Modelling of passenger transport with respect to time valuation

Overview of PhD theses

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1. The precedents of research work

1.1. Actuality of research work

The tasks of passenger transport-system are: to determine the transport demands and its satisfaction on a level accepted by society, with other words: organise safe transport not only paying attention to human environment, but save resources, to reduce damaging environmental impact.

The transport system is complex, dynamic, open and stochastic. I stress the importance of dynamic among others, concerning theme of this dissertation, in which temporal character of transport emphatically is reflected. Transport needs area, energy, time and financial sources.

The growing of settlements or moving of people to the surrounding territories of the town enlarges the journey distance, which involves increase of journey time more often than not. As the dwelling places and the work places move away from another, so becomes the possession of a car more and more necessary, so grows dependence on the car, it is used by more and more people. So make the growing of populated area and the territorial separation of working force an influence on the development of transport. Decisions connected with change of place and selection of place influence each other, therefore had the „land-use transport feedback cycle” come into being.

The change of place has more or less disadvantageous conditions. It must be paid regard to the following negative fluencies in the course of planning and operating of sustainable transport with respect to surrounding:

- air pollution and noise emission,
- accident risk,
- traffic jam.

The traffic congestions cause time losses, make efficiency of transport worth, and there is a higher pollutant emission at the same time. Traffic congestions cause one of the most important external costs, which refer to the whole society. In 15 member-states of EU, Switzerland and Norway in 1995 were the calculated traffic jam costs of road traffic roughly 33,3 thousand million Euros, which is 0,5% of GDP of Europe. According to forecasts the whole costs of traffic jam will run into 80,2 thousand million Euros in 2010. Yearly costs of time losses are estimated 128 thousand million Euros, which is 1,9% of GDP.

The quantitative and qualitative demands of society develop; they become differentiated in course of the improvement. The development involves increasing spatial modal share. Length and frequency of place changing grow. Journey time also grows in case of constant speed. Therefore the time was named fourth dimension of the settlement. It was said with good reason. That’s exactly why one of the most important duties of transport policy is the improvement of reachableness, namely to make shorter inhabitants’ regularly with place changing spent time. Inhabitants consider time wanted to spend with journeys in dependence of their possibilities. Time
saving which is available for orders of inhabitants results that time for resting, culture, another kind of activity, perhaps for some type of work is growing. It means that reduction of transport time is a task similar to reduction of working time.

The value of journey time is not independent – from viewpoint of the traveller – of financial surroundings, of income conditions, of circumstances of spending the time, of activity of the person, of that fact whether he lives in a town or a village. On the other hand the length of possible time saving is also important. Its usability, its value depends on its quantity, which is a subjective category.

1.2. Review of literature

Working out of dissertation has been based by Turányi [40] with detailed description of passenger transport process. Kövesné [22, 23, 24] made possible the change of place in time and space with analysing her issues. She helped the detailed exploration of the rudiments of time with stochastic analysing of the city public transport flow.


Kerékgyártó and Stuber [18] did research on efficiency of transport time saving.

Falussy [13] explains the fundamental structural changes of time consumption in line with long-term passed off determining incidents in society and economy. He mentions changing, which related to change of place during his time balance researches. He establishes that the defined time in social including determinant full-time working hour’s decreases and the spare-time gradually increases.

Tánczos, Bokor [38] stated their researches about general and modal specific part of social cost of transport. Legeza [27] dealt with planning and evaluating of integrated transport systems, and she studied scientific researches referring to economy of transport.


Schäfer, Victor, Johnson [33, 34] established, that the daily time of passenger transport do not depend on area and year. Journey distance travelling by people increases in spite of constant travel time. It can only be quicker vehicle using. They studied distinguish number of journey pieces and length by different transport motivation. They studied detailed the spatial-temporal connections among transport demand, cost and time.

Walter [46, 47] explored the relationships between subjective perception and certain time elements of changing of place. He specified different factors
for every time elements, on the basis of his surveys. Transport planning methods can be specified with these factors.

Ackermann, Werner [1] studied improvement of vehicles connected with transport length by means of Berlin’s example. They analysed the connection between urbanization process and transport. Kriebernegg [26] made models the increasing transport demand in passenger transport, with especial regard to the view point of vehicle choosing.

Wee, Rieveld and Meuers [48, 49] queried the general opinion in technical literature, that the daily journey time is constant in spatial and temporal. They stated in their paper, that the longer journey length and the modernization of vehicles account for Dutch people’s daily journey time increasing.

Richardson [32] suggested two important domains concerning to: modelling of travel behaviour and travel demand evaluation domain. Results of his research show, that there is a group of passengers to whom don’t important question the financial expenditure reducible journey time. Recognising of being this group opens new services possibility. He lays down that the travel time reduction is one of the most important factor as a fact.

The author joined in research in TU Department of Transport Technology in 1988. He studied the traffic surrounding and journey time evaluation [6, 9, 20]. The next results were the public transport examine and function of demand and supply analysis [7, 19]. His research was the traffic study and the time of change of place reduction, too [8, 10, 11, 12, 21, 25].

1.3. The method and results of the research work

In my dissertation I analyse the system-characteristics of passenger-transport from point of view of the time. I made a model, which goes thoroughly into changing of place from the view point of the passenger. I set as an aim to appraise of place changing from the view point of the time. I shortly sketched resources which need to place changing, and I demonstrated for this unpleasant side-effects.

I detailed showed the well separable parts of passenger transport process, and problems connected with them. I analyzed and evaluated the time elements of public and individual transport with motor vehicle. Among others I described to calculate in principle the waiting time for a vehicle, I mentioned the characteristics determining the time of getting in/off a vehicle, respectively the length of time to spend with searching for a parking place.

There is a close connection between the measurements of settlement and the distance of place-changing. The adequate connection is guaranteed by the speed-ability of the used vehicles. The time spent with place-changing is organic part of people’s daily routine. International analysis describes the tiny growing of it, while examinations in our country don’t reflect it.

I determined the value of time during working hours and during the spare-time. A decisive part of place-changing occurs beyond working hours.
Every process in time has a value, which is determinable. The time of value during the spare-time can be calculated, when we know the income, which is at someone’s disposal, the number of inhabitants, and the length of spare-time. In dependence of personal income I found function, how the value of spare-time is changing.

1. Figure. Model of examine concerning to time value of passenger transport

I disaggregated the average value of spare-time with using of data of household statistics. I paid attention to 28 categories: seven income-groups, active-inactive households, households in town and village. I determined function how the sum given out for fares of public transport and automobiles is changing in dependence of income per capita in the households. Analysis of supply (fares of public transport and costs of individual transport) and the examining of demand connections with paying attention to the costs of the households both regard the length of an average journey. The common reference-basis makes possible comparing supply and demand, the point of
intersection of two multitudes of curves determine the way of transport, which one can yet afford, in the different income-categories.

The household data were published divided into regions in 2003, so I made also spatial calculations, with them I can prove data of the transport-development ideas of the regions. The developed program-package reflexes the tendencies waited for, so it can be used to evaluate the regions.

I compared the proportion of the costs spent for place-changing in Hungarian and foreign households. The two proportions are similar to each other.

To determine the price of extra fares for shorter place-changing time, which results a better service, I showed international and Hungarian experiences and results of assembling the data. (I collected them.) The value of spare-time is comparable with reduction of the time getting to. (journey time) This supposition is reflected by the result of the done opinion poll. The people asked about it would be ready to pay more then a sixth part of the journey-value of an average half-hour-long journey for a five minutes shortening of the time getting to.

I discussed about the complex examination of a number of characteristics with the help of examples of foreign analysis and I suggest making it in Hungary and evaluate it.

I analysed what an effect the modification of time place-changing on journey habits has, I described the model which examines the forms of behaviour-reactions.

To establish the analysis in Hungary I published the results of an examination in Germany, this research deals with subjective passenger’s judgment of elements of place-changing time. The results after similar examinations made in Hungary make possible the calibration of models used by the traffic planning in greater accordance to the real facts.

To analyse how the place-changing time really forms I made measuring. I created a method for measuring; I chose the appropriate measuring instrument. I made a great number of measuring in connection with going to work and during the place-changing between two important traffic centres. I determined the most convenient way in these two cases, respectively the using of the best vehicle from the view point of the time getting to.

I explained that shortening of the place-changing time in the urban passenger transport is in many spheres possible. It has naturally also environmental aims. To improve the transport-systems quality the place-changing time has an important role in all parts of goal-device system. I put the possibilities of transport-expectations’ moderation in order, development of walking and biking circumstances can help us to cover first of all short distances. The improvement of the quality of public transport offers an effective option on the congested public roads for people who travel in slow cars. The increasing application of integrated transport helps us to moderate the time getting to, if there are great or average spatial-temporal demands.
2. How to use the achievements?

The results of examination of passenger transport from the view point of time-value mean a basis for the development on many areas:

2.1. **On the area of transport-strategy**

- The costs for passenger transport of average people living in regions appropriate to the new forming government system are comparable with the costs of transport services. The analysis of comparison shows us not only the demand of changes in the region, but it helps us to make a basis for the developments in the all country.
- For the reduction of place-changing time are some people for some reasons ready to pay money. The proportion of this people and the offered money give a possibility to enlarge and develop the transport-services. The simple questionnaire made by me fits for realization of the proportion of paying people and the offered money.
- The problems of traffic-planning are often complicated; we can describe them with many parameters depending also from each other. Because of complication and largeness there are modern computer-models to solve this problem on the possibly highest level. Using of software needs the subjective decision-mechanism of people using transport service. My suggestion making the international examination in Hungary showed by me makes a basis for a more detailed and precise cognition.

2.2. **On the area of teaching, professional training**

- Determining, describing the elements of place-changing, showing of factors making an influence on them help to have an appropriate system-view in the teaching, make a good basis for another examinations and for analyzing of interactions of time-factors.
- One of the most important qualitative parameter of the place-changing is the time spent with it. It is essential to know it to make developments and modifications with an effective method. Without choosing the appropriate measuring-appliance is not possible to make well the assessment of transport. As a result of my examinations I can state that the most convenient measuring-appliance for walking, biking and travelling by car is a measuring-appliance with GPS system, for using city public transport is the most suitable instrument the hand computer.

2.3. **On the further research sphere**

- Following the daily time-balance continuously with attention bring change of place period changing to one’s notice. The full knowledge of the changing establishes the reasons seeking, then necessity of intervention.
Analysing of changing of place demand and supply sides make passenger transport expenses and costs of services of people – living among given income relation – comparing possible. Certain mode of change of place relative increase, or decrease can determine with method developing by me.

For the change of space spending proportion in budget of household stresses importance of this. Changing of proportion shows in the change of space habit resulting changes, and shows increasing or decreasing of the costs, which spend for passenger transport.

3. The further development of research

I find fit to continue this examinations about research of time (since 1985), because it can bare the changing of income relations of inhabitants, and development of usage of transport services by passengers. Giving more characterisations (infrastructural and passenger transport data) about the regions helps to explore differences more detailed among the regions’ transport services, and it can result the better distribution of sources according to necessity. I stress among suggested in my dissertation examinations, searches the importance of adaptation to Hungarian conditions of place changing time-elements evaluated subjectively by passengers.

4. New scientific achievements and theses

I summarize as follows the new scientific achievements worked out in my dissertation in four theses:

1/a I created a model of the passenger transport from the time-value’s point of view, and I performed examinations about system characteristic of passenger transport from point of view of the time.

Efficiency of transport restraining congestion, the change of place distances increasing and the other factors sustain the importance of time-factor, which is the determinant part of passenger transport. In the course of examination of time-factor I specified the different parts of journey time, determinant elements of extent of time. I enabled theirs examination to be resumed, and I established theirs further study, possible domain of theirs reduction.

1/b I developed the specifying method of time-value in passenger transport for examination of global place changing time. I created a disaggregated indicating system which helps spatial-temporal comparison. I determined the average time-value of working time and spare-time. I created differential factors considering income cluster from the average spare-time value.
I exhausted available domestic statistical data and transport parameters to this. The developing model formed by me differentiate treats the spare-time value according to income cluster, kind of settlement and activity of household. This method doesn’t require another traffic count, therefore it is cost economical.

I determined the function changing between personal income and spare-time value:

\[
\begin{align*}
\text{in 1995:} & \quad y = 47,183 \cdot e^{0.1469 \cdot x}, & r^2 = 0.9538, \\
\text{in 2003:} & \quad y = 133,7 \cdot e^{0.1568 \cdot x}, & r^2 = 0.9497,
\end{align*}
\]

where \( x = 1 \) (1. decilis) … \( x = 10 \) (1. decilis) (-),
- \( y \): spare-time value (Ft/h/capita),
- \( r \): correlation coefficient.

2/a I developed the differentiated factor system which is proportional to spare-time value of transports’ costs, considering income-condition of households. This is the demand factor.

I determined the function changing between household income per capita and transport expenditure:

\[
\begin{align*}
\text{in 1995} & \quad y = 716,4 \cdot x^2 - 4305,8 \cdot x + 15374 & r^2 = 0.9179, \\
\text{in 2003} & \quad y = 10302 \cdot e^{0.0026 \cdot x} & r^2 = 0.9816,
\end{align*}
\]

where \( x = 1 \) (1. decilis) … \( x = 10 \) (10. decilis) (-),
- \( y \): transport expenditure per capita by the year (Ft/year/capita),
- \( r \): correlation coefficient.

2/b I determined the differentiated supply factor system proportional to spare-time value on the basis of fares and costs of a car.

In connection with it I determined the function changing between the inter-urban average journey distance and time:

\[
y = 0,0272 \cdot x^2 - 0,1887 \cdot x + 29,835, \quad r^2 = 0.8885,
\]

respectively the local average journey distance and time changing:

\[
y = 0,0007 \cdot x^2 - 0,0226 \cdot x + 4,115, \quad r^2 = 0.8861.
\]

where \( x = 1 \) (1985.) … \( x = 20 \) (2004.) (-),
- \( y \): average journey distance (km),
- \( r \): correlation coefficient.

2/c I realised the graphic analyse of demand and supply’s balance with above mentioned disaggregated factors plotting in one diagram.

It can be seen on this diagram, that people can pay in which income-category which passenger transport service. In 2. figure there is a sample for some possible questions and answers.
2. Figure. Active households’ demand-supply diagram concerning inter-urban journeys

3. I determined the spare-time value of certain regions according to Hungary’s new administrative regional arrangement (3. Figure), as well as the demand and the supply factors.

I determined the function between average spare-time value of people living in region and average motorization of region.

\[ y = 0.0039x^2 - 1.2304x + 384.48 \quad r^2 = 0.9317, \]

where \( x \): average motorisation (car/1000 inhabitants),
\( y \): average spare-time value (Ft/h/capita),
\( r \): correlation coefficient.

I developed the spatial dividing of the demand and the supply side index-system, the demand and the supply factors by region, which make these from view point of transport new comparison. (4. Figure) This new assessment helps development of transport of region.

3. Figure. Free time value of regions in 2003

4. Figure. Demand and supply data of inter-town passenger transport in average households in 2003
To verify the model made by me I worked out a method with a strategy of measuring and examining the largeness of traffic. This method can be used to fix the time elements with taking account to using conditions of electronic instruments. (This is the side of the operator.) In addition I worked out another method which can be used to find out how passengers are satisfied. I determined the place-changing time’s reduction able spheres in spatial and temporal in urban traffic. (The place-changing time is ineffective time!).

I controlled the model and I founded that using of a hand computer is most suitable for journeys with public transport in urban-traffic; it is the less trouble-sensitive data collecting instrument, if we want to measure the time getting to. To make measurements on cars and bikes is the most suitable instrument the GPS, because the measurements can be done so that the person making the measurements doesn’t take part in the process during the measurement, and it can be continually guaranteed that the acquired number of satellites can be seen.

To control the passenger-side’s model I made a measurement about passenger traffic. I gave a questionnaire out and determined the sum offered by passengers for reduction of place-changing time. The result is an average amount and it is near equal to the value of leisure time determined statistically. The value determined with help of the passenger-traffic questionnaire verifies the results deduced from statistical data. The passengers’ opinion helps to reach a differentiated service-level of appropriate quality; respectively it gives information, how to make a fares-system.

To approve the quality of the traffic-system we need a goal-device system. In frame of this system I marked the most important spheres of place-changing. (5. Figure) I determined in details the measures we should take to reduction the time getting to in the spheres of walking (short distance place-changing) and biking. I propose to make these measures to reduction the time getting to. Preferring public transport, if it is the main strategy of transport’s development, helps to reduction the place-changing time. Beside the systems already used in the praxis: bus lane, protected lane spherical calotte etc., I suggest making a bus lane, which works in a one-way street opposite the other side, and left-turning possibility only for public transport vehicles.

I suggested also take following points of view in account: not only establish P+R parking places on the right spots while realizing integrated transport, but impose parking prizes, find convenient places for stops in the city, guard the vehicles on the parking places, give possibility for buying near the parking places.
Quality of life

Environment quality insurance

Job division in city transport

Economy insurance

Preferring walking and biking in case of the short run place changing

Preferring public transport in case of great spatial-temporal need

Individual and public transport in competition situation in case of average spatial-temporal need

Preferring individual transport in case of average spatial-temporal need

Walking and biking quality improving

Public transport quality improving

Individual vehicle transport restriction

Individual transport quality improving

Transport demands moderation

5. Figure Goal-device system of urban transport system quality

(the references refer to the appropriate chapter of the dissertation)
5. The technical literature concerning to author’s dissertation (numbering the dissertation accordingly)

Passage in a book:


Article in foreign language:


Articles in learned journal:

6. Debreczeni G.- Kövesné Gilicze É.- Füzy F.- Kocsis Z.:
Városi forgalmi körülmények értékelése számítógépi modell segítségével

7. Debreczeni G.- Kövesné Gilicze É.- Füzy F.:
Időtényező alapuló keresleti és kínálati függvények a városi közlekedésben

10. Debreczeni G.: Forgalomcsillapítás és globalizáció

11. Debreczeni G.: Forgalomtechnikai mérések kisszámítógéppel

20. Kövesné Gilicze É. - Debreczeni G. - Füzy F.:

Költségkimelő számítógépes utasforgalmi adatfelvételek

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