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POLICY BRIEF

The Sustainability of Alternative Last-Mile Delivery Strategies

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Issue

In the last decade, e-commerce has grown substantially and transformed individual shopping behaviors. Most shopping activities—at least part of the search, if not the purchase itself—now involve an online component. This has consequently changed commodity flow and urban goods distribution. E-commerce has the potential to reduce the negative impacts of shopping on the environment by substituting individual shopping trips to stores using personal cars with optimized truck deliveries. However, shopping behavior is often more complex than this one-to-one substitution.

Additionally, e-retailers entice consumers with free shipping, free returns, same-day, one-hour or two-hour expedited deliveries, and more in a quest for increased market share. These enhanced services result in additional distances driven, emissions, and operational costs for the e-retailer. The increasing customer expectations around lead time, delivery time, and return policy present a need for more sustainable delivery options, particularly for the “last mile” between the distribution center and the customer. Last-mile operators are considering alternatives to traditional diesel truck-based, door-to-door delivery such as use of alternative fuel (e.g., electric) vehicles, delivery from micro-hubs using cargo bikes, customer pickup at collection points, and crowdsourced deliveries. Researchers at the University of California, Davis developed models for e-commerce demand, last-mile delivery operations, and cost and sustainability assessment, then applied this modeling framework to a case study in Southern California to evaluate the potential impact of these strategies under different delivery scenarios.

Key Research Findings

Costs and emissions rise exponentially as delivery times get faster. As delivery time windows get shorter, vehicle consolidation

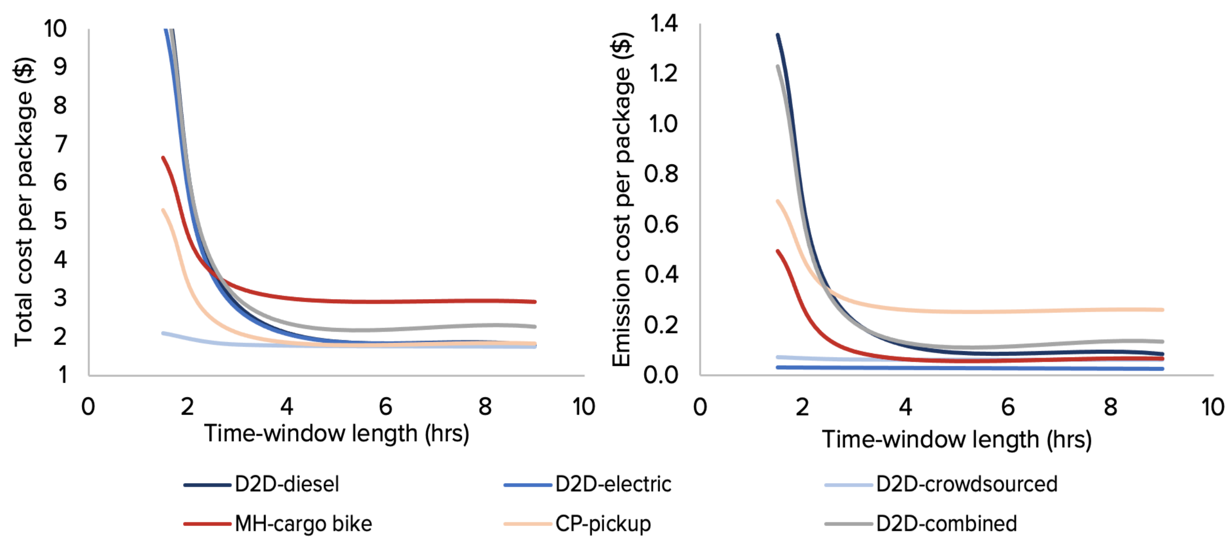

Figure 1. Per-package total costs and emissions costs by different last-mile delivery strategies under various delivery scenarios. Note: D2D-diesel = Door-to-door deliveries with diesel vehicles; D2D-electric = Door-to-door with electric vehicles; D2D-crowdsourced = Door-to-door deliveries with fleets of crowdsourced vehicles/drivers; MH-cargo bike = Deliveries through micro-hubs using cargo bikes; CP-pickup = Delivery to collection points for customer pickup; and D2D-combined = Hybrid system with door-to-door deliveries, use of micro-hubs with cargo bikes, and collection points.

level (volume utilization) drops, leading to higher delivery frequencies, more trips, and the need for a larger fleet size, and thus the total cost and emissions per package rise. This is a fundamental challenge with fast deliveries.

Strategies that outsource delivery offer advantages for meeting short time windows (Figure 1). Outsourcing a delivery (if feasible) adds flexibility to a distribution structure, allowing much easier scaling up than an e-retailer-owned fleet when time windows get strict. The use of pickup points and crowdsourced deliveries offers the most competitive costs under shorter time windows regardless of customer density. However, some of these strategies could increase vehicles miles traveled as they outsource the last-mile travel to many lower capacity vehicles. The extent of the resulting emissions increase will be dependent on the mix of crowdsourced vehicles. A fleet of owned and crowdsourced vehicles offers the lowest cost and highest flexibility for e-retailers with large market share.

A system of distribution micro-hubs paired with delivery cargo bikes can out-perform truck deliveries in certain circumstances. Low-cost, low-volume cargo bikes can flourish when fast delivery times are required in densely developed areas where they can avoid the congestion and access constraints that face delivery trucks. The number of micro-hubs and the share of packages serviced through them inform the efficiency of micro-hubs-based delivery. As more micro-hubs are established, it gets easier for cargo bikes to cover the service region, although the marginal benefit from adding another micro-hub is diminishing due to additional fixed costs. Still, cargo bikes generate significant emissions reductions.

Distributing packages to central collection points for consumers to pick up can save operational costs but may increase emissions. As in the case of the micro-hub cargo bike strategy, the number of collection points and share of packages serviced through them inform the efficiency of collection-point-based delivery. The savings for the e-retailer come at the expense of additional externalities from individual customer travel to the collection points, the extent of which depends on the customer travel patterns and mode/vehicle choices.

Delivery with electric trucks renders lower costs than delivery with a diesel fleet. Electric vehicles' high procurement costs are offset by lower operational and maintenance costs over time. However, vehicle and charging infrastructure costs and availability still constrain the electrification of last-mile delivery fleets. Locating distribution facilities closer to consumers and other logistics decisions can compensate for the vehicles' technical limitations.

Policy Implications

These results highlight the importance of considering emerging freight trends in land use planning efforts. The "logistics sprawl" dynamic of locating large facilities on the outskirts of cities is changing along with the retail landscape. Planning to accommodate freight distribution facilities (from distribution and fulfillment centers to micro-hubs and collection points) near customers will reduce overall emissions and costs, although the increased freight activity may generate negative impacts locally. Fostering zero-emission last-mile delivery vehicles through incentive programs or the development of supporting infrastructure would help mitigate some of the increased capital and operational costs.

More Information

This policy brief is drawn from "Analytical Modeling Framework to Assess the Economic and Environmental Impacts of Residential Deliveries, and Evaluate Sustainable Last-Mile Strategies," a report from the National Center for Sustainable Transportation, authored by Miguel Jaller and Anmol Pahwa of the University of California, Davis. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/analytical-modeling-framework-assess-economic-and-environmental-impacts-residential.

For more information about the findings presented in this brief, contact Miguel Jaller at mjaller@ucdavis.edu.

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