Assessing the Economic and Environmental Impacts of Peer-to-Peer Crowdshipping in Relation to Spatial Structure

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Freight transport accounts for approximately 8% of global greenhouse gas emissions (Greene, 2023), while it is projected to triple by 2050 compared to 2019 levels (Olivari et al., 2025). The rapid expansion of e-commerce has further intensified sustainability concerns, as the rise of direct-to-consumer deliveries tends to reduce freight consolidation, generating more frequent trips with smaller loads (Calabrò et al., 2023). In parallel, public and private institutions set clear targets for reducing greenhouse gas emissions (Olivari et al., 2025), prompting interest in alternative delivery models.

Among these alternatives, crowdshipping – where private individuals deliver parcels using personal vehicles along planned trips – has gained attention as a potentially cost-efficient and sustainable solution (Mohri et al., 2023; Pourrahmani & Jaller, 2021). In this system, crowdshippers accept to detour from their original route, within certain bounds, to pick up and deliver parcels in exchange for financial compensation (Archetti et al., 2016; Behrend & Meisel, 2018). By exploiting the unused capacity of existing personal mobility, crowdshipping aims to lower the need for dedicated delivery vehicles, thereby reducing delivery costs and emissions (Pourrahmani & Jaller, 2021).

However, knowledge on the actual impacts of crowdshipping remains limited (Buldeo Rai et al., 2018). The term itself covers a wide spectrum of models that differ by transport mode (e.g., car, bicycle, public transport), delivery configuration (e.g., direct, multi-leg, locker-based), and platform business models (Pourrahmani & Jaller, 2021; Mohri et al., 2023). Existing studies report mixed results, showing that the economic and environmental outcomes of crowdshipping are sensitive to several factors, among which we highlight: the spatial structure, the trip deviation, the matching mechanism, and the transport mode.

Building on these observations, this work evaluates the potential economic and environmental impacts of peer-to-peer car-based crowdshipping and identifies the spatial and operational conditions under which such impacts are observed. Particular attention is given to factors such as parcel demand, the number of participating crowdshippers, the sensitivity of mobility/logistics flows to distance, and the spatial characteristics of the system – namely the hierarchy of city sizes and their spatial configuration.

Unlike much of the existing literature, we explicitly model the assignment of crowdshippers to parcels and account for the dynamic and uncertain nature of crowdshipping. To address this, we adopt an approximate dynamic programming (ADP) approach based on value function approximation (VFA), developed in previous work. This approach enables assignment decisions over time under uncertainty, accounting for stochastically arriving parcels and crowdshippers. We conduct a set of computational experiments, varying key parameters. This exploration helps identify the conditions affecting the economic and environmental performance of peer-to-peer car-based crowdshipping.

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