Influence of network features on the parameters of the macroscopic fundamental diagram

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The macroscopic fundamental diagram (MFD) is a well-defined and reproducible relationship between average network density and average network flow for an urban road network (Geroliminis & Daganzo, 2008). Among others, the MFD allows cities to design their traffic management system to operate at the maximum network flow (Zheng, Waraich, Geroliminis, & Axhausen, 2012) and to analyze the effects of road space allocation to traffic network performance (Zheng & Geroliminis, 2013). The analytical approximation (Daganzo & Geroliminis, 2008) and stochastic approximation (Laval & Castrillón, 2015) of the MFD explain partially the differences in the performance of urban road networks based on network design parameters, e.g. free flow speed, average link length, and traffic control parameters, e.g. total cycle length and green time. However, neither these models nor empirical studies explain how urban congestion and the parameters describing the MFD are linked with network features such as connectivity and circuity. In this research, we use traffic data from stationary sensors (measuring flow, occupancy and/or speed) from more than 20 cities worldwide to address this gap.

Smeed (1961) discusses the maximum flow as a function of the space in an urban environment dedicated to cars and the shape of the road network. In the two-fluid-theory (Herman & Prigogine, 1979) investigate the effects of network features, e.g. traffic signal density and average speed limits, on travel times. Modelling urban traffic and congestion from a macroscopic perspective was re-initiated by Daganzo (2007) and resulted in the MFD. For the early macroscopic traffic models, relationships between urban structure and road network features could be linked with the parameters of these models (Williams, 2001), but not empirically for the MFD. Besides these macroscopic traffic models, related research focuses on linking network features with traffic outcomes, e.g. speed prediction (Hackney, Bernard, Bindra, & Axhausen, 2007) and average annual daily traffic (Sarlas & Axhausen, 2016).

Typically, two different groups of features of the urban road network exist. First, the elements that make up the streets, e.g. number of lanes, design of intersections, traffic lights and the spacing between intersections. Second, the design of the road network itself, e.g. in terms of network's archetypes (grid, center orientated or radial networks (Thomson, 1977)), connectivity (Kansky, 1963) and centrality (Freeman, 1978). Recent work in the field of graph theory (Chan, Donner, & Lämmer, 2011) and shape grammar (Vitins & Axhausen, 2014) offer additional possibilities to describe complex road networks.

In this paper, we first present the available datasets from Basel, Berlin, Bern, Bordeaux, Bremen, Cagliari, Darmstadt, Dusseldorf, Frankfurt, Graz, Hamburg, Kassel, Constance, London, Lucerne, Madrid, Paris, Santander, Speyer, Stuttgart, Toulouse, Vilnius, Wolfsburg and Zurich. Second, we discuss the variables in our analysis, i.e. the measures to describe urban road networks as explanatory variables for the dependent variables of parameters that characterize the MFD, e.g. capacities, critical densities and relevant speeds. Finally, we present preliminary findings from our ongoing research.

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