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PROPOSAL FOR REDUCTION OF CALIBRATION PROCESS IN REFERENCE TO TRIP DISTRIBUTION METHOD

ABSTRACT

The nowadays applied different macro models or parts of those, which describe the urban environment, can originate in a four-step modelling process. The paper focuses on the trip distribution process (the 2nd step) because of its significant calibration requirements. Therefore, it is possible to make the entire modelling process more reliable (dependent upon the reliability of the available databases).

KEYWORDS

urban transportation, urban modelling, trip distribution

1. INTRODUCTION

As the rapid growth of world population and its concentration in cities around the globe is taking place, sustainable urban development constitutes a crucial element affecting the long-term outlook of humanity [2]. With the desire to achieve urban development that "meets the needs of the present without compromising the ability of future generations to meet their needs" [3], urban development is required to minimize threats from wasteful use of non-renewable regenerations, to avoid the uncompensated geographical or spatial displacement of environmental costs onto other places, and not to draw on the regeneration base and waste generation capacities to the levels which disrupt dynamic equilibrium of the ecosystem ([4], [5]).

Urban structures can be understood as result of the relationship between transport and land-use. The interaction is known as a two-way process. This process, however, is more complicated than other reciprocal processes that are frequently encountered in everyday life. This is mainly because various interactions take place over different time scales and involve fac-

tors with varying degrees of certainty. Hence, an analysis of the interaction between transport and land-use requires disentangling diverse relationships among the factors that makes it a difficult task.

To avoid the reduction of the competitiveness in the urban sector, we need to plan the structure of cities in a way ensuring effectiveness and sustainability. The basic step of the enhancement of operation effectiveness shall be the development of transportation modelling considering the possibility of decreasing the subjective and iterative methods during the modelling process.

Through this research we focused on the traditional four-step modelling. Examining the steps, the trip distribution module seemed to be the most questionable point. Besides, it is very important for it to be well described, because many research topics are based on the structure of traffic flows (urban structure, transportation economy, social structure, land-use optimization).

The first step of the four-step model - the trip generation is based on statistics and practical experiences describing the given model zones, so, usually, it does not cause any theoretical anomaly.

The modelling steps of mode split and traffic loading use the result of the distribution method so these last mentioned two steps depend on the distribution process, and besides, these two modules are usually both consistent and well usable.

However, the trip distribution has many different ways to be defined (gravity model [1], growth factor models, synthesized models, multiple linear regression models) and apart from the importance of the structure of traffic being well modelled, there are still some key questions that should be answered in reference to the examined topic. Hence, this paper tries to define the possible ways of enhancing the reliability of the trip-distribution method.

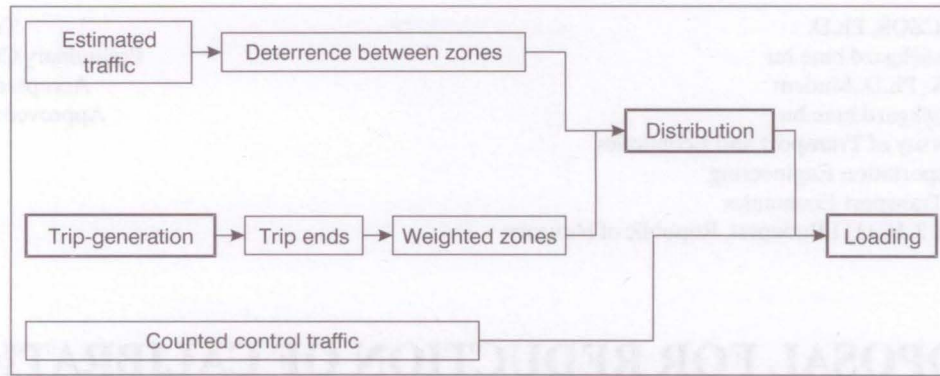


Figure 1 - The role of trip distribution in the traditional transportation model

2. TRIP DISTRIBUTION

Trip distribution is one of the important stages in transportation planning model, by which decision-makers can estimate the number of trips among zones. As basis, the gravity model is commonly used [1].

Several gravity-type models have been developed for the prediction of the trip demand distribution using information based on the prevailing traffic conditions, as reflected by traffic counts at selected links of the network ([10], [11]) and/or the output of a transportation planning model fed by survey-based demand estimates ([12], [13]) [8].

Figure 1 shows the position of trip distribution in the transport modelling process. We can observe two different methodical steps in the Figure which are required to distribute the occurred travel demands. The result of the trip generation process let us define the different weights of the separated urban zones, which make it possible to distribute the travel demands on the infrastructural elements of the examined urban area.

Figure 2 shows the required steps to the O-D matrix according to the traditional transport modelling. This Figure will make it possible to compare the traditional model to the developed demand assignment model.

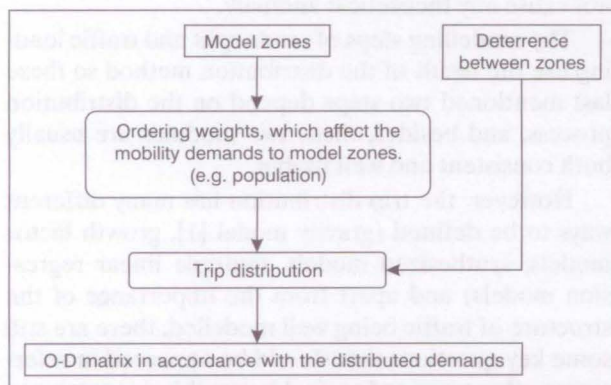


Figure 2 - Defining the O-D matrix based on traditional trip distribution process

3. LOGISTIC APPROACH

The object of the trip distribution method is to define the ratio of the traffic flows among the links of the network. However, it would be more specific, if we could define the exact location of the demands and the supplies of the movements (all the generation points and the attraction points of the traffic structure) and we could link them. In this case we would solve the modelling problem with an assignment process (linking directly the generation and attraction points) instead of the distribution process (estimation of the ratio of traffic-flows among each other). In this way of modelling the traffic links have direction, so this results in an ordered graph.

Ordered graph can also be applied by modelling goods traffic. We can define input and output values for a model zone based on the properties of the specific production activities (regeneration requirements, production capacity) located in the given model zone. Then the lorry traffic can be defined based on the input and output volume of goods flows relating to a given model zone (goods-mass divided by goods-mass per vehicle).

Figure 3 shows the way in which maximum links can be defined between model zones.

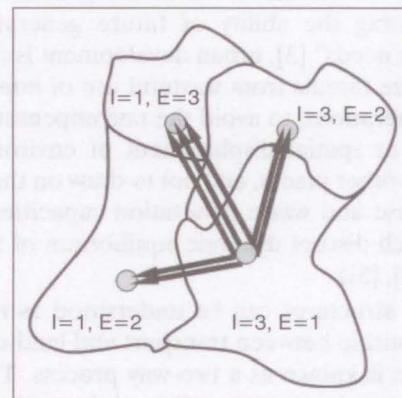


Figure 3 - Maximum number of demand-pair assignment between zones (e.g. employees and employments)

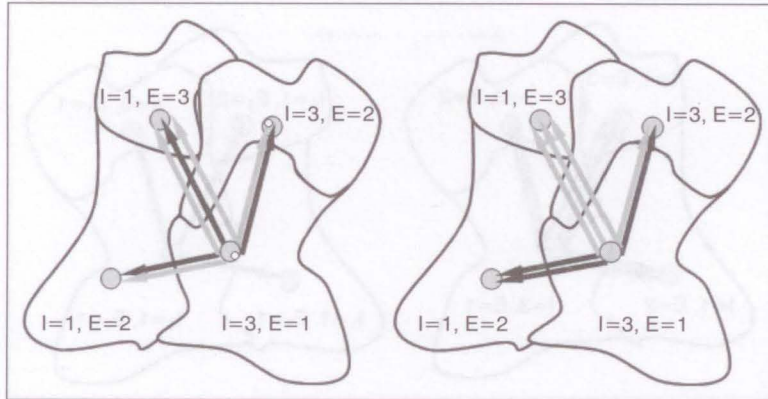


Figure 4 - Variations of possible demand-pair assignment (employees-employments) structures

The direction of the links results from the location of the interconnected generation and attraction points. The maximum number of links between two interconnected zones can be defined based on the number of generation and attraction functions in the interconnected zones (e. g. there can be defined maximum two links in one direction between a zone with three inhabitants [I=3] and a zone with two employments [E=2], see Figure 3).

Contrary to the above mentioned case, the number of realised links between two interconnected zones is smaller than the maximum number, because the already linked demand-pairs shall be subtracted from the number of the connectable demands (e. g. there can be a defined maximum of two links [L=2] in one direction between a zone with three inhabitants [I=3] and a zone with two employments [E=2], there can be a defined maximum of three links [L=3] in one direction between the given zone with three inhabitants [I=3] and a zone with three employments [E=3], which is a total of five links [L=5], although the total number of trips set out of the given zone can result only in three links in one direction [I=3 > L=3], see Figure 4).

Figure 4 clearly shows that there can be many variations of the demand-assignment process. Hence the objective of further investigation is to narrow the sets

of the linkable generation and attraction points (e. g. interconnecting the demands for employing a worker and being employed).

4. NARROWING THE SETS OF LINKABLE TRAFFIC GENERATOR LOCATIONS

We can significantly narrow the sets of solutions of the assignment process by considering different social aspects. Our aim is to divide the examined basic set into subgroups which are applicable from the generation and the attraction point of view as well. Hence, we need such a social classification, which can be applied by both kinds of demand type (generation-attraction: e. g. employee - employment, inhabitant - recreation, etc.). Consequently, we can classify the examined basic set by the rate of wages, gender or for instance, the age. In that way we can enhance the reliability of the trip distribution process as far as possible depending on the subtlety of the available database (e. g. I_1 - inhabitant with high school qualification, I_2 - inhabitant with a degree, E_1 - employee with high school qualification, E_2 - employee with a degree, see Figure 5).

Figure 6 shows the decrease of the set of solutions with the classification of the generation and attraction

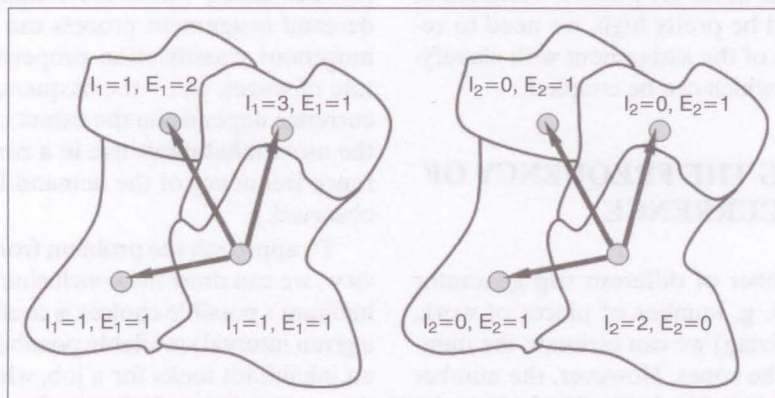


Figure 5 - Classification of the basic set of the demand-pair assignment process

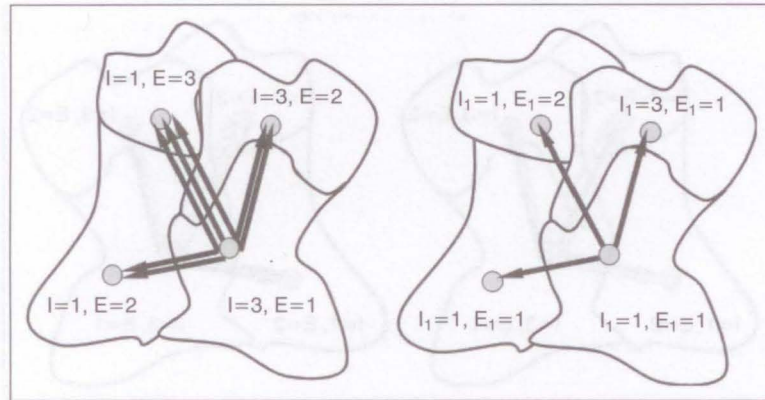


Figure 6 - Narrowing the sets of assignable demand-pairs

sets (e. g. the examination of female employees and inhabitants). Thus, according to the Figure, it can be seen that in the right bottom zone there is one place of work and three inhabitants. Thus, it is to be expected that there will be four trips between the examined zone and other zones in accordance with this simple motivation-chain. Although we are not able to define yet the locations of the workplaces of our three inhabitants or the location of the outside inhabitant, who will be employed in this zone, the Figure presents the maximum number of the possible demand-pair assignments between the zones.

Since this model is based on category classification, it is reasonable to compare our model with the US cross-classification method. The most conspicuous difference between the two models is the role they played in the modelling process.

The cross-classification method is used during the trip generation, where the aim of the classification is to measure the change in one variable (trips) and taking into account the changes in other land-use-socio-economic variables. Cross-classification stratifies "in" independent variables into two or more appropriate groups, creating an n-dimension matrix [15].

On the other hand, the aim of the demand assignment is to couple demand and supply pairs in reference to the generated trips. Thus, it must be taken over by trip generation. Since the possible variation of trip assignment would be pretty high, we need to reduce the possible sets of the assignment with classifying the demand pairs which can be coupled.

5. CONSIDERING THE FREQUENCY OF DEMAND OCCURRENCE

Based on the number of different trip generator types of the zones (e. g. number of places of work, number of places of living) we can estimate the number of trips between the zones. However, the number of the variations of the linkable demand-pairs are relatively high, and there are several methodologies to

narrow the set of solutions. Beside the classification of the linkable demand-pairs, we should consider the frequency of different travel demand effecting decisions (e. g. choice of work, habitation, etc.).

The short-term routing choices of the travellers, the medium-term choices made by the inhabitants referring to the place of living or work and the long-term choices made by the firms referring to their production places have serious effect on the structure of urban traffic. The frequency of the demand occurrence (e. g. an inhabitant looking for a workplace or a firm looking for an employee) affects the structure of the demand-pair assignment.

The traditional four-step transportation models do not investigate the effects of the temporal properties of the demand occurrence or the demand-pair assignment (e. g. frequency); however, in practice, the time for supplying a demand is limited. A system component does not wait for the possibility, which mostly meets its requirements, (usually the qualitative properties of a workplace are fixed - e. g. the rate of wages, the required qualification; but the acceptable distance or the travel time between the linkable demand-pairs changes according to the fixed properties of the actual available possibilities). Hence, in the zones with higher demand occurrence frequency, more demands per time unit arise and are satisfied (in such cases, where the examined basic set of the demand assignment process can be described by homogenous classification properties - e. g. the same rate of wages, etc. - the frequency of the demand occurrence depends on the extent of the basic set - e. g. the more inhabitants live in a zone, the higher occurrence frequency of the demand for workplace can be observed.).

To approach the problem from a practical point of view, we can draw the conclusion that the set of an inhabitant's possible choices is confined to the actual (in a given interval) available possibilities. For instance, if an inhabitant looks for a job, which can be described by an exact interval of rate of wages and qualification requirements, a time interval can be defined, until the

inhabitant would like to satisfy the occurred demand for the job. If the examined inhabitants find a job, which meets their requirements except for the distance from the inhabitant's home, the inhabitants will not increase the interval (hence, this phase of the trip distribution based on the occurrence frequency). Therefore, the demand satisfaction processes of the urban system components needed to be done over a given time interval; otherwise the demand-pair assignment is limited in time.

The demands (looking for a demand-pair, e. g. inhabitants looking for workplace) which arise in the same time interval need to be coupled by considering the distance between the zones (hence this phase of the trip distribution based on the distance between the zones).

Since the model explicitly considers the opportunity availability into certain zones, it is reasonable to compare it to the model of the intervening opportunities method even if we need to take into account that intervening opportunity models are used to describe migration processes.

The most significant deviation between the two methods beside the modelled process (urban mobility, migration) is that the technique of intervening opportunities measures the probability of migration across a country boarder geared to the number of the intervening attraction points (depending on spatial density) [16], while according to our demand assignment model the target of the work motivated urban travels firstly depends on the frequency of demand occurrence and secondly on the spatial density.

Figure 7 shows the process of the developed demand assignment model. Based on the Figure it is possible to form the algorithm of the assignment of the demand-pairs. Besides, we can describe the importance of the occurrence-frequency in defining the linkable demand-pairs in the given time period.

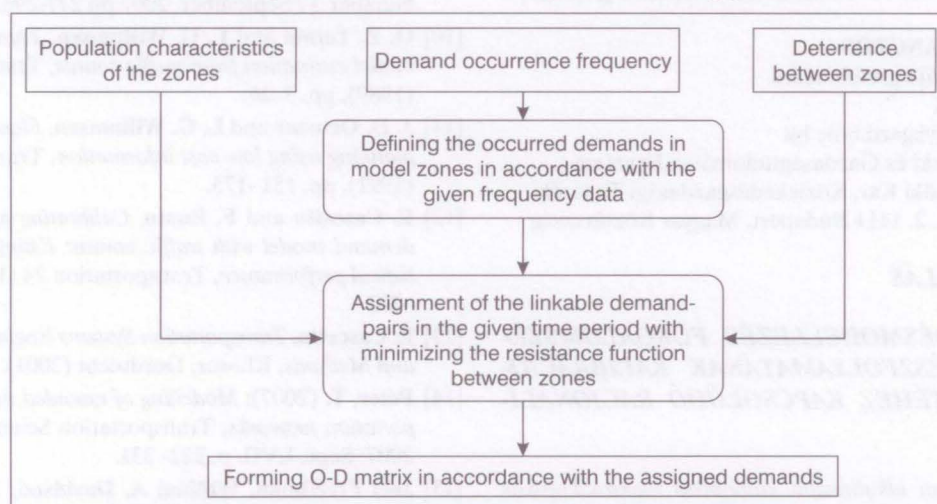


Figure 7 - Defining the O-D matrix in accordance with trip assignment process based on demand occurrence frequency

6. COMPARISON OF THE CLASSICAL TRIP DISTRIBUTION AND THE DEMAND ASSIGNMENT METHODS

Comparing Figures 2 and 7, we can understand the essential difference between the two methods.

The traditional four-step method (Figure 2) is based on the spatial structure of the modelled urban area (trip distribution depends on the distances and weights of the zones).

On the other hand, the basic data of the demand assignment method (Figure 7) is the frequency (density in time) of the demand occurrence complemented with the population characteristic of zones. So, the model assignment method defines the trip structure of the urban area based on the demands occurring in the same time period (depending on demand occurrence frequency).

We can assume that frequency and other statistical data (population characteristics) can be exactly measured, while the zone weights applied in the traditional modelling need to be implemented in a generation function, whose parameters must be calibrated. It can be seen that the application of the demand assignment model can reduce the calibration method.

7. CONCLUSION

The basic comparison of the traditional distribution method and the demand-pair assignment method results in the following:

1. The traditional distribution process can describe the modelled urban system unambiguously; on the contrary, the demand assignment process can produce a high number of variations of the demand-pair connecting process.

2. Although the generated traffic depends on other important factors, which are not covered by the traditional modelling, a complex calibrating process is inevitable. The limited temporal property of the traffic-flow influential mid- and long-term decisions or the social classification of the basic set of the occurred demands is just outside the mentioned traditional considerations.
3. The high number of variations of the demand-pair assignment process solution can be significantly reduced by the classification method and the consideration of the demand occurrence frequency and hereby the ratio of the calibration can be reduced as well.

Apart from the above mentioned properties of the demand-pair assignment method, it needs to be taken into consideration that the motivation chains usually include more than two components. The presented methods (classification, consideration of occurrence frequency) can be applied by the extended motivation chains as well (e. g. home – work – shopping - home), but there are other kinds of traffic generator functions, which require other kinds of approaches [14] (e. g. study-motivated location choices are less affected by the frequency – because in most cases the frequency is the same – grade school, high school, university can be chosen once in a year).

Further research will focus on the possibilities of the practical application. Szeged – a south-eastern Hungarian city will be the object of our next review. On the basis of the database of COWI Hungary Consulting and Planning Ltd. we could compare the results of different transport modelling methods. However, beyond the nowadays applied planning methods the experiences of BUTE Department of Transportation Economics in the area of sustainable urban development (Urbanet, Imprint-Net, GRACE, HEATCO) let us continue the research of the evaluating models.

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ÖSSZEFOGLALÁS

A KÖZLEKEDÉSMODELLEZÉS FORGALOMSZÉ- TOSZTÁSI RÉSZFOLYAMATÁNAK KALIBRÁCIÓ- SZÜKSÉGLETÉHEZ KAPCSOLÓDÓ RACIONALI- ZÁCIÓ

A napjainkban alkalmazott különböző makroszkopikus közlekedés modellező eljárások, vagy egyes meghatározó modell komponenseik visszavezethetők a hagyományos négy lépéses közlekedési modellre [1]. Az alábbiakban ismertetett kuta-

tás során a forgalom szétosztással (a négy lépéses modell 2. lépése) kapcsolatos kérdésekre, kalibrációs problémákra koncentráltunk.

KULCS SZAVAK

Városi közlekedés, városmodellezés, forgalom szétosztás,

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