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Can sidewalk autonomous delivery robots reduce traffic and battle climate change?

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Issue

The online food delivery industry has experienced remarkable growth in recent years, with its revenue tripling over the past five years. This surge, characterized by small but frequent deliveries, has resulted in an increase in delivery vehicles on urban roads, which exacerbates traffic congestion and greenhouse gas emissions and comes in direct conflict with California's climate goals.

Notably, most online food orders are small and occur within a 2-mile radius, creating an ideal environment for the adoption of sidewalk autonomous delivery robots (SADRs). These robots are fully electric, compact, and operate exclusively on sidewalks and in crosswalks, offering the potential to mitigate road congestion and emissions. However, research on SADRs remains limited, with existing studies primarily focusing on parcel delivery and often comparing SADRs to conventional delivery vans. This leaves a notable gap in understanding the environmental and traffic impacts of SADRs, particularly in comparison to human-operated delivery vehicles for on-demand delivery services.

To quantify the impacts of SADRs, the researcher addressed two critical research questions:

1. How do SADRs compare to conventional human-operated delivery vehicles in terms of vehicle miles traveled and emissions, specifically in the context of food delivery?
2. Can SADRs serve as an effective solution to reduce traffic congestion?

Study Approach

The researcher used continuous approximation, a specialized logistics method, to model vehicle miles traveled (VMT) associated with food deliveries from human-operated delivery vehicles, and drew on methodologies from Ai et al. (2021). Coco Delivery, a Los Angeles-based SADR company, provided data to model VMT for human-operated delivery vehicles. Additionally, the Emission Factors Model (EMFAC) 2021, developed by the California Air Resources Board, was used to model the tailpipe emissions of human-operated delivery vehicles based on the modeled VMT. The researcher obtained emissions data for electricity generation from the eGRID 2022 Data and eGRID 2020 PM2.5 Data from the United States Environmental Protection Agency (EPA). The total emissions, including tailpipe emissions and electricity generation emissions, for both conventional human-operated delivery vehicles and SADRs, were estimated using VMT figures from the continuous approximation model and Coco Delivery data.

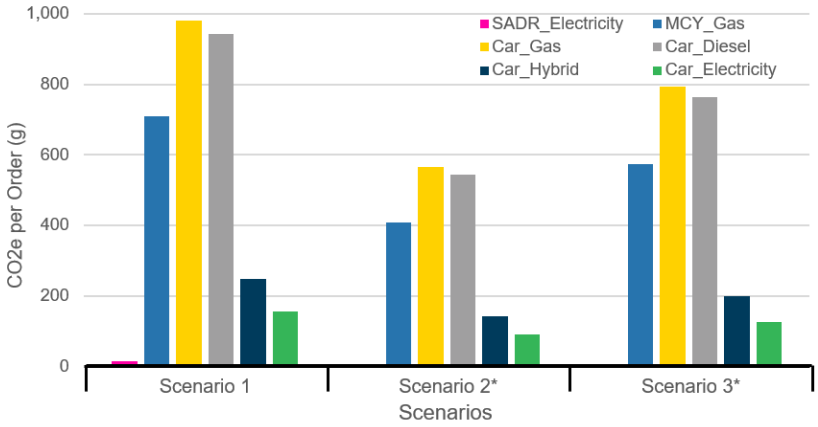

Figure 1. Carbon Dioxide Equivalent Emissions per Order in a 3-Order Delivery Trip
Scenario 1 depicts one-to-one delivery. Scenario 2 is one pick up to multiple customers. Scenario 3 is multiple pick ups to multiple customers.

Key Findings

SADRs can reduce VMT on the road, potentially alleviating traffic congestion, though this may increase sidewalk congestion. SADRs can reduce VMT on the road by 1.59 miles per delivery in a one-to-one delivery scenario. Even when considering batched deliveries — where multiple orders are fulfilled simultaneously by human drivers, which can reduce VMT by 14.1% to 55.3% in various scenarios — SADRs still achieve a minimum reduction of 0.71 miles per delivery. However, this reduction in road traffic shifts VMT to sidewalks, potentially causing sidewalk congestion.

SADRs can significantly reduce emissions compared to other types of human-operated delivery vehicles for food delivery. For one-to-one deliveries covering the same distance, SADRs can reduce emissions by 90% to more than 99.9% compared to fuel-based vehicles, and by 86% to 94% compared to electric or hybrid vehicles (Figure 1). In batched delivery scenarios, SADRs can reduce emissions by 82% to more than 99.9% during a three-order delivery trip, and by 67% to 99% during a five-order delivery trip.

Conclusions

SADRs are substantially cleaner and more sustainable than human-operated delivery vehicles for short-distance food delivery in dense urban areas. They can significantly reduce emissions in the food delivery industry and lower VMT, potentially alleviating traffic.

However, their adoption is limited by the need for high-quality sidewalks (e.g., wide, barrier-free, and continuous pathways) which many cities lack, and insufficient government recognition of their traffic-alleviating and environmental potential. Many states also lack legislation supporting SADRs, hindering their widespread use.

To promote the adoption of SADRs, local, regional, and state governments should:

- Develop SADR-friendly infrastructure. Wide, barrier-free, and continuous pathways would support efficient deliveries while also benefiting seniors and people with disabilities who require such pathways.

- Enact legislation that supports the use of SADRs in dense areas to encourage further adoption.

Chu, Y.-C. (2024). The Impacts of Sidewalk Autonomous Delivery Robots on Vehicle Travel and Emissions — A Focus on On-Demand Food Delivery. (Master's capstone, UCLA). Retrieved from: https://escholarship.org/uc/item/2r3286pg

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