Could we have predicted the increase in urban travel distances observed in the last twenty years using the "old" gravity model of trip distribution?

Jorge CABRERA[1] and Patrick BONNEL[1]

21/03/2012

Abstract submitted for the Symposium on Quantitative Methods in Transportation Systems
Lausanne, September 4-8, 2012

In the last twenty years, urban travel distances have increased as a consequence of suburbanization. Analysis of travel survey data for the Lyon conurbation shows that the mean distance in a straight line between workers' homes and workplaces was of 4.47 km in 1985 and of 5.01 km in 2006, keeping a constant perimeter of study. If the perimeter is allowed to widen so as to follow suburbanization, the increase is more dramatic: from 4.47 km in 1985 to 7.28 km in 2006.

For planning purposes, the determination of flows between origins and destinations (and therefore travel distances) is usually done with the "old" gravity model of trip distribution, as a part of the classical four step modelling sequence. Despite significant advances in the theory of travel behaviour over the past twenty five years, the four step model still stands as the main tool for producing medium-long run (10-20 years) travel forecasts for different planning purposes (CERTU, 2002; TRB, 2007; Cambridge Systematics, Inc., 2010). Arguably, this longevity owes much to one of the main conditioning factors in modelling practice in general: the cost and (un)availability of data. The four step classical modelling approach is compatible with the data constraint because it is static and needs cross-sectional data (which is the kind of data usually available). When forecasting, the assumption is made that the parameters of the different models (in particular those of the gravity model) remain constant over time (Ortúzar and Willumsen, 2001; Bonnel, 2004). Given the forecasting horizons, this assumption is far from self-evident. First, errors in forecasts are common. Flyvbjerg et al. (2005) find that on average demand for road projects is underestimated by 9.5 % and that for rail projects is overestimated by 51.4 %. Trip distribution is on third and first rank, respectively, among the factors explaining the errors for each type of project. Second, the analysis of travel survey data suggests a regular increase in travel distances but, in the absence of network level of service data, it is impossible to ascertain whether this is due solely to the more frequent access to motorized transport and the resulting increase on average speeds, or if individuals wish (or need, depending on interpretations) to expand their area of daily activity, which in turn would have an impact on the deterrence function parameters.

The scarcity of data is not an issue restricted to practitioners. It equally affects academic research on empirical model validation. Moreover, as the data constraint is not new, the more recent modelling approaches (activity based, for example) are not the only ones suffering from lack of data for testing and implementation. As Fox and Hesse (2010) note, the classical

[1] Laboratoire d'Économie des Transports – École Nationale des Travaux Publics de l'État – Université Lumière Lyon 2. Contact jorge.cabrera@entpe.fr, patrick.bonnel@entpe.fr.

approaches have also had little empirical testing, particularly in the aspect of what is more commonly referred to as the temporal transferability of models. This is especially true for the gravity model.

Smith and Hutchinson (1981) note that calibration criteria and goodness of fit measures can be classified into two basic approaches: (i) the similarity of certain macro-characteristics, in particular the distribution of trip lengths, and (ii) entry by entry comparison of observed and simulated matrices. The few existing studies on the temporal validation of the gravity model have mostly used the latter. This is somewhat problematic because the measures used are not always coherent with macro properties of the gravity model. Also, the zoning system has a strong impact on overall fit measures (Openshaw, 1977; Volet and Hutchinson, 1986, Mozolin et al., 2000). The former has the advantage of producing indicators that meet some concrete objectives of modelling. In our work we have used both kinds of indicators. For the former we produce basic statistics and the $\chi 2$ in order to compare the different distribution of distance (observed, estimated and simulated). For the latter we use RATE (relative aggregate transfer error, (Elmi et al., 1999)) indicators which correspond to ratio of RMSE (root mean square error) or SRMSE (standardized root mean square error). We also use TI (Transfer Indicator (Koppelman et Wilmot, 1982)) which is a ratio of log likelihood for different estimation and simulation contexts.
Our objective in this presentation is to test the ability of the gravity model of trip distribution to account for the dynamics of the urban system and more precisely the increase of distance that have been observed during the past ten or twenty years. The analysis is performed on the Lyon conurbation for which we use the three last household travel survey data (1985, 1995 and 2006). Our approach is tour based and we focus on the most and least constrained travel purposes, i.e. work and leisure, respectively. We proceed, as is usual in studies of temporal validation, by calibrating gravity models with the 1985 households travel survey data and then applying them at forecasted time horizon (1995 and 2006) in order to analyse the ability of these models to reproduce both 1995 and 2006 households travel survey data. The tests are done over different perimeters. Network level of service data comes from modeled transport networks corresponding to the dates of the surveys (1985, 1995 and 2006) which have been coded within the SIMBAD project (development of a LUTI model on Lyon conurbation) on a coherent basis which allows dynamic analysis of network performance. The analysis of travel time and distance distributions shows a good fit for both of them in calibration (when using a 2 parameter deterrence function) and also when forecasting in 1995 and in 2006. Analysis at the matrices level also show similar results quality for estimated and forecast models. These results are maintained even when the perimeter of the study is wider and the horizon of forecast is farther. This means that we are able to simulate the increase of average distance between 1985 and 2006 with 1985 calibration even with a wider perimeter.

Paper will presents the methods, the indicators of goodness of fit both for comparison of matrices and comparison of distance distribution and the results obtained on Lyon data.

Key words: *gravity model, trip distribution, four step model, empirical validation, temporal transferability, increased travel distances*

JEL classification: C52, C53, R41, R48