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MODAL SPLIT IN THE ŽILINA TRANSPORT MODEL

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Summary: The transport modeling is established process for many transport project all over the world. The four step model (FSM) is the primary tool for forecasting demand and performance of a transportation system. The trip generation, trip distribution and modal split are three steps which are calculated step by step or jointly. The calculated origin-destination matrices are used in final step – assignment. The article deals with the modal split of transport model of Žilina. The mentioned transport model has been used for transport master plan. The modal split requests the large data database from solved area. The data were evaluated from mobility survey. The quality of modal split mostly depends on utility of defined transport systems in the transport model. The most serious problem of modal split is the filling of database and them correctly evaluation.

Key words: transport model, modal split, utility.

1. INTRODUCTION

The current FSM might best be viewed in two stages. In the first stage, various characteristics of the traveler and the land use - activity system (and to a varying degree, the transportation system) are "evaluated, calibrated, and validated" to produce a non-equilibrated measure of travel demand (or trip tables). In the second stage, this demand is loaded onto the transportation network in a process than amounts to formal equilibration of route choice only, not of other choice dimensions such as destination, mode, time-of-day, or whether to travel at all. (1)

The third step - the modal split, requests the large data database from solved area. The input data of Žilina demand model were evaluated from large mobility survey. The transport model of Žilina district is the oldest transport model in Slovakia. The official urban town zoning system were used as a base system. It includes the statistical area units. The special areas (shopping centers, university…) were defined as the independent zones. The Žilina model area includes 60 town zones and 58 extra-urban zones. There are six different types of activity like work, shopping, education, university, leisure and home, which is the first and also last activity of every agent: i.e. they start and finish their daily activities at home.

2. MODE CHOICE

However, the most challenging task in transportation forecasting process is to identify the influencing factors on a traveller's choice.

The mode choice is the process where the means of traveling is determined. The means of travel is referred to the travel mode, which may be by private automobile, public

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transportation, walking, bicycling, or other means. Mode choice is formulated as a discrete choice model with alternatives corresponding to the specific tour or trip modes.

The discrete choice models have commonly selected transport modelling for characterization of each traveller's behaviour (2). The discrete model is represented by a theoretical framework in terms of the utilitarianism. Utilitarianism is a theory which is based on the utility maximization of a choice from a set of alternatives. The higher the utility of choice, the greater the value and benefit which the consumer will get from it and the greater the possibility that this choice will be selected.

The utility for alternative would consist of a systematic attributes which is a function of relevancy to decision-making process and a constant representing the uncertainty derived from individual behavior and modeller measurement errors (2).

GORR (1997) defines mode choice by assuming individual preferences; i.e. the indifference curves (all modes on one and the same curve are preferred equally) differ between different homogeneous groups. The sum of all characteristics results in a specific attraction of each mode and is crucial for choosing a mode together with individual preferences. The threedimensional figure 3 demonstrates this context (4) (Fig.1).

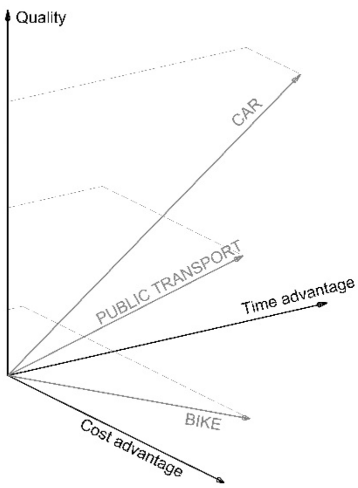


Fig. 1 – Individual preferences for transport mode choice (4)

2.1 The utility function

The utility functions derived from the discrete choice model help to discover the comparative attractiveness of each mode. The interaction of each attribute in a utility function of a mode is shown by its coefficients. The positive values of these coefficients apply a positive impact on the utility function, while negative values apply a negative impact.

The attributes related to the car selection are the network, parking space, parking cost, reliability, ownership cost, fuel cost, toll frequency, toll cost, traveling time, and traffic. In contrast, attributes related to the rail travel are accessibility distance, network connectivity, service frequency, transit interval, traveling time, traveling cost, reliability, parking availability, and cabin environment. For bus the attributes are accessibility distance, network connectivity, service frequency, transit interval, travelling time, traffic, traveling cost, reliability, and cabin environment. Based on the attributes listed, the initial assumptions of the utility functions for the three modes are shown in the equation below (2).

$$U_{car} = constatnt_{car} + b_{1car} * car\_network + b_{2car} * car\_parkingspace + b_{3car} * car\_parkingcost + b_{4car} * car\_reliability + b_{5car} * car\_price + b_{6car} * car\_fuelprice + b_{7car} * car\_tollno + b_{8car} * cat\_tollcost + b_{9car} * car\_time + b_{10car} * car\_traffic \quad (1)$$

$$U_{rail} = constatnt_{rail} + b_{1rail} * rail\_accessdistance + b_{2rail} * rail\_network + b_{3rail} * rail\_transittime + b_{4rail} * rail\_transitno + b_{5rail} * rail\_time + b_{6rail} * rail\_cost + b_{7rail} * rail\_reliability + b_{8rail} * rail\_parking + b_{9rail} * rail\_comfortlevel \quad (2)$$

$$U_{bus} = constatnt_{bus} + b_{1bus} * bus\_accessdistance + b_{2bus} * bus\_network + b_{3bus} * bus\_servicetime + b_{4bus} * bus\_transitno + b_{5bus} * bus\_time + b_{6bus} * bus\_traffic + b_{7bus} * bus\_cost + b_{8bus} * bus\_reliability + b_{9bus} * bus\_comfortlevel \quad (3)$$

In the case of strict requirements to the minimum levels of key criteria, the process should be realized by selective diagram, which assesses the ability of the various transport systems meet these requirements.

Based on the utility function of each mode, the proportion of travelers who would use car, rail, or bus will be

$$P_{car} = \frac{e^{U_{car}}}{e^{U_{car}} + e^{U_{rail}} + e^{U_{bus}}} \quad (4)$$

$$P_{rail} = \frac{e^{U_{rail}}}{e^{U_{car}} + e^{U_{rail}} + e^{U_{bus}}} \quad (5)$$

$$P_{bus} = \frac{e^{U_{bus}}}{e^{U_{car}} + e^{U_{rail}} + e^{U_{bus}}} \quad (6)$$

In the case of strict requirements to the minimum levels of key criteria, the process should be realized by selective diagram, which assesses the ability of the various transport systems meet these requirements.(6)

2.2 Mode choice model in Visem

Visem (PTV Vision software) calculates three logical work units: trip generation, trip distribution and mode choice. These logical units are interlocked. Trip distribution and mode choice are calculated simultaneously, with a single method. For all three work units, the calculations are based on the behaviour-homogenous groups and activity chains. (5)

Visem calculates a discretes distribution model. The calculation provides the trip of each route link (for a person group) and chooses one from modes i. If the first mode is a nonexchangeable mode, the entire trip chain is maintained independent of the attributes of this mode of the successive trip. If an exchangeable mode was selected for the first trip, mode choice is carried out for the remaining chain trips, however, only within the exchangeable modes.

For the logit model, the choice probability for individual g and mode m has the form:

$$P_{gij}(m) = \frac{e^{U_{gij}(m)}}{\sum_{k=1}^{M} e^{U_{gij}(k)}} \tag{7}$$

i, j	Indices of origin and destination zones.
$P_{gij}(m)$	Choice probability for mode m by person group g
$U_{gij}(m)$	Objective utility value of mode m for person group g
m	Number of alternative modes

The structure of the utility function U_{gij} is of special importance in this respect. The following utility function from [3] illustrates possible components of a utility function for the mode choice:

$$U_{gij}(m) = p_{1gm} * T_{ijm} + p_{2gm} * Z_{ijm} + p_{3gm} * \ln\frac{D_{ij}}{p_{4gm}} + p_{5gm} * C_{ijm} + p_{6gm} \tag{8}$$

with the parameters per group g and mode m:

p_{1gm}	marginal utility of one minute ride time,
p_{2gm}	marginal utility of one minute access/egress time,
p_{3gm}	marginal utility of logarithmic relative distance increases (impact of distance advantage),
p_{4gm}	advantage distance of mode m,
p_{5gm}	marginal utility of one monetary unit of a ticket price,
p_{6gm}	constant utility of mode m,

and the mode dependent attributes:

T_{ijm}	ride time from i to j with mode m,
Z_{ijm}	sum of access time at i and egress time at j for mode m,
C_{ijm}	costs of trip from i to j with mode m,
D_{ij}	distance from i to j.

The parameters p1, p2 and p5 have a negative utility, so they have a negative sign. The parameter p4 (advantage distance) indicates from what distance a particular mode of transport is considered to be useful by travellers of a specific group. Only when the distance dij exceeds the advantage distance p4 (dij > p4) the quotient dij / p4 is greater than 1 and the logarithmical term ln (dij / p4) turns positive. As a consequence, distances below the advantage distance result in a negative utility. The distance relevant parameters p3 and p4 are important to give preference to the modes walking and cycling on short distances, as their p4 is defined smaller than for the modes of transport car und PrT and their p3 is negative compared to the others.

2.3 Implementation of survey data to the modal split

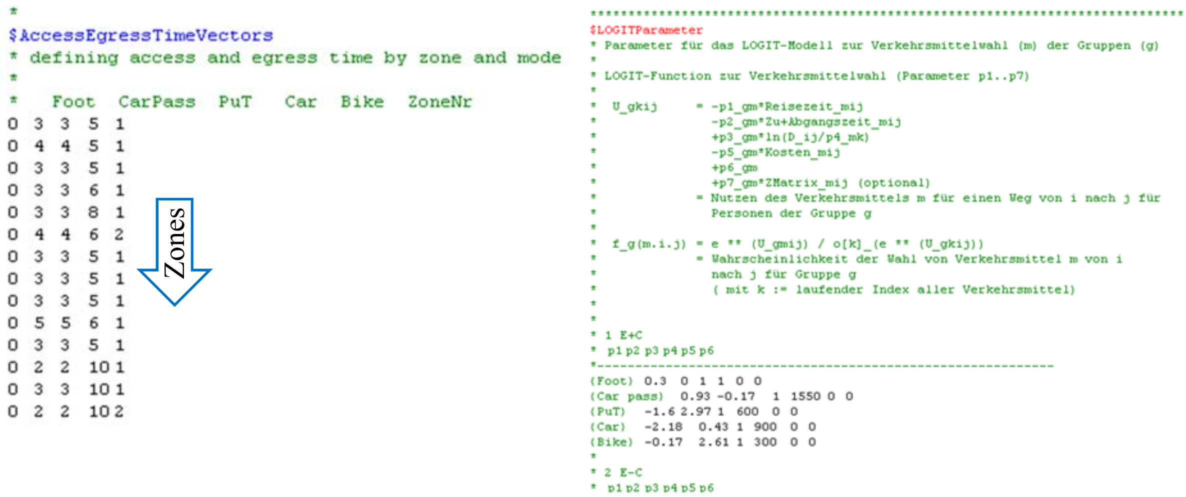
The sum of origin trips determines the transport production and the sum of destination trips determines the transport attractiveness. The amounts of the origin and destination trips are needed to distribute into the matrices by using transport modes or purpose of trips. Tab. 1 presents the probability of trip chain of specific inhabitants group. The data from mobility survey or another sources cannot be used for direct calculations of the trips distribution or mode choice. The data are implemented to the demand model through the parameters setting (Fig. 2).

Tab. 1 - The example of input data for modal split – trip chains

The probabilityof trip chain realization	**Employed persons - car available**	**Employed - no car available**	**Not Employed persons - car available**	**Not Employed - no car available**	**Children**	**Students**	**Pensioners**
	E+c	E-c	NE+c	NE-C	Child	Stud	Pens
HPH	8.41	6.49	14.29	4.41	11.76	4.51	14.68
HJH	41.05	49.92	71.43	57.35	29.41	46.46	24.31
HPH	8.41	6.49	14.29	4.41	11.76	4.51	14.68
…							
HPSH	0.66	0.34	0.00	1.47	1.96	0.39	1.38
…							

Source: Author

Each trip is recorded, with mode, purpose at destination address, and number of people on the trip, the departure and arrival times, trip duration, the household vehicle used, and other pertinent information about the trip (Fig. 2).

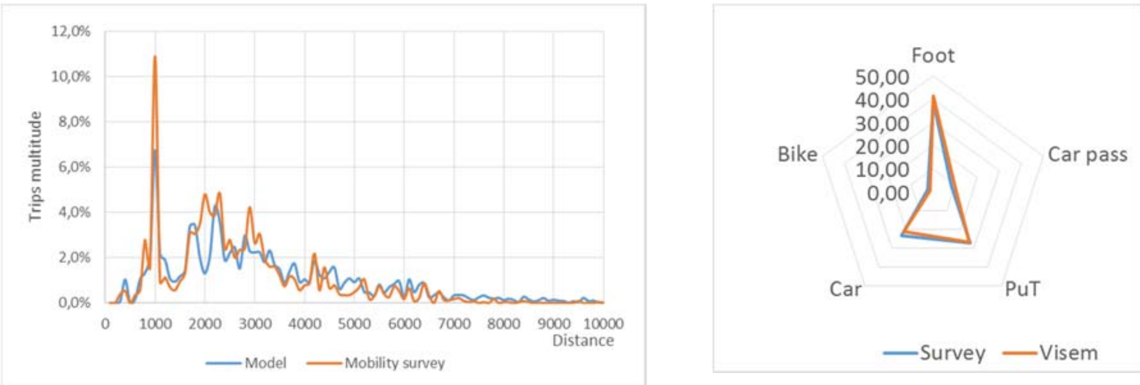


Source: Author

Fig. 2 – The Acces and Egress time vectors data from Visem

The main data for model choice were:

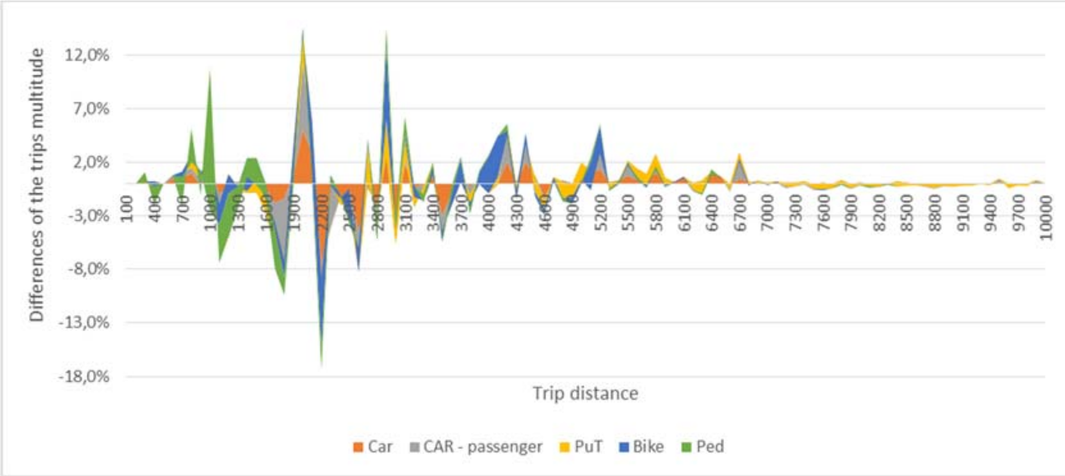
- Trip chains file –linking trip into activity by people groups
- The Acces and Egress time vectors
- The trip relative frequency during the day
- Logit parameters.



Source: Author

Fig. 3 – The comparation beetwen number of paths multiplicity from mobility survey and Visem output data (left) and total modal split (right)

Fig. 3 and Fig. 4 present the final differences of the trips multitude obtained from mobility survey and Visem output data. The greatest discrepancies in amount of trips show the trips with distance of more than1900 and less than 2200m. However the discrepancies were less than 5% for each one transport mode (Fig.4).



Source: Author

Fig. 4 – The difference between mobility survey and Visem output dada

CONCLUSION

The definition of the demand model calculation is based on the large database of the survey data. The Software Visem has not been upgraded itself. Currently it is implemented into the software Visum (the tour based modul). The mathematical process, issue is still identical. The modal split is calculated within one process together with the trip generation and trip distribution. The mode dependent attributes were derived from survey data. Logit parameters were taken from Austria database. The final modal split model was calibrated and validated on behalf the mobility survey data. The total difference of modal split between mobility survey and Visem output data was less than 3%.

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"Podporujeme výskumné aktivity na Slovensku/Projekt je spolufinancovaný zo zdrojov EÚ"

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