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# Comparison of non-fixed and fixed locations for subsistence activities in destination choice

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**Abstract**

Decisions regarding destination choice for subsistence activities, such as employment and education, are typically taken on a medium or long-term basis. In activity-based modeling for transport research those are traditionally modeled after the allocation of daily activity plans to the individuals, with a few exceptions. This paper presents a comparison of two proceedings, namely the modeling of the destination choice for subsistence activities in advance and its traditional late modeling. Firstly, different destination choice models for employment and education were developed for the agent-based demand model TAPAS. In order to perform the comparison two scenarios were simulated: a base scenario and a scenario with a fee-based parking zone in the city center of Berlin. The results show the validity of both proceedings and their different application.



*Keywords:* travel demand forecasting; agent-based modeling; simulation; destination choice; subsistence activities

## 1. Introduction

In the literature related to activity-based modeling for transport research, one can find different meanings of the term primary activity. Antonisse et al. [1] consider attributes like the nature of the activity, the time spent on it and its chronological position to make a hierarchy of activity purposes in general. This results in work and education as the most relevant purposes, and thus as primary activities. Bowman [2] differentiates three classifications for activities. First of all, there are primary and secondary activities regarding priority within the activity-plans. The next classification refers to the activity purpose and it is based on Pas' work [3]. According to this classification, activity trip purposes can be divided into three classes, subsistence (employment and education), maintenance (shopping and further personal matters) and leisure activities. Furthermore, each of the pair priority/purpose alternatives can be either on-tour or at home.

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Taking into account Bowman's classification of activities, the destination choice for primary subsistence activities tend to be the result of medium or long-term decisions. Those are infrequent mobility decisions that have an influence on frequently adapted daily travel decisions and secondary activities [2]. A long-term decision like the place of residence is usually modeled in early steps, for instance, during the generation of the synthetic population. On the contrary, the modeling of the destination choice for employment or education traditionally takes place after the activity schedule generation and assignment. A different proceeding is for example shown in the activity-based model system SACSIM [4] or MTC's Travel Model One [5], which model the subsistence location choice at an upper level, prior to the generation of the daily activity schedule. For its part, MATSim considers long-term decisions for the simulation as long as that information is provided with the input data [6]. Bowman [2] points out that a main advantage of modeling medium and long-term mobility decisions in earlier stages is the ability to represent behavioral patterns more accurately. In contrast, the complexity of the model increases proportionally to the number of modeled long-term choices. Modeling habitual choices is also relevant in the implementation of transport policies, since these cannot easily influence repetitive behavioral structures, at least not in the short run [7].

The purpose of the present work is to compare both proceedings. These are, on the one hand, the modeling of the destination choice for the subsistence activity in advance (fixed locations), and on the other hand, the modeling of the destination choice for the subsistence activity after the activity schedule generation (non-fixed locations). To the authors' knowledge a comparison between both proceedings in the context of agent-based modeling does not exist yet. The analysis puts the focus on how transport behavior is affected by changes in transport policies implemented in the short term. To this end, a scenario with the city center of Berlin as background for the implementation of daily parking fees is simulated.

The remainder is organized as follows. The next section presents the simulation system as well as different models for the subsistence activities. Section 3 presents the scenarios to be simulated. Section 4 examines the results, which are then discussed in the last section.

## 2. Simulation framework

This section outlines the simulation framework chosen for the research. TAPAS (Travel-Activity PAttern Simulation) [8] is described in the first part. Next, there is a description of the destination choice models for subsistence activities.

### *2.1. Traffic demand simulation system*

TAPAS is a microscopic activity-based travel demand model, developed at DLR Institute of Transport Research. It involves the steps of trip generation, generation and assignment of daily schedules and destination and mode choice, and is assisted in the step of the traffic assignment by the traffic flow simulation package SUMO [9]. Each individual is grouped into a household with particular attributes related to income, available mobility resources (i.e., cars or bicycles) and a geographic location representing the place of residence. Individuals are described by socio-demographic features as well as by their availability of a driving license and a travel card. Further information used by TAPAS are for instance features about locations of activities (e.g., workplaces, shops, schools) or matrices with information about accessibility for every mode of transport. Each individual is assigned an activity schedule from a set of 23 plans according to their characteristics. That set was generated after analyzing activity plans from a time-budget survey conducted all over Germany [10], only considering data collected on Tuesday, Wednesday and Thursday. Following this, destination and mode for every activity are chosen. In a further step, the validity of the activity schedule with respect to time budget or costs is tested. In case of invalidity, destination and mode choices have to be recalculated. Furthermore, TAPAS is assisted by SYNTHESIZER [11] for the generation of a synthetic population (more information in Section 3).

### *2.2. Destination choice model for subsistence activities*

Destination choice occurs after assigning an activity-plan to an individual. TAPAS traditionally uses a gravity model for destination choice; thus, it considers capacities and mode-weighted travel times to make the selection.

Therefore, mode and destination choice are loosely coupled, since the average temporal accessibility is also considered when it comes to selecting a destination. This is the traditional proceeding used for the non-fixed location approach. On the other side, the modeling of the fixed location for subsistence activities was done differently depending on the specific purpose: work, primary school and secondary school. Students and trainees in tertiary education were also assigned a fixed location. However, in the absence of significant data, a totally random study-location was assigned to them. The combined model for work and school was implemented as a separated module for TAPAS and it was run once in advance. As a result, the destination choice for subsistence activities remains fixed regardless of changes in the travel daily schedule, while locations for other activities are kept flexible. Furthermore, all models take capacity constraints of each location into account. The different models are explained below. Apart from the differences in the location choice, the rest of the TAPAS-framework is the same for both proceedings.

*Workplace location choice.* The workplace location was modeled according to behavioral patterns in the city of Berlin with respect to trip length. A curve was fitted to the trip length distribution for working individuals provided by the survey ”Mobility in cities” – SrV (Mobilität in Städten – SrV) [12]. The resulting model is a difference of two exponential functions with two calibration parameters, $\beta_1$ and $\beta_2$, and $d_{ij}$ as the distance between i and j (1) [13]. This model was used for the synthetic working population, where a suitable workplace location is allocated to each individual. Figure 2 shows the fitted model and the trip length distribution from the survey ”Mobility in cities”.

$$f(d_{ij}) = e^{-\beta_1 d_{ij}} - e^{-\beta_2 d_{ij}}, \qquad \text{with } \beta_1 = 0.109 \text{ and } \beta_2 = 0.230 \tag{1}$$

*Primary school.* The city of Berlin offers places for children in primary schools within their school enrollment zones, which are the closest available primary schools to their homes. It is possible to request another school, but this has to be done formally and well-founded [14]. It was therefore considered that the number of children attending schools further afield was not representative. The destination choice for pupils in primary schools corresponds to the next-located school from their home, within the bounds of the school capacity.

*Secondary school.* An heuristic approach was used for choosing a destination in case of students in secondary school. This was carried out in two steps. Considering that the data set for locations of activities differentiates between different secondary school options according to the German schooling system, students were distributed according to the number of opportunities for each secondary school type. To this end, the total capacities for all the different types of schools were used to build a discrete probability distribution. According to this distribution, a type of school was assigned to each student. Subsequently, each student was assigned a random school selected from a set with the five closest schools from their home.

## 3. Simulation scenarios

The simulated region is the city of Berlin with its around 3.3 million inhabitants for the year 2010. This synthetic population was created by means of SYNTHESIZER. Population sample data as well as the marginal totals of the base-year (2010) have their origins in the German Microcensus 2010 (Mikrozensus 2010) [15], which represents a micro-data sample of the population in Germany. Additionally, the demographic data was combined with micro-data regarding individual socio-economic characteristics and mobility behavior from ”Mobility in Germany” – MiD (Mobilität in Deutschland – MiD) [16], a survey conducted all over Germany, and from the survey ”Mobility in cities”.

Two scenarios for the year 2010 are simulated. Firstly, the base scenario describes the traffic demand for 2010. And secondly, another scenario represents a situation with a daily parking fee of 5 euros for motorized vehicles within the city center. It should be noted that the base scenario also has three small zones with parking fees, although these only cost 1 euro. In the second scenario this fee-based parking zone is extended to the city center and the amount of the fee increased by 5 euros. As illustrated in Figure 1, the central area of the city is densely populated and also encompasses numerous workplaces. The aim of the last scenario is to analyze the effects of changes in transport policies over the population with the assumption that subsistence activities are the result of decisions made in the medium and long term. Therefore, both scenarios are simulated using the proceedings mentioned above, that is, assigning a fixed location for the subsistence activity and with this location being selected after the allocation of the daily schedule.

For the simulations it is supposed that co-drivers are susceptible to changes in relation to parking charges, just like drivers. This is intended to avoid a disproportionate increase in the number of co-drivers, as they need a driver to carry them.

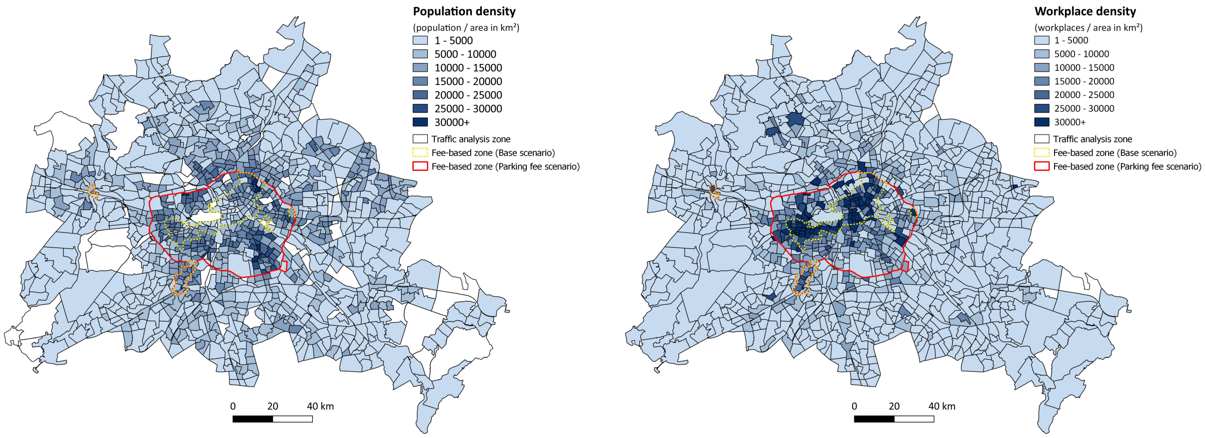


Figure 1: Both maps represent the city of Berlin divided by its traffic analysis zones. There are three small fee-based zones for the base scenario, marked with a yellow dotted line. The zone marked with a red line corresponds to the city-center-wide area with a daily parking fee for motorized vehicles for the second scenario. On the left we see the population density. The zones of the map on the right are shaded by workplace density.

## 4. Results

The survey ”Mobility in cities” was used, as mentioned before, for modeling the destination choice for working population. Therefore, it can be used to assess the resulting trip length distribution of the simulations. Figure 2 shows this comparison for both approaches as well as the fitted model. The simulation with fixed locations shows in two distance classes closer values to the distribution from the survey, namely under 5 km and between 15 and 20 km. The remaining distance classes result in close shares for both approaches.

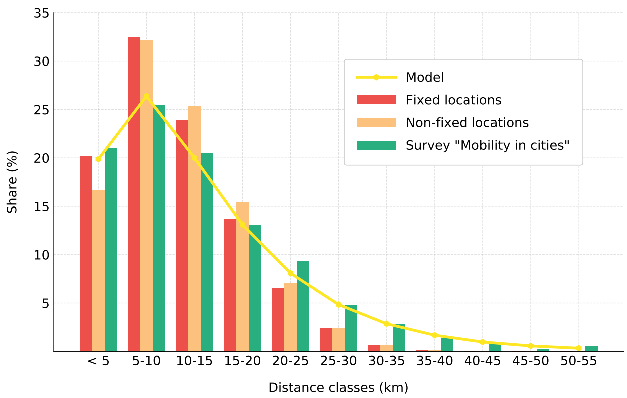


Figure 2: Trip length distribution for the purpose work for all modes of transport. The green bar corresponds to data from the survey ”Mobility in cities”. In addition, the resulting trip distribution for the modeling of the usual workplace in advance and the modeling during the assignment of the trip schedule are represented in red and orange, respectively. The fitted model is depicted by the yellow line.

One can see differences between the average trip length for educational purposes and to a lesser degree for employment in the case of the simulations with non-fixed locations and the ones with fixed locations. Pupils and secondary students travel on average around 1.9 km more in the case of non-fixed locations. Comparing both scenarios the simulation with non-fixed locations shows a decrease of around 150 m in the scenario with a fee-based parking zone, in contrast to the around 10 m decrease of the simulation with fixed locations (Table 1).

As shown in Table 2, the modal share for both proceedings is very similar. Comparing the two scenarios there is, as expected, a significant decrease of the use of car in both proceedings in the scenario with a city-center parking fee, from 25.3 and 25.2% respectively to 16.6% in both of them. This leads, at the same time, to an increase in the use of

Table 1: Average trip length by purpose for each scenario (in meter).

| | Survey "Mobility in cities" | Base scenario non-fixed locations | Base scenario fixed locations | Parking fee scenario non-fixed locations | Parking fee scenario fixed locations |
|---|---|---|---|---|---|
| work | 11127.0 | 10107.9 | 9698.7 | 9952.6 | 9686.4 |
| school | 4795.0 | 5007.2 | 3123.8 | 4875.9 | 3116.1 |

non-motorized transport modes and public transport. Looking at the results for trips with employment purposes, the difference between both proceedings is more noticeable. Both proceedings show indeed a decrease of around 10% in the use of car. But we see in the modal share for the simulation with non-fixed locations a larger increase in the case of walking and bicycle in the scenario with a parking fee, whereas the parking fee simulation with fixed locations shows a bigger increase in the case of public transport.

Table 2: Modal share within Berlin for the simulated scenarios.

| | Survey "Mobility in cities" | Base scenario non-fixed | Base scenario fixed | Base scenario non-fixed (work) | Base scenario fixed (work) | Parking fee scenario non-fixed | Parking fee scenario fixed | Parking fee scenario non-fixed (work) | Parking fee scenario fixed (work) |
|---|---|---|---|---|---|---|---|---|---|
| Walk | 28.1% | 26.6% | 26.8% | 7.0% | 6.2% | 28.8% | 28.8% | 8.6% | 6.9% |
| Bicycle | 12.5% | 12.5% | 12.5% | 14.2% | 14.7% | 16.4% | 16.2% | 18.1% | 18.4% |
| Car | 25.1% | 25.3% | 25.2% | 38.8% | 38.0% | 16.6% | 16.6% | 28.7% | 28.2 % |
| Car (co-driver) | 6.4% | 6.7% | 6.7% | 3.2% | 3.0% | 4.8% | 4.8% | 2.3% | 2.3% |
| Public transport | 27.0% | 28.9 % | 28.8% | 36.8% | 38.0% | 33.4% | 33.5% | 42.3% | 44.1% |

Table 3 presents the proportion of trips inside the zone with parking charges for employment purposes for both scenarios and proceedings. The simulation of the parking fee scenario with non-fixed locations shows a decrease of 1.2% in the proportion of trips inside the parking zone, the decrease in the case of fixed locations being 0.4%. Taking into account only the car as mode of transport, there is a big drop in the proportion of trips for both proceedings in the situation with a city-center parking fee. Furthermore, this difference is more significant in the case of the simulation with non-fixed locations.

Table 3: Proportion of trips with employment purposes inside the zone with parking charges for all modes and only for car.

| | Base scenario non-fixed locations | Base scenario fixed locations | Parking fee scenario non-fixed locations | Parking fee scenario fixed locations |
|---|---|---|---|---|
| All modes | 35.8% | 32.5% | 34.6% | 32.1% |
| Car | 29.6% | 26.8% | 10.6% | 9.9% |

## 5. Conclusion

This article presented a comparison between the modeling of the destination choice for subsistence activities (employment and education) after the assignment of the daily activity plan and its modeling in advance. For the latter different models for employment and education for the city of Berlin were implemented for the agent-based traffic demand model TAPAS. Both proceedings were compared by simulating two scenarios for the year 2010 equally calibrated: a base scenario and a scenario with a fee-based parking zone in the city center.

The trip length distributions of both proceedings replicated, to the extent possible, the trend shown by the survey "Mobility in cities". We found big differences between both approaches in the average trip length in the case of trips with educational purposes. For primary and secondary education this can be due to the importance given in the modeling of the fixed locations to shorter distances. Furthermore, as expected, the average trip lengths showed minimal changes between the base and the parking fee scenario for working trips in the simulations with fixed locations, since the destination choice for the subsistence activity remains unchanging. The small differences may be due to the allocation of different plans to the agents, so that even though the destination of the subsistence activity for both simulations is maintained, the destination choice for maintenance and leisure purposes or the number of trips can vary. For the modal share, as might have been expected, the percentage of the use of car decreased significantly in both simulations with a fee-based parking zone. When looking at trips with employment purposes substantial differences are noticeable. Short-range modes of transport like walking and bicycle gain more weight in the case of the simulation of the parking fee scenario with non-fixed locations. In the simulation with fixed locations there is a shift towards public transport. Hence, persons with long car-trips to their workplace in the city-center have to seek for a long-range alternative in form of public transport. We saw also that the proportion of workplaces within the fee-based parking zone remained more or less constant, since numerous workplaces are situated within that zone and the capacity constraints force all work places to be equipped with employers (See Figure 1).

The question is where one proceeding should be used to the detriment of the other. The modeling of the destination choice for subsistence activities in advance has the advantage of representing discrete behavioral patterns for the different travel purposes. This proceeding makes it also possible to model specific aspects of reality like administrative restrictions or characteristics of workplaces, such as level of education needed or salary. Like we said, choices regarding employment or education are usually made in the medium and long term. For this reason individuals may need more time to make adjustments in their lives to adapt to changing scenarios, e.g. due to new transport measures. Therefore, we could say that the proceeding with fixed locations can be advantageous in short-term simulations. On the other side, the proceeding with non-fixed locations can be better applicable to medium and long-term planning, e.g simulating the situation for five years after introduction of a transport measure. Another advantage of the proceeding with non-fixed locations is its ease of implementation. Taken as a whole, both proceedings are valid for specific situations and it depends on the scope of research, which one should be used.

To further our research we intend to improve and verify the models for trips with educational purposes. We also intend to model the workplace choice in a more detailed way, adding more variables.

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