Evaluation of driving restriction zone policy with travel behaviors of intermodality in the Paris case study

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Abstract

Over the last decades, a growing number of cities in Europe have implemented urban access regulations with various schemes, such as low emission zones, urban toll schemes or congestion charging. The city of Paris recently announced a ban on motorized traffic crossing the city center in 2024, aiming at reducing pollutions and noise, as well as freeing up more space for pedestrians and cyclists. According to the plan, the Driving Restriction Zone (DRZ) consists of four central districts located within Paris' innermost ring of boulevards – about 14 square kilometers. Previous works have found that DRZ policies limit the traffic inside the zone, but increase traffic outside the zone in the short run because of detours (Fensterer et al., 2014). In the medium run, modal shift may occur as some users stop using their cars and opt for public transport and bicycles instead (Wang et al., 2014). Even so, the impacts of the DRZ on travel behaviors and on the environment might substantially differ from one city to another depending on land use patterns, demographic characteristics, network structures, and mobility patterns. Furthermore, there is still limited knowledge of how the various economic impacts vary across space (i.e. within and outside the zone) and across individuals (e.g. with regard to income, age…). Agent-based simulation is especially suited to investigate the expected impacts of DRZ policies and carry out a disaggregate analysis of the economic impacts.

It is challenging to model and simulate multimodal (or intermodal) mobility in the Paris region due to its complex multimodal networks. An application on agent-based mobility simulation in the Paris region (so-called Île-de-France) was realized in (Hörl and Balac, 2021), using Eqasim's novel Discrete Mode Choice (DMC) extension under the MATSim framework. Eqasim also provides a pipeline to generate synthetic population and the reproducible Île-de-France scenario. The parameters in the DMC for the Île-de-France scenario study were calibrated with the regional HTS of 2010. Although Eqasim can simulate large-scale human mobility, the kinds of trip intermodality, such as access/egress walking stages and Park-and-Ride (P+R) are not included yet. The access/egress walking stages are configured in MATSim, and may also be defined in Eqasim. Assuming that there is a strict restriction for non-residents driving in the zone, these drivers have to park their car at the zone edge and walk to the destination if the distance is acceptable. Otherwise, they may use alternative modes. In addition to car – walk intermodality, our study also considers P+R intermodality (car – public transit). P+R trips are common in the Paris region, especially for commuters living in the suburbs. From the regional HTS of 2010, P+R trips amount to about 1% of total daily trips. To facilitate motorist access to railway stations and promote intermodality, the regional transport authority increases the numbers of P+R facilities and parking places year by year. P+R investments are currently further accelerated with the Grand Paris Express Plan, which consists in the development of new automated metro lines going through the suburbs by 2035. While other forms of intermodality do exist (e.g. bike or micromobility plus public transit), these do not fall within our study scope here.

Our study aims to investigate the impacts of the DRZ policy on mobility behaviors and on the environment. Special attention is put on intermodality, regarding multi-stage car trips, i.e. on car trips with access/egress walking legs or combined with public transit using P+R facilities. To do

this, we first enrich utility functions with the cost of the access/egress walking distance and add the new utility function of P+R mode in the existing DMC model in Eqasim. Then, we calibrate related parameters in the DMC model. At last, the DRZ policy scenario is designed with assumptions and specific configurations in Eqasim. To learn about the local and regional impacts of the DRZ, we simulate the daily mobility of 10% population of the whole Paris region. The performance indicators are measured, in terms of mobility behaviors by agent groups (such as travel time, distance, and modal shares) and traffic emissions (such as CO_2 emissions and local pollutants). The details of the scenario design are given below.

The reference Île-de-France scenario is simulated based on the synthetic population from the Eqasim's pipeline. The sample of 10% population (about 1.2 millions of agents) in the reference year of 2010 is considered. Since we consider the integration of the two kinds of intermodality into Eqasim, the parameters for the utility functions in the DMC model should be calibrated again. The previous work of the P+R integration and its calibration has been done in the case study of Lille metropolis (Diallo et al., 2021). Similarly, we re-calibrate the parameters in the reference scenario with the regional HTS of 2010.

For the DRZ scenario design, we assume a strict traffic limit that among the private car drivers only the local residents can drive into the zone, and there is also no limitation for freight delivers and car passengers (the network has these mapping modes). To execute this condition, the sub-population of local residents and their mode access of driving cars need to be assigned. Therefore, we modify two files in the reference scenario so as to constitute the policy scenario. One is the population file where we extract the local residents and label them as "Person_internal", otherwise, "Person_external". The other modified file refers to the transport networks. In the regional area, we add all car permitted links a specific mode of "Car_internal" that is used exclusively by "Person_internal" (i.e., local residents), and remove the mode of car, if exists, for all links within the DRZ. By this way, private car drivers living outside cannot drive in the zone, due to the zone links without any car mode attributes. Here, the "Car_internal" has the same attributes and settings as the mode of car.

For the scenario comparison, the performance of mobility behavior is measured by the modal shares of number of trips, total travel time and distance per mode. We analyze first the mobility differences of all simulated agents in the region, and then focus on the analysis of modal shifts with the DRZ related trips by three agent types, i.e., residents, workers, and visitors. A resident is who lives in the zone; a worker is who works in the zone and does not live there; a visitor is who visits the zone and does not live or work there. The DRZ related trips are all trips for residents, as well as all trips for workers and visitors related to the zone (strictly inside, entering, and exiting trips). We apply the emission module that is integrated into the MATSim framework to calculate pollutant emissions based on the simulated traffic information. The environmental impact is then measured by the changes of amounts of CO_2 emissions and local pollutants. Through this evaluation, policy makers could adjust the DRZ strategy or consider other measures in combination to optimize the mobility system.

Reference

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