“Systematic Assessment of the quasi-dynamic assumption for congested and uncongested networks”

A. Romano, G. Cantelmo, F. Viti, V. Marzano, F. Simonelli

Dynamic origin-destination (OD) matrix is a fundamental input for both offline (medium- to long-term planning and design) and online (real-time management, ITS) transport applications. Starting from an existing (a-priori) demand estimation, the problem aims at searching for time-dependent OD demand matrices able to best fit the observed data and thus minimise the error between simulated OD flows and measured OD flows data. However, Marzano et al. (2008) demonstrated that this process is effective only when the ratio between the number of unknown variables (i.e. the OD flows) and the number of observations (i.e. observed link flows) is close to one. Since this ratio is usually greater than unity, the problem comes out underdetermined. In order to tackle this issue, researchers proposed different dimension reduction techniques, which we classify in “*data driven”* and “*assumption based”.* The former reduces the solution problem space by analysing the observed data structure (e.g. PCA) while the latter introduces a specific hypothesis on the evolution of OD flows across time.

This work brings research on “*assumption based*” approaches one-step further. Specifically, the main objective of this paper is to provide a cross comparison between two methods: the GLS-based quasi-dynamic estimator (QD-GLS) and Two-step (TS) approach. The QD-GLS estimator works in the within-day dynamic context under the quasi-dynamic assumption, according to which OD shares are constant across a reference period, whilst total flows leaving each origin vary for each sub-period within the reference period. Following the same assumption, the TS approach separates the dynamic demand estimation problem into two sequential optimizations. The first step uses a strict quasi-dynamic assumption (i.e. all OD shares are constant over time) to correct the total flow generated for each traffic zone while the second adjusts distribution values running a traditional optimisation procedure. By comparing the two methods, authors can provide an exhaustive assessment of the quasi-dynamic assumption evaluating in which context both models can gain the best performances, not only in terms of variance of the solution, but also in terms of necessary inputs to implement both formulations. The main difference is that, while the QD-GLS leverages an analytical approximation of the objective function to update the demand flows, the TS uses simulation based approaches, such as the SPSA. This means that the TS is more flexible as it does not require knowing the assignment matrix to update the OD-flows. However, this comes with a significant computational cost. Investigating on this purpose is crucial, as both methods reported satisfactory results in terms of reducing the solution space size and performed better estimates when compared with traditional estimators in terms of both variance of the solution and optimization efficiency. Validation of the quasi-dynamic assumption will be developed by means of extensively testing both estimator performances both on congested and uncongested networks. Results will be presented in terms of estimation accuracy (different starting matrix, different formulations of the objective function) reliability and computational performances.