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MODELS IN PLANNING URBAN PUBLIC PASSENGER TRANSPORT

ABSTRACT

The solving of complex problems in public transport requires the usage of models that are based on the estimate of demand in planning the transport routes. The intention is to predict what is going to happen in the future, if the proposed solutions are implemented. In the majority of cases, the public transport system is formed as a network and stored in the computer memory in order to start the evaluation process by specifying the number of trip origins and destinations in each zone. The trip distribution model which is used to calculate the number of trips between each pair in the zone is based on the overall travel frictions from zone to zone.

KEY WORDS

forecasting, models, modal-split, simulations, public transport, passengers

1. INTRODUCTION

Modal-split models that are of special interest in planning the public transport, estimate the number of trips made in a city by automobile, and the number of trips made by public transport. In different studies, different standardization models have been developed.

In this work, the models of estimating demand for public transport are classified as:

- modal-split models,
- disaggregate models,
- simulation models.

2. MODAL-SPLIT MODELS

Modal-split are classified into three types that differ in where they come in the sequence:

- trip-end models,
- trip change models
- trip interchange models.

Trip-end model is studied before the distribution phase, and after the trip planning phase. The model contains the variables that describe the characteristics of passengers or their place of residence as origins of travelling (Figure 1). Common variables in the first group are automobile ownership, income, number of household members, age, and occupation. Examples of variables in the second group are population density and the distance from the trip destination zones. Sometimes, the trips are classified according to purpose, usually those to work, shopping, cultural, recreational, etc. and according to the number of those with the destination in the central city zone.

Trip change model goes before the phase of defining the trip purpose, and after the trip distribution phase. This model allocates trips according to the attractiveness of the public transport compared to the automobile, for every change from zone to zone, based on the passenger travel friction (Figure 2). It is not assumed that all the selected trips are the trips with least travel friction. The percentage of passengers who will use public transport is estimated from the travel friction. This model may ignore the socio-economic characteristics of passengers such as the income and car ownership.

Passenger friction is measured by the time spent on travelling and cost, which are combined by the use of monetary value of the time spent on travelling. Sometimes only the door-to-door travelling time is used, and sometimes this is divided into travel-only time, which means in-vehicle and out-of-vehicle time. The cost consists only of fuel costs, tolls and parking charges. The decision-making process on using the mode of transport, according to research done in New York City in 2005 is mostly affected by the marginal

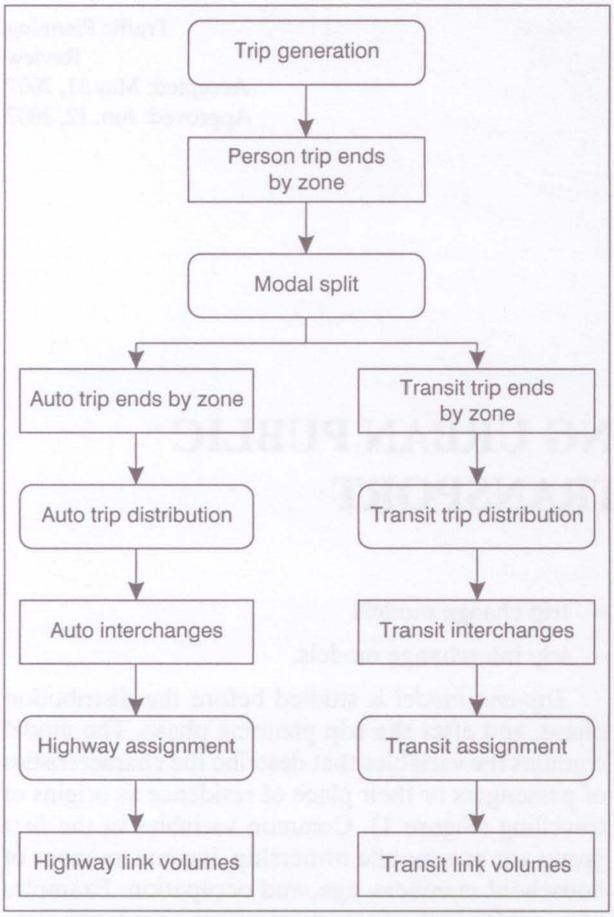

Figure 1 - Forecasting sequence with trip-end modal-split model

Source: Black, A.: Urban Mass Transportation Planning, p. 298.

costs quantified by the attitudinal variables such as comfort and convenience.

An empirical method used in the mentioned research of forecasting the percentage of trips by automobile, the trend has the following form:

$$Y = 39.65\,e^{-0.029x}$$

Y – percentage of trips by car;

x – duration of public transport time minus time of travelling by car in minutes.

The costs are converted into the travel time of HRK 0.16 per minute. Public transport has advantage over the automobile which includes high costs of parking. The research was done with the aim of reducing the number of automobile trips if certain improvements in public transport were implemented. If the travel time by public transport decreased by five minutes, according to trend, it was found that 5.4 per cent of passengers would shift from automobile to public transport.

The transport technologists have criticized the trip-end model, because the availability of the passenger transport service is not accounted for (vicinity of stops and inter-stop distance). The drawback of these models lies in the fact that the number of trips allocated to public transport does not change in opening new lines or, if the number of stops on the existing lines is increased by reducing the inter-stop distances.

Those who advocate the trip-end models claim that the socio-economic characteristics and location determine the transport mode selection, and that the service quality is of little significance.

Trip interchange models are used in more complex research, although first the trip-end models were developed, used in simpler research. It would be best to use both types of models and to predict the number of public transport users. The trip-end model could be used to estimate the number of passengers who have no access to a car, and this estimated number can be then added to the number of public transport users. The passengers who can choose between the car and public transport would be estimated and allocated to transport modes using the trip exchange model. The passengers would choose automobile or public transport depending on the offered service that best suits the trip type, whether it is travelling to or from work, shopping or to satisfy one's recreational, sport or social needs.

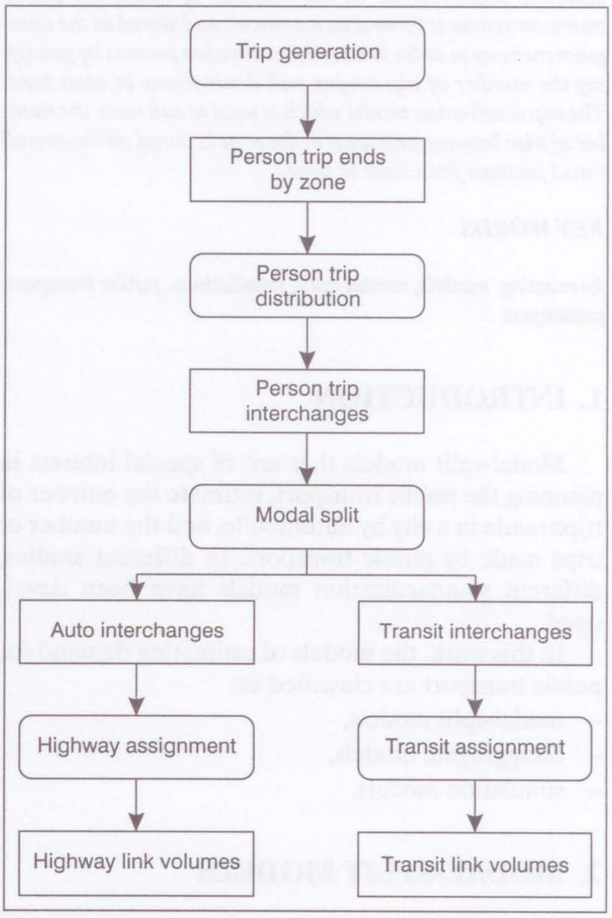

Figure 2 - Forecasting sequence with trip interchange modal-split model

Source: Black, A.: Urban Mass Transportation Planning, p. 299.

3. DISAGGREGATE MODELS

The older modal-split models used traffic zones as the units of analysis and formed them out of adequate surveys carried out per households, percentages per zones. The obtained data served for the making of models. In this way there were masks of variations within the surveyed population, and the possibility of making errors in forecasting was increased. It may happen that trips done by citizens of one zone in which the assumption is that every household has one car, is different from the assumption made in the other zone where 50 percent of citizens had no car, and in the third zone where 50 percent had two cars. Another problem would appear if the travel resistance among the zones is average. Little significance was assigned until now to the sensitivity of the models to the policy, since the reactions to measures such as increase in taxes, initiative for buying a car or restriction on car usage could not be evaluated.

In order to minimize the forecasting errors, it is necessary to develop separate models that foresee the behaviour of single persons or households in the observed zones. The most common methodology that is used in studying the modal split is the determination of the models of driving to work, shopping and for other purposes. These models are called *behavioural models*, since they are based on the theories of individual human behaviour. The models are used to embody causal relations, rather then statistical regularities.

Apart from studying the travelling methods the models have been applied also in studying the frequency of travel and choice of destinations and routes. They may incorporate all the steps of the conventional travel forecasting process in the cities. As one advantage of the segregated models is the one that it may include the variables based on the social and economic characteristics of the one realizing the ride, aspects of ride such as the purpose of travelling, time of day, and the characteristics of the transport system through the speed of the transport means, traffic interval, travel fare, etc.

Disaggregate models can be calibrated with a relatively small set of data, so that the standard model can be used, including a minor number of interviews, which means without the need to carry out massive surveys per households. Further advantage is the flexibility, since the model can be adapted to the available data or problems that are subject of the survey, including the fares, staggered working hours, or influence on special groups of passengers such as the disabled or the elderly.

The results of disaggregate models have to be aggregated to traffic zones in the forecasting process, since the relations are not linear. Usually the passengers are grouped into "market segments" that are relatively homogeneous regarding their behaviour. The emphasis is on the empirical analysis, i. e. finding the regularities in the huge amount of data that have been obtained in massive researches of passenger trip origins and destinations. Some technologists still prefer this approach, since it is precisely the large volume of passenger traffic and not the travel behaviour of individuals which is important in planning.

The difference between the aggregate and disaggregate models is similar to that between macro- and microeconomics. Although behavioural models dominate in the research of the modal choice of the passengers in the cities, they have not wide application in planning, because of the resistance to changes, scepticism on the accuracy of disaggregate models, complexity of their calibration and usage. In the modal-split analysis they have developed a gap between the theory and practice.

4. SIMULATION MODELS

Modal split-models in the analysis of the complex systems and processes related to public transport in the cities are very important in organizing the approach, procedures and the results of analysis. Mathematical models form quantitative relations and give exact results, but when the systems are very complex or include stochastic processes, they become complicated in order to be set and solved. In such situations, the models that use computer simulation become useful tools in the analysis.

In the public transport system there are numerous situations in which computer simulation provides fast and useful solutions. The simulation models allow introduction of a much greater number of influencing factors. In finding the solution for random arrival of passengers, different times of entries and exits, i. e. to avoid disturbances in traffic, the simulation model provides easy testing of various modifications, new procedures and multiple scenarios.

The simulation models can use physical projects, such as networks or traffic objects. When the model is set and the numerical data for a specific case input, the model should be verified, i. e. the numerical results tested regarding their accuracy in actual conditions. After the verification and evaluation, it is necessary to prepare the model and check the analysis. The passenger flows, ticket charging and many other traffic situations in urban public transport are also subject to simulation as well as many other forecasting models for the evaluation of the passenger demand.

With permanent development of automation in various design phases of the public transport system, along with the modal-split models, the simulation models are also expected to be used in the system of public transport planning.

5. CONCLUSION

The significance of the models lies in the fact that they allow analysis in the form of parameters, i. e. usage of symbols for all the variables and parameters. The introduction of numerical values into the model for various groups of conditions is allowed. If the model is complicated, the numerical values can be used in order to get specific solutions for individual cities.

The results of the models provide new insights, describing the relations, cause-effect relations and the sensitivity of the system to single variables and components introduced as parameters. The understanding of the results of the analysis and making conclusions represent the final step in modelling.

The applicability of the model in this work is restricted to the situations in which the made assumptions are valid. The trip-end model could be used for the estimation of the number of passengers who have no access to a car. The passengers who have the choice between a car and public transport would be assessed and classified according to the transport modes, using the trip change models. The trip interchange models would mean that the cars were used until the entry to the public transport terminal and then parked (park and ride), and the travel continued by a provided transport means of the public transport. A passenger travelling by bus or by some other transport means, who would have to make connections two, three times, has every reason to belong to the group of captive car drivers.

The modal-split models estimate the probability that a passenger will choose the transport means on the basis of the utility ratio that might be obtained by the offered alternatives. Utility is an abstract concept and not directly observable, but it can be assessed statistically.

In using the simulation models, it is necessary to define the problem, the objectives (any short-term or long-term ones), local conditions and restraints. The computer simulation model allows the introduction of a number of factors. The level of complexity depends on the type of the system or process which is simulated. Simulation is suitable for the operations of public transport on the traffic routes, since the traffic conditions are arbitrary, which is not the case in fast public transport on completely controlled right-of-way roads.

The implication of this research is in the reduction of the use of automobiles, and increase in the usage of public transport of passengers in the cities.

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SAŽETAK

MODELI PLANIRANJA JAVNOG PRIJEVOZA PUTNIKA U GRADOVIMA

Rješavanje kompleksnih problema u javnom prijevozu zahtijeva korištenje modela koji se baziraju na procjeni potražnje kod planiranje pravaca prijevoza. Namjera je da se predvidi što će se u budućnosti dogoditi, ako se provedu predložena rješenja. U većini slučajeva sustav javnog prijevoza formiran je u obliku mreže i pohranjuje se u memoriju računala kako bi započeo proces procjene, specificiranjem broja izvora i ciljeva putovanja u svakoj zoni. Model distribucije vožnje pomoću kojeg se računa broj vožnji između svakog para u zoni, zasnovan je na ukupnom otporu putovanja od zone do zone.

KLJUČNE RIJEČI

prognoziranje, modeli, sektorizacija, simulacije, javni prijevoz, putnici.

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