MEASURING THE COST TRADE-OFFS BETWEEN ELECTRIC-ASSIST CARGO BIKES AND DELIVERY TRUCKS IN DENSE URBAN AREAS

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INTRODUCTION

Understanding the complexity of freight deliveries in dense urban areas is increasingly important. As urban populations and e-commerce rise, so do delivery needs. It is clear from the traffic congestion, idling trucks, and the lack of sufficient Commercial Vehicle Load Zones that the current freight infrastructure will be challenged to accommodate the diverse and dynamic delivery needs of the last mile, which is described as the costliest part of the supply chain in which goods are transported between a distribution center (DC) or warehouse and the recipient’s location (1).

To address urban freight delivery challenges, electric assist (EA) cargo bikes are being utilized to complete last-mile deliveries in dense urban cities (2). The potential for freight movement via EA cargo bikes is large, mainly because of unique economic and environmental advantages such as utilizing bike lanes to travel and the sidewalk to park. In this paper, four urban delivery scenarios are modeled. The cost of using either an EA cargo bike or urban delivery truck is quantified and compared while also considering constraints associated with each mode. The objective of this research is to capture route costs associated with each transportation mode in four different delivery scenarios. These findings can be used to support decisions to match delivery routes and cargo volumes with EA cargo bikes or delivery trucks. Although Seattle is used as a case study, the results from this study are likely applicable to other major U.S. cities.

METHODOLOGY

To build a more reliable and accurate framework for our model, three players in the cargo-bike industry were interviewed. These interviews provided unique and valuable knowledge about the cargo bike industry, which supported the assumptions made to calculate the cost trade-offs.

In addition to interviewing relevant stakeholders, a well-established courier company was shadowed for a day in order to have a better understanding of what a typical truck delivery entails. During this trip, the total delivery time, number of delivery stops, and total number of parcels delivered was recorded. This information became the benchmark for the comparative model in which we look at the trade-offs between deliveries via trucks, cargo bikes, and a combination of both modes.

In order to compare the cost trade-off between deliveries completed by a delivery truck and EA cargo bike, four delivery scenarios were modeled. Each scenario manipulates one independent variable while keeping the other three variables constant.

The values given for each constant variable are based on the information captured while shadowing the courier company and serves as a proxy for delivery characteristics common to downtown Seattle. A change in one of these characteristics can influence which mode of
transportation is the most cost-effective for the last mile. Figure 1 is a diagram of the basic scenario and independent variables examined in this study.

Independent variables:

1) **distance between distribution center (DC) and neighborhood** - larger distances impact overall delivery time and costs due to differences in vehicle speeds and driver fatigue (EA cargo bike).

2) **number of stops** - the more frequent a vehicle has to stop, the more time spent sorting packages and looking for parking, which impacts overall delivery time and costs.

3) **distance between stops** - larger distances between stops influences the amount of time a vehicle spends in congestion and in transit, which impacts overall delivery time and costs.

4) **a total number of parcels per stop** - each vehicle type has its own unique cargo capacity limitations. This influences the number of vehicles required to complete deliveries on any given route and impacts the costs associated with that delivery.

In order to quantify the cost trade-offs between delivering items via truck or EA cargo bike, values have been allocated to each of these variables from our time shadowing the company.

FIGURE 1 Diagram of independent variables
Findings

By changing one of the four independent variables at a time, each scenario has been modeled to depict how costs between an urban delivery truck and an EA cargo bike compare to one another. The characteristics of the observed route during data collection in Downtown Seattle have been applied and modeled using nine cost functions, and the results can be seen in Figure 2.

**FIGURE 2** Graphs depicting delivery truck and EA cargo bike costs for the four scenarios

In scenario 2a, the distance between the DC and delivery neighborhood is modeled from 0 miles to 10 miles. This shows that where the distance between DC and delivery neighborhood was 3.5 miles (5.63 km), it was more cost efficient to use a delivery truck in comparison to an EA cargo bike. If the DC were to be located closer to the delivery neighborhood, it would be slightly more cost effective to use an EA cargo bike on the route observed.

In scenario 2b, the distance between delivery stops is modeled from 0 to 1 mile, assuming that anything beyond 1 miles indicates deliveries are occurring in less dense urban areas, which is outside the scope of this study. Figure 2b shows that the cost lines for both vehicles types are almost constant.
In scenario 2c, the number of parcels was modeled from 1 to 70 parcels per stop. Adding 5 parcels per stop increases the number of EA cargo bike trips required due to capacity limitations. Additionally, each package increases handling time at the stop, slightly increasing total route cost. For the observed route during data collection, if there were more than 25 parcels per stop on average, it would be more cost efficient to use a truck instead of an EA cargo bike because otherwise, two or more EA cargo bikes would need to serve some stops.

In Figure 2d, the number of stops on the route was modeled from 0 to 25 stops. The graph shows that if the route has three or fewer stops on the route, the cost for EA cargo bike and truck will be the same.

Based on modeling results, we can conclude that EA cargo bikes are not the most cost-efficient vehicle type for the modeled route. This is mainly due to the cargo capacity restrictions associated with an EA cargo bike. The average number of parcels per stop was 50 parcels, which instantly surpasses the capacity of a single EA cargo bike which is 40 parcels. Therefore, at least 2 cargo bikes would have to be deployed to each stop. It would take 10 EA cargo bikes to replace a single unleaded delivery truck completing the observed route during data collection.

CONCLUSION

The four scenarios modeled indicate that EA cargo bikes can be a more economical and environmentally sustainable alternative for last-mile deliveries, but this is contingent upon the distance between DC and neighborhood, number of stops, the distance between stops, and number of parcels per stop as discussed in the paper. Cargo bikes have some competitive advantages over delivery trucks in that cargo bikes have more choices to maneuver through a city using the road, bike lane, sidewalks, and accessing pedestrian-only areas to find the quickest or shortest route to the destination. The time spent looking for parking and the act of parking the bike itself is negligible. However, smaller cargo capacity, slower speeds, and severe weather conditions limit the potential of cargo bikes.

These simulated results should be expanded to consider less dense neighborhoods and to analyze more route scenarios using our cost function.

The growing number of cargo bike companies in the United States and research efforts are certainly promising. This research contributes to this growing research field and reveals the complexities associated with costs trade-offs of a specific delivery route.

REFERENCES
