Data Driven Analysis of Planning Processes for Demand Responsive Public Transport Systems in Rural Areas

Master‘s Thesis of B. Sc. Max Reichert

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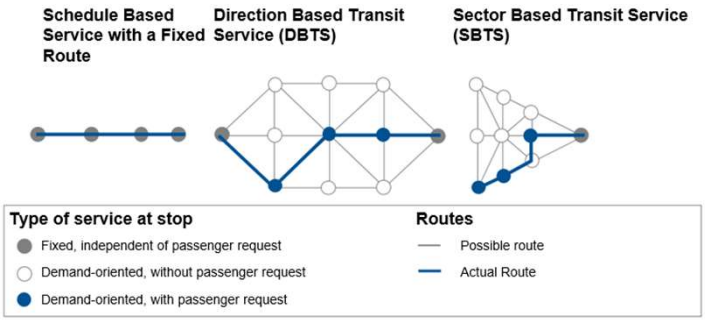

Figure 1: Forms of operation in rural PT networks[1], translated

Public transport (PT) systems are part of public services in Germany. But in rural areas with low PT demand, demand-oriented systems can be more cost efficient than regular transport services. The reason for that is that in contrast to regular bus services, demand-oriented systems serve certain stops only in case of passenger requests, see **Figure 1**. Thus, demand-oriented networks operate only when passengers request trips in the disposition center. But, planning demand-oriented systems comes along with difficulties. One main reason for that is the operation in dependency of the occurring passenger requests. Due to that, the exact operational procedures are unclear in the planning phase. Thus, current planning methodologies use assumptions for variables which are closely related to the operation. But these assumptions can contain errors. Therefore, the thesis examines the accuracy of such assumptions. In doing so, the main interest is an assessment whether the assumptions are a feasible description in the planning process. Therefore, the Master thesis examines data from the research project Mobilität digital Hochfranken. Amongst other things, the data set contains information on trip registration, routing information or price calculation from a sector-based transit system in Münchberg.

Current planning procedures consider the possible errors between assumed planning variable and occurring variables during the operation through a continuous evaluations of PT systems. Within that operational data are used to calculate the planning variables which occur during the operation. These calculated variables then replace the values originally assumed. Based on the available information and the existing assumptions in planning literature, one assumption was selected for a review within the thesis. The selected assumption considers passenger requests as rare events. Thus, it assumes that the occurring passenger requests follow a Poisson distribution. For reviewing this assumption the, the analysis uses a statistical χ^2 – test . This test compares the difference between a theoretical distribution and the distribution of the sample values. Additionally, selected statistical key values and graphical representations describe the characteristics of the data set. The analysis is performed in Python with its libraries Panadas, SciPy and matplotlib. The analysis is performed among a combination of spatial relations and temporal dimensions. The spatial relation is determined by the origin and destination of the trips. Further, the temporal dimension is defined by the departure time of the trip at the originating stop.

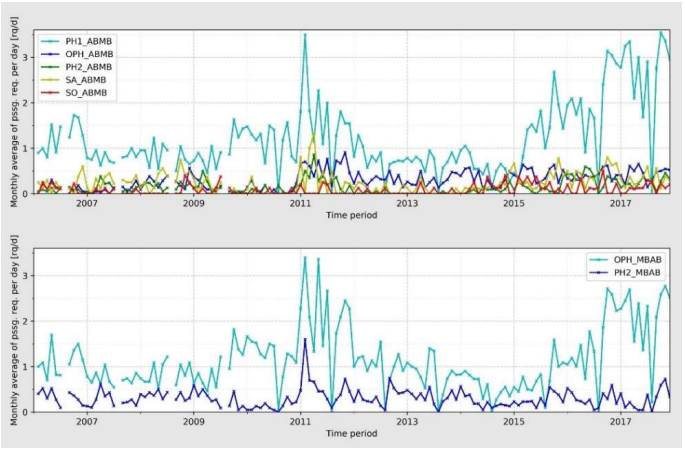

Figure 2: Time series of the mean number of passenger requests per month for the exemplarily selected spatial relations ABMB and MBAB, own depiction

	PH1_ ABMB	SA_ ABMB	OPH_ MBAB	OPH_ GDMB	PH2_ GDMB
μ	1.22	0.23	1.15	0.27	0.04
s	1.14	0.57	1.17	0.56	0.21
n	3020	1208	3020	3020	3020
X^2 - test value	201.7162	57.8411	144.0437	5.6971	Nan
$\chi^2_{crit(0.95;df)}$	9.4877	3.8415	9.4877	5.9915	Nan
Test result	Reject H_0	Reject H_0	Reject H_0	Accept H_0	Nan

Table 1: Exemplarily selected statistical key values and results of the X^2 – test

Figure 2 shows the time series of occurring passenger requests for trips inbound (ABMB) and outbound (MBAB) to Münchberg as a result of the analysis. **Table 1** shows the statistical key values and the results of the X^2 – test. Based on the test, one must reject the hypothesis of a Poisson distribution in 14 out of 18 cases. But based on the preconditions of the χ^2 – test, it is not possible to apply the test in cases where the transport demand low. This results in seven cases where it is not possible to apply the test. But the Poisson distribution is selected for modelling the process by assuming that passenger requests are rare events. Since rare passenger requests correspond to a low transport demand, this limitation reduces the information value of the results. Nonetheless, the results question if the Poisson distribution is a feasible model. But additional research which examines more samples and uses a more feasible methodology in cases where transport demand is low is necessary. Since more precise models are currently not available a further use of the assumption is possible. But using the assumption increases the need for the continuous review of the PT system, as recommended in the literature.

1 : Tsakarestos, A. (2014). Weiterentwicklung der Methodik zur Nahverkehrsplanung für ländliche Räume vor dem Hintergrund veränderter Randbedingungen (Zugl.: München, Techn. Univ., Diss., 2010). Technische Universität München, München.