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A new look at the environmental assessment of logistics sprawl Part 1:
The Environmental Impact of Urban Road Freight: A Modeling Exercise for the Paris Region

Research Brief 4.1j

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Project Objective

This research aims at improving knowledge on the environmental impacts of urban road freight (URF). It questions the gap between common beliefs about the environmental impact of URF and its specific empirical measurement.

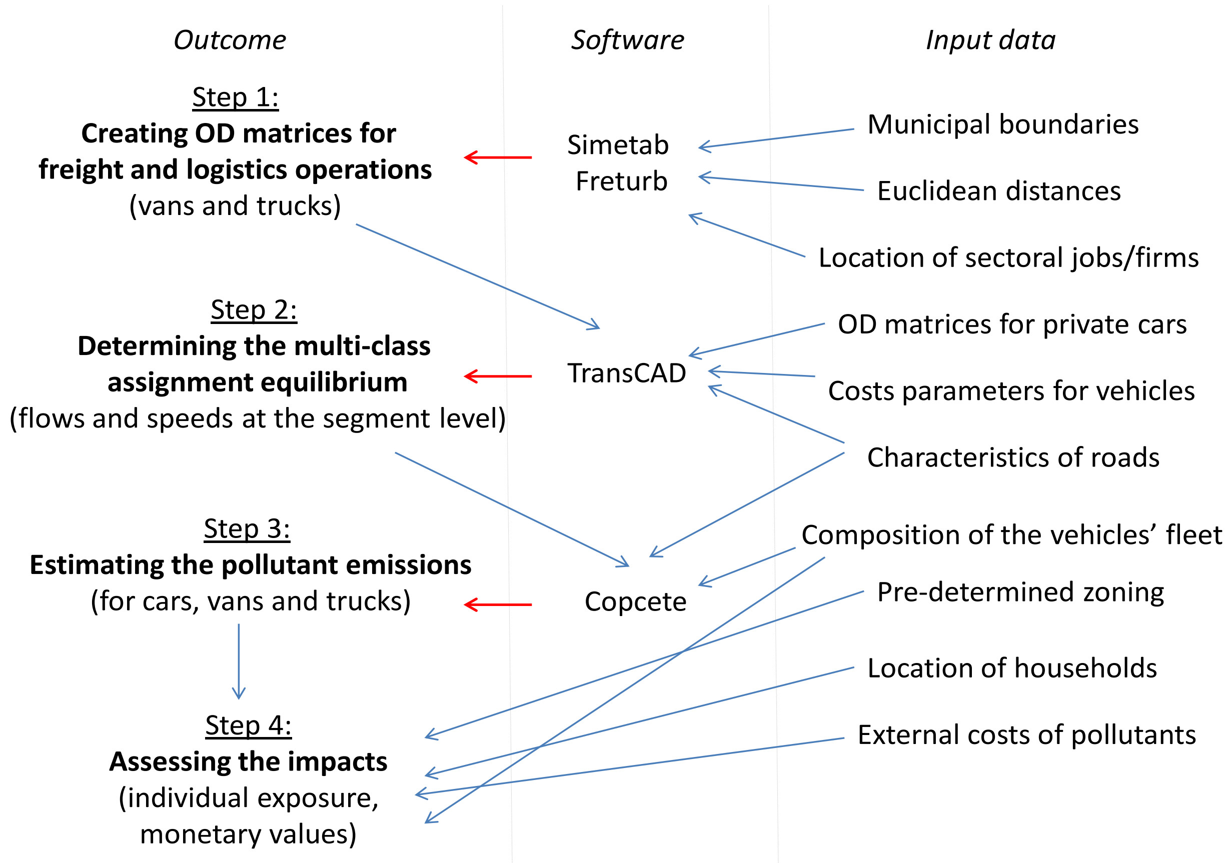
Research Methodology

Figure 1 illustrates the four stages of our method. The first one relates to URF basic data. We take advantage of the Simetab-Freturb software's (Routhier and Toilier, 2007; Gardrat et al., 2014) to estimate "generation coefficients" (number of weekly deliveries and pick-ups to establishments) of firms[1] in the Paris region and to construct Origin-Destination (OD) matrices for URF. The second stage is based on the TransCAD software and computes the traffic assignment equilibrium (Ortuzar and Willumsen, 2011) for different time periods using a multi-class framework (Dafermos, 1972; Moridpour et al., 2015). OD matrices for both URF and PCs are combined with transport costs parameters and capacities of the road network to have information on traffic flows, compositions and speeds at the road link level. Based on these data, we derive pollutant emissions using the Copcete calculator (Demeules and Larose, 2012). After selecting the

[1] By firm we mean any establishment engaged in an activity, including public administrations, small and large businesses, etc. This does not include private households (B2C e-commerce flows, therefore, are not included in the data).

technological composition of the vehicle fleet and the infrastructures' characteristics, Copcete estimates emissions due to road traffic for each link and for each vehicle class. Lastly, this whole information can be crossed with spatialized socioeconomic data and external costs of pollutants to assess the environmental impacts of URF. Apart from CO_2, which contributes to global warming and the impacts of which are worldwide (Tol, 2009), NOx and PM_{10} indeed generate various diseases to the exposed (local) populations (Kampa and Castanas, 2008; Ricardo-AEA, 2014; WHO, 2016).

Figure 1 – Analysis architecture



Sources: authors

Research Results

This project provides three main results.

First, we established that Simetad and Freturb models are powerful tools to generate and to distribute URF flows over a given urban area, OD matrices for vans and trucks being rarely available at that geographical scale. In the case of the Paris region, we have seen that each economic establishment emits and/or receives 6.3 goods' movements per week in 2012, thus generating 890,000 freight trips per day. Heterogeneity in the freight behaviors of firms and spatial concentration of activities explain why a huge majority of URF is linked to the core of the Paris region.

This information was useful to determine the traffic assignment equilibrium in a multi-class framework, where Light Goods Vehicles (LGVs) and Heavy Goods Vehicles (HGVs) share the roads with private cars (PCs). Using the TransCAD software and following Wardrop's principles, we have found that URF corresponds to 7.8% of total distances traveled in the Paris region, with a higher share in the core of the metropolitan area (15-10%). Our results clearly exhibit that the more densely populated the areas, the higher the traffic flows and the lower the vehicles' speed. Important differences across peak and off-peak periods were also observed.

This knowledge being available at the road-segment level, we were finally able to estimate pollutant emissions from PCs, HGVs and LGVs thanks to the Copcete calculator. Freight vehicles are responsible for 20-30% of total emissions and the share of CO_2, NOx and PM_{10} emissions due to URF is at least 2.5 times larger than the share of freight vehicles in regional traffic. Moreover, we have made explicit that the contribution of LGVs and HGVs to air pollution is larger in the central areas of the Paris region, where more people are exposed to the environmental nuisances. Finally, social costs of air pollution caused by road traffic in general amount to 0.9% of the regional GDP in 2012. If we consider only freight vehicles, collective losses are very important relative to the volume of traffic: 0.4% of the regional wealth.

Further research: "Part 2"

While the negative environmental footprint of URF has been empirically confirmed in the case of the Paris region, this article calls for further research, which we are currently carrying out in "Part 2" (planned to be finished in 2018).

Among the many directions to follow, a first one consists in simulating the effects of various policy scenarios aimed to reduce the negative externalities from URF (Demir et al., 2014; Russo and Comi, 2016). As discussed above, an intervention targeting the substitution of HGVs by LGVs may be worthy of investigation, given the observed differences in vehicles' load rates but also the varying impacts of these vehicles on the road capacities. Moreover, the equilibrium assignment model could be adapted to consider environmental tolls, speed limits or zoning strategies (such as urban consolidation centers or low emission zones) and to look at changes in the route choices of drivers. With that respect, a sound modeling framework should integrate possibilities of mode shifts (towards cargo-bikes for instance) for the freight operators, as well as their equipment choices (towards cleaner vehicles).

A second valuable research agenda is linked to the evolution of URF in the Paris region **over years**. Freturb actually enables one to isolate URF trips for a variety of economic activities. Given the growing interest around the so-called "logistics sprawl" phenomenon (Aljohani and Thompson, 2016), our methodology would allow assessing the environmental impact linked to the relocation of warehouses towards the fringes of the metropolitan area. Opposite effects may be at stake here since more peripheral logistics facilities will coincide with increased traveled distances only if customers (e.g. goods' receivers) have moved to a lesser extent. In addition, we have shown that pollutant emissions greatly depend on the traffic speed, and their societal impacts are a function of the density of exposed people. As a consequence, an accurate environmental analysis of the logistics sprawl observed in the Paris region over the last decade should consider all these dimensions, which is made possible thanks to the research protocol presented here.