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The Evolution of Consumer Preferences in Last-mile Delivery Methods and the Impact on Urban Logistics--A Simulation Study

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Job van Vliet

Authors
Job van Vliet, Significance (presenter)
Michiel de Bok, Significance, Delft University of Technology
Goncalo Homen de Almeida Correia, Delft University of Technology
Bilge Atasoy, Delft University of Technology

Short abstract
This paper presents a hybrid system dynamics and agent-based model to simulate the dynamic evolution of consumer preferences for parcel delivery. Scenarios provide insight about preference development and capacity growth of delivery services.

Abstract
The growing demand for parcel delivery causes significant problems for freight logistics, particularly in cities. The increasing number of delivery vehicles leads to traffic congestion, high emissions, and rising costs. To address these problems, new and sustainable delivery methods must be implemented in the parcel last-mile. However, estimating the impact of a different logistics system is complex, as it depends on consumer adoption of these new delivery methods.

Research on consumer preferences is scarce, especially that which is empirically based. The integration of multiple different delivery methods in one consumer preference model is similarly limited. The problem with the conventional revealed preference (RP) or stated preference (SP) survey data is that it cannot measure future preferences (RP-data) or consider the dynamics between demand levels and capacity and the development of new solutions (SP-data).

This paper presents a simulation model that captures and explores the interconnections between multiple delivery methods and consumer preferences for those delivery methods. Two distinct effects on consumer preferences are simulated: consumers' response to the performance and availability of delivery methods is simulated and the sharing of knowledge via word of mouth and familiarisation. System dynamics is used at an aggregate level to simulate the evolution of consumer preferences for last-mile delivery via multiple methods. At a disaggregate level, an agent-based model calculates the operational performance of the delivery methods which affects consumer preferences in the system dynamics model. This enables us to simulate the evolution of the interaction between urban logistics supply and demand, and thus obtain data on consumer preferences and the delivery method operations at consecutive time points.

With the proposed model, the parcel freight logistics of the province of South Holland in the Netherlands are simulated for a forecast horizon of five years. The base scenario consist of van delivery to consumers' homes and to pick-up points. Additionally, in two other scenarios crowdshipping and drone delivery are included.

Results of the case study show that consumers change their preferences due to the introduction of new

delivery methods. This preference change in preference strongly dependents on the ability of carriers to fulfil the demand. The dynamic interaction between supply and demand causes a reinforcing feedback loop, where the adaptiveness from the carrier is crucial to the success of a delivery method in the long term. In addition, the spatial results reveal that there are zonal differences in the performance of the delivery methods.

Pick-up points function best in dense and urbanised zones, which indicates that it is a sensible delivery method in cities and the centres of villages. The drone services are very quick in the vicinity of the carrier depots, consequently a strong level of service is apparent in the central part of the study area. On the contrary, the performances of crowdshipping and van delivery are quite insensitive with respect to the delivery location. For zones at the edge of the study area where both pick-up points and drone delivery are less occupied, conventional van delivery seems the best option from the perspective of the consumer.

The results of this study reveal that in each scenario the total vehicle kilometres and CO2 emissions will increase due to the rise in parcel demand. Yet, the average number of van kilometres per parcel and the average emission of CO2 per parcel will reduce with a growing parcel demand. This is because van delivery, to consumers' homes and pick-up points, becomes more efficient with the increasing density of the orders. However, a disadvantages of this phenomenon is that a larger proportion of vehicle kilometres and emissions will come from intrazonal travel, bringing complex problems such as congestion and nuisance to urbanized areas.

To reduce the total emissions and solve the congestion problem of van delivery, other delivery methods must be introduced. Pick-up point delivery and drone delivery can offer high levels of service in many zones, and it can be expected that a large share of consumers will choose those delivery methods. However, capacity of these systems is an important aspect and large investments will be needed to develop the pick-up network and especially the drone facilities to deal with the corresponding demand. The dynamics in this model show that if those investments are not made, a negative feedback loop will originate, because of which the consumer preference for pick-up points and drone delivery will diminish.

Programme committee
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