a vendor appears in more backhauls than it has deliveries for, the heuristic picks the routes that have the shortest time trip times. This is for a number of reasons. The first is that the routes that are the shortest are the least expensive because drivers are spending less time on the road. Picking the shortest trip time also minimizes the amount of time the truck is driving empty from the store to the vendor.

Results

With the proposed backhauls, we calculated the cost savings from moving the transportation from the third-party carriers to backhauls using the company's private fleet. From the 18 backhaul solutions, the weekly cost savings are $6,051 and result in annual savings of $320,000. Extrapolating these results for the rest of the company, we determined that Ahold Delhaize could save up to $1.6 million from this backhaul heuristic.

Adding backhauls reduces the total distance traveled by vehicles used for outbound and inbound shipments and also reduces CO_2 emissions. Using the methodology for calculating CO_2 emissions described earlier, the reduction in CO_2 emissions for Food Lion is 3,208 pounds per week, which correlates to 166,800 pounds annually. Extrapolating these results to the other brands, Ahold Delhaize could reduce their carbon footprint by 830,000 pounds per year. The carbon emissions reduction is illustrated in Figure 3.

Figure 3: Environmental Impact of reduction of carbon emissions
Source: US EPA website.
https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)

With the results from this analysis, we have identified routes that can have backhauls added to them. Although this methodology has identified feasible backhaul opportunities, not all of these solutions will be practical. Based on the results from the sensitivity analysis, some solutions are not practical to implement because they are too sensitive to changes in the parameters. The most practical solutions have a large amount of buffer time (greater than three hours), and the routes with buffer times between two to three hours are a little riskier. The routes with a buffer time below two hours are not recommended to be implemented immediately since they are the riskiest and are unlikely to return to the DC within 14 hours if they encounter any delays.

With this list of practical solutions, there are still some considerations to review before implementing any changes. The first is the flexibility of pickup times at the suppliers. In the heuristic, we assumed that the suppliers would have flexible pickup windows, and with these results, we would need to confirm with each supplier that they could accommodate a backhaul delivery option. The second consideration is the impact of increased fleet utilization. With trucks taking longer routes, there will be less flexibility in the overall scheduling of shipments out of the distribution center.

With both of these considerations in mind, the managers at Food Lion should look at the practical solutions and implement them in a stepwise fashion.

Conclusion

With rising transportation costs and increasing supply chain complexity, companies need to be constantly looking for opportunities to increase efficiency to maintain profitability. By reducing the number of empty miles a truck is driving, companies can generate cost savings by reducing the amount they spend on expensive 3PL's. In this capstone project, we developed a methodology to identify feasible backhaul routes using an established routing program. The case study for this analysis was performed on Food Lion, an operating unit in Ahold Delhaize. We were able to identify 18 backhaul opportunities for Food Lion, which results in $320,000 in cost savings and 166,800 pounds reduction in carbon emissions. These results can be extended to the entire Ahold Delhaize operations in the US and generate a potential of $1.6 million in cost savings and a reduction in carbon emissions by 830,000 pounds annually. These significant results could be achieved by any other company with a large scale transportation network.