Testing the 'Freight Landscape' Concept for Paris

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Project Objective

The objective of this research is methodological first. Following the research work from Giuliano et al. (*1*), we explore the use of available secondary data to estimate urban freight traffic. Can urban freight flows' spatial patterns be accurately generated "using simple measures of population, employment and transport access" (*1*)? The authors define the concept of 'freight landscape' as "a description of freight activity imputed from population, employment and transport network characteristics," with the hypothesis that "freight flows depend systematically on the spatial organization of freight suppliers and demanders as well as on the transportation facilities within the metropolitan areas." To test the hypothesis, they analyze the relationship between the distributions of population, employment, and transportation supply, and truck flow using the data from Los Angeles. The estimation of spatial regression models indicates the systematic relationship between those factors and truck traffic. In this line of work, as suggested by Giuliano et al. (*1*) in their conclusion, we add another case study from Paris, which is the largest urban cluster in terms of population and business activities in France, and one of the largest in Europe.

Research Methodology

The Paris region consists of 1,281 local municipalities, with an average size of 9.3 km^2. A 'municipality' is the most detailed unit for analysis for which population, employment and establishment data are fully available. This spatial unit also matches the availability of the road network and truck traffic data, which do not include the municipal road network.

The purpose of this research is to test whether widely available socio-economic indicators, such as population, employment and establishments, and transportation accessibility, can describe freight traffic with the level of accuracy that warrants the use of such indicators for urban freight traffic analysis. We develop regression models for estimating TKT per square km, which represents truck traffic demand. The model development is conducted in four steps, using the following groups of indicators for independent variables: (i) population and employment indicators,

(ii) population and establishment indicators, (iii) transportation accessibility indicators, and (iv) population, employment or establishment, and transportation accessibility indicators.

As the spatial auto-correlation becomes an issue in this type of analysis in which the effects from neighboring municipality influence truck traffic demand, we use a spatial lag model.

The spatial lag model requires spatial weight matrix. We tested various formulas including Radial Distance Weights, Power Distance Weights, Exponential Distance Weights, and Queen Contiguity Weights, and found that the Power Distance Weights provide the highest fits for the tested models.

For the analysis, all variables, including independent and dependent variables, are log-transformed as it gives higher Pseudo R^2 and AIC. "Spdep" package in R, the software environment for statistical computing, is used for estimating models, applying the maximum-likelihood method. The model estimations are conducted in the way to find statistically significant independent variables and minimize AIC.

As data, we use population, employment, and the number of establishments at the municipal level in the Paris region as the independent variables. The Paris region is a monocentric metropolitan area. Population, employment and establishments (especially the latter two) are concentrated in the center of the region, the city of Paris, and the first ring of suburban municipalities. The source for detailed employment and establishment patterns is the "Local Knowledge of the Productive System" (CLAP) database provided by INSEE. This database uses the European NACE classification (Statistical Classification of Economic Activities in the European Community). In this analysis, we use an aggregated version of the CLAP database that groups the NACE classes into 17 categories.

The list of infrastructures (roads) in the Paris region was provided by the French Institute for Geography (IGN). We use the Route 120® database which gave us all the roads and highways as well as road nodes and intersections to calculate the road accessibilities to logistics infrastructures, for the year of 2015. The database of logistics infrastructures is the product of our own compilation from HAROPA (Ports of Paris) and SNCF (French National Railway Company) information. Truck traffic data was provided by the Regional bureau of infrastructures and urban planning for the Paris region (DRIEA). We use the hourly average truck traffic volume of morning rush hours on the road network in the Paris region in 2009 that were estimated based on the samples collected by each Department (equivalent to county) of the Paris region. It should be noted that the data do not contain light commercial vehicles.

Research Results

For the Los Angeles case, the results mostly validate the hypothesis with nuances. Giuliano et al. find that there is a systematic relationship between density and truck traffic. In L.A., truck volume goes together with employment density, especially for services, manufacturing, and trade. Their analysis also shows that transportation supply and highway access are good indicators explaining truck traffic, although the accessibility to major freight generators (airports and seaports) is not. The intensity of truck activity is strongly and negatively associated with population density and household income.

We develop and test models using TKT per km^2 on the Paris region's road network as a dependent variable for finding the approach to estimate urban freight traffic with an adequate level of accuracy. As for independent variables, we test various demographic, economic and accessibility indicators that are usually available, such as population density, employment density, and the accessibility indicators to the transportation system. Main results are the following:

(i) In the Paris region, the distributions of the residential population and employment are monocentric and quite similar, i.e. population and employment are located close together. Thus, the contribution of population for estimating truck traffic demand is limited when employment variables are also in the model. However, the addition of accessibility variables highlights the significant negative effect of population to truck traffic.

(ii) Employment is a better business activity indicator for estimating truck traffic than establishments.

(iii) The following activities: trade & automobile and motorcycle repair; transportation and storage; and manufacture of electrical equipment, electronic, computer & manufacturing machines show the largest effects on truck traffic demand.

(iv) Among all accessibility variables, the distance to freeways is most important for truck traffic demand prediction.

(v) Distance to rail-road intermodal terminals is also significant and its effect on truck traffic demand is strong.

(vi) The highest fit of the model is achieved by the set of the variables including population, employment in the three industrial categories mentioned earlier, the distances to freeways and rail-road intermodal terminals; and

(vii) The income level is always insignificant.

We identify the relationship between population, employment and accessibilities, and truck traffic demand in the Paris region, similarly to the L.A. case, but with a lot of differences. It is not surprising, as the urban structure of the Paris region is monocentric and different types of activities are located close to one another, while in L.A., the urban area spreads widely with a more evenly distributed road network.

The analysis presented in this research has shortcomings. One of them is that we did not consider van traffic, which represents more than half of the vehicles used for deliveries and pick-ups in the Paris region. The updating of the analysis using comprehensive freight traffic flow data is a future research task. Also, the methodology to improve the predictive performance of the models using the secondary data needs to be further studied for making the models of use in urban freight planning practices.