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Operationalizing a spatial differentiation of trip generation rates using proxy indicators of accessibility

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ABSTRACT

Based on a synopsis of the relevant literature, this contribution documents a recent empirical study of the accessibility – trip generation dependency, conducted with Germany's all-embracing MiD household survey data set of the year 2008. The analysis is motivated by a further development of the German National Transportation Model to include effects of accessibility on trip rates within the model part of trip generation. Ensuing from the national data protection legislation, the investigation cannot use geocoded trip origin and destination data, but needs to rely on reliable secondary data sources. The study sets out to address trip generation rates versus the spatial environment, using two proxy indicators of accessibility in a four-way approach: Linear models are complemented with the descriptive analysis of sample means and effect sizes, and a discrete trip frequency choice onset. Selected explanatory variables of the personal trip rates of more than 60 k respondents, with emphasis on home-based work and shopping trips, are systematized. The results lead to the conclusion that spatial connectivity of the household location has a relatively small impact on personal trip rates, as compared to socio-demographic and socio-economic household characteristics. Secondly, our findings support the assumption that significant spatial effects still occur for substitutable activities and their consideration in travel demand models could improve results.

1. Introduction

1.1. Problem statement and objectives

Trip rates (also trip frequencies) are, among others, such as car mileage and total travel times spent, standard measures of mobility. Furthermore, they are one of the most important input variables for travel demand models and influence the total number of trips within the study area. In the actual planning practice, one weekday is commonly taken as a reference period for trip rates. That is to say, we count per capita trips generated every 24 h. The 24 h period is also used for the German National Transportation Model (GNTM), which has been developed at the Institute of Transportation Research within the German Aerospace Centre (DLR) (Mocanu and Winkler, 2016). The research on travel behavior discussed in this paper is motivated by the key role of trip rates in travel demand models such as the GNTM model. This large-scale model for Germany has been applied for different projects and could be improved on the basis of the results of this study.

The trip generation sub-model combines the specific daily per-capita trip generation rates with the number of inhabitants of a traffic zone as the elementary unit of the underlying regional model. Trip generation is always the first step of sequential travel demand models (Fig. 1), whereas the destination, mode, and route choice aspects will be treated during the subsequent workflow. The question of interest is whether, and if so, to what extent the accessibility of potential trip destinations is one of the factors affecting the trip generation rate per trip purpose. Taking a static approach at first, one could differentiate fixed trip rates by a zone's accessibility index, thus influencing the fit with real data without involvement of subsequent modelling steps. A dynamic, policy-sensitive approach establishes a functional relationship between changes on the transportation supply side and the average trip frequency through the depicted loops. Technically, the four-step algorithm is open to several conceivable interaction paths with the supply side model throughout the workflow to feed back the service levels into the decision problems on the demand side.

Although accessibility is a widely accepted and discussed compact determinant of transportation demand in general, a

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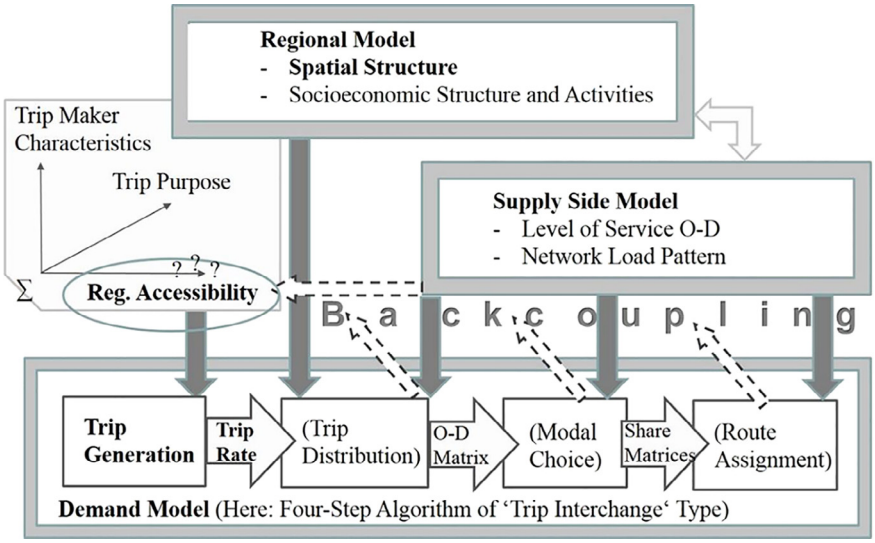

Fig. 1. Framework to Consider Accessibility at Trip Generation Step (Source: Own Representation).

substantiation of this functional dependency is not straightforward: The provision of feedback loops from subsequent computational steps, conveying the quality level of transportation supply through log-sums to the trip generation step, is technically feasible, but requires a sound empirical basis (DfT, 2014). In practice, spatial aspects of home-based trip generation rates are covered merely indirectly – through the disparate population sizes and the heterogeneity of household type distributions across origin traffic cells, sufficiently addressing relevant medium to long-term effects of demographic change and internal migration. In practical applications, a disproportionate level of sophistication between the stages of the four-step algorithm can be observed. In most practical cases, the trip generation computation remains static, making this part of the model insensitive to major improvements in the transportation infrastructure, for example, due to the inauguration of high-speed rail or a newly built motorway links. In the specific context of Germany, the country's data privacy legislation to date complicates the release of georeferenced household-related mobility data at the necessary level of detail. At present, there is no sufficient database for estimating mode and/or destination choice for a nationwide travel demand model. This situation makes a feedback loop for providing accessibility information for trip generation by log-sums a priori impossible and requires alternative concepts for investigating the impacts of accessibility on trip rates of people living in Germany.

1.2. Article overview

This article was motivated by the recent results proposed by Hellmann et al. (2015), exploring spatial variations of trip generation rates on the basis of the most important German national household travel survey Mobiliaet in Deutschland (MiD) 2008 (INFAS and DLR, 2009).

The topic was not approached theoretically, with the ambition to establish the general relationship between trip rate and spatial variables. In contrast, our research is taking the practitioner's perspective, as the applicability of all findings is coined by the existing model suite and the actual data availability. Experience has shown that an existing model apparatus is not easily discarded, it is modified at the most. Pragmatically, the essential objective is to build in a spatial dependency of the trip generation step of the four stage algorithm, which is according to the experience of the authors not common to most of the models used. The commonly diagnosed 'disproportionate state of sophistication' means that trip generation – if not coupled in a generation-distribution model – is the weakest link in the four-part chain.

The investigation was conducted under the given terms of limited data availability – thus requiring the introduction of 'proxy' indicators to operationalize spatial aspects. The German data privacy legislation prohibits the straightforward use of geocoded household and trip origin and destination. Nevertheless, some characteristics of the household's surrounding area can be extracted from MiD 2008 and used as proxy variables for accessibility. Since the (partial) loss of the spatial dimension is not desirable, this contribution seeks to demonstrate how to overcome this deficiency.

The effects of spatial variables are tested by contrast with a shortlisted set of trip-maker characteristics in a sequence of four methods, comprising descriptive analysis with cross-tabulation, linear regression, discrete trip frequency choice, and effect size classification. The investigation of trip rate levels focuses on the two demand segments of home-based work commuting trips and home-based shopping trips. The two different trip purposes are supposed to exemplarily represent the demand segments of mandatory and non-mandatory mobility.

To existing research, we contribute findings from an in-depth analysis of the most recent national household travel survey (NHTS) for Germany from the perspective of accessibility. The innovative feature of our approach is the use of zonal proxy indicators. Furthermore, and more specifically, we approach the question, whether we can improve the GNTM trip rates with regard to accessibility on the basis of MiD 2008.

The remaining paper is organized as follows: Section 2 provides the background for our analysis by a short introduction of the GNTM (2.1), the collection of personal transportation data under the legal restrictions of data privacy (2.2), a brief overview of related literature (2.3), and principles of operationalization of spatial effects in transportation models (2.4). Section 3 introduces and formalizes the MiD data set as well as the methods of analysis. The findings are given in Section 4. Section 5 concludes and suggests directions for further research.

2. Background

2.1. German National Transportation Model

The German National Transportation Model (GNTM) has been developed at the Institute of Transportation Research (German