

EVALUATION OF THE EFFECTS OF THE TIME FACTOR IN PASSENGER TRAFFIC

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Received October 1. 1988.

Abstract

Demands on passenger transport is also influenced by time factors. The usability of time must be taken into consideration when evaluating the time factor in passenger transport.

The value of the time during working hours can be approximated on the basis of the national income and the number of those who produce it. To determine the value of time saved during free time the national income and the number of consumers can be used.

This paper calculates the average value of the working hours and free time. This article determines the transport supply functions by transport means and branches according to income, activity and settlement categories and the traffic demand function for 28 categories as the quotient of spare time and travelling time.

A model for the computer analysis of the effects of the time factors is created.

The demands on passenger traffic are influenced by several factors;

- population: number, composition, area dispersion, density, demographic characteristics, employment and the distribution of employment according to the branches of the national economy;
- economic development: national income, standard of living, living conditions, pattern of working hours, degree of motorization and level of fares;
- situation of labour division in different sectors: settlement conditions, settlement networks, patterns of land utilization and settlement policy;
- lay-out conditions: shape of land-use zones, configuration of the terrain and the size of the areas;
- development of transport: technical level, traffic situation and economic basis;
- weather conditions, seasonal effects;
- effect of tourism and through traffic;
- development of systems decreasing the demands on passenger traffic, development of goods delivery and telecommunication.

The influencing factors listed determine the number of journeys, their average distance and the journey-time.

The time for one inhabitant of a certain area spent in travelling is directly proportional to the specific transport demand, the average travelling distance and is inversely proportional to speed. The time spent in travelling is evaluated differently according to our income, employment activity, age, settle-

ment conditions, transport possibilities, motivation of our journey and the distance, etc.

The usability of time must be taken into consideration when evaluating the time factor in passenger transport. From this viewpoint two periods can be differentiated. The time again originating from favourable transport facilities during working hours can be used to increase the national income while time saving during free time appears only indirectly in the increase of the national income, it first of all serves relaxation, entertainment and reproduction of the labour force.

The value of time during working hours can be approximated on the basis of the national income and the number of those who produce it, that is:

$$\hat{E}_{tm} = \frac{J}{L_f \cdot T_m}$$

where

- \hat{E}_{tm} : value of time during working hours
- J : the produced national income at current prices
- L_f : number of employees
- T_m : the annual work time basis

To determine the value of the time saved during free time, the national income and the number of consumers are to be used as starting points. During free time the entire population uses the consumption basis of the national income. Consumption basis is used not only during free time but its decisive part belongs to this period.

The value of time saved during free time can be determined by the following function:

$$\hat{E}_{tsz} = \frac{F_j}{L \cdot T - (T_m + T_a)}$$

where

- \hat{E}_{tsz} : value of time during free time
- F_j : consumption basis of national income at current prices
- L : number of inhabitants
- T : annual time basis
- T_m : annual working time basis
- T_a : average annual period of sleeping.

The calculations in the test are based on 1985 figures. This is the most recent year with the necessary statistical figures. The calculations can naturally be repeated in an identical structure utilising the data of any year.

National income, however, is produced in the second economy too, and at an increasing rate at present. Therefore the daily surplus working hours are to

Table 1

Daily surplus working hour (hour/capita)	Annual working hour (hour/capita)	\bar{E}_{tm} (Ft/hour)
0	2.132	80.85
1	2.392	71.97
2	2.652	64.92
3	2.912	59.12
4	3.172	54.28
5	3.432	50.16
6	3.692	46.63

Table 2

Daily surplus working hour (hour/capita)	Annual working hour (hour/capita)	\bar{E}_{tsz} (Ft/hour)
0	3.708	16.12
1	3.448	18.41
2	3.188	19.92
3	2.928	21.69
4	2.688	23.80
5	2.408	26.37
6	2.148	29.56

be considered, too. The rate of the working hours and free time calculated in this way is shown in Tables 1. and 2.

Knowing the average values does neither ensure the evaluation of the time factor by social strata, nor the revelation of sociological relations. A survey enabling the continual repetition of the enquiries is necessary, and on this basis the relations between travelling costs and time factors for certain social strata can be traced. A traffic survey concentrating on a single purpose would indicate the effects of the time factor in one time cross-section better and more accurately but this is too expensive, involving significant manpower and time requirements and access to the result is possible only in the long run. The repetition of surveys is also expensive. The Statistical Office regularly takes samples in strata of an identical structure to determine the expenses of certain households. The personal expenses can be seen in the so-called household statistics publications in detail but is a small sample (12 000 households) according to:

Activity of the household (active, inactive),
type of settlement (town, village),
income (7 categories)

The motorization of households (number of cars, motorcycles per 100 households), expenses for transport distributed by local, and inter-town jour-

neys, public and individual transport are at our disposal as traffic characteristics in the above breakdown.

The journeys can be divided into local and inter-town ones, the inter-town journeys into ones in connection with work and for other reasons and according to means: public versus individual transport (the former according to subbranches). The results of Hungarian research, timetables and fares can be used for the characterization of the journeys (specific travelling demand, average travelling distance, speed, fare).

The household statistics published regularly by the Central Statistical Office (KSH) enables to determine the value of working hours and spare time in money per member of the household in 28 categories according to the national income or the consumption basis of the national income. This may be refined by consumption units and all the conclusions may be drawn on this basis too. The surveys of the population and the expenses of 12 000 households enable the analysis and determination of the travel expenditure in every category in addition to spare time value. On basis of the fare in the valid timetable, the annual travelling figures of the traffic statistics, the travelling possibility and the value of spare time can be compared in each category. In this way the so-called transport supply function can be determined by transport means and branches according to income, activity and settlement categories. Tables 3. and 4. show the relations for average households. Considering the traffic expenditure, traffic characteristics constituting the basis of traffic development plans, the traffic demand function in a dimension in accordance with the supply function may be plotted in 28 categories, in connection with travel motivation and period as the quotient of spare time and travelling time (Tables 5., 6., 7., 8., 9.). The changes in the demand function can be shown, too, as a function of the utilization of spare time and the changes of the expenses spent on one journey. The flow diagram demonstrating the computer analysis of the time factor is shown in Figure 1.

Table 3

*Quotient of inter-town travelling expenses and spare time in average households
daily 2 hour surplus work*

	Annual personal income per capita (Ft/year, capita)							on the average
	below 21600	21601—31200	31201—40800	40801—50400	50401—60000	60001—69600	above 69600	
Stopping train II. class	3.28	1.960	1.49	1.18	.98	.84	.59	1.15
Stopping train I. class	5.329	3.190	2.420	1.919	1.590	1.36	.97	1.86
Express train II. class	7.239	4.340	3.29	2.619	2.170	1.85	1.31	2.53
Express train I. class	9.399	5.630	4.27	3.400	2.82	2.410	1.710	3.29
Bus	5.070	3.039	2.31	1.830	1.52	1.3	.92	1.77
Car 1 person	13.449	8.060	6.119	4.860	4.030	3.440	2.440	4.699
Car 2 persons	6.73	4.030	3.059	2.430	2.00	1.72	1.22	2.349
Car 3 persons	4.48	2.690	2.039	1.62	1.34	1.15	.81	1.570
Car 4 persons	3.359	2.019	1.53	1.22	1.00	.86	.61	1.18

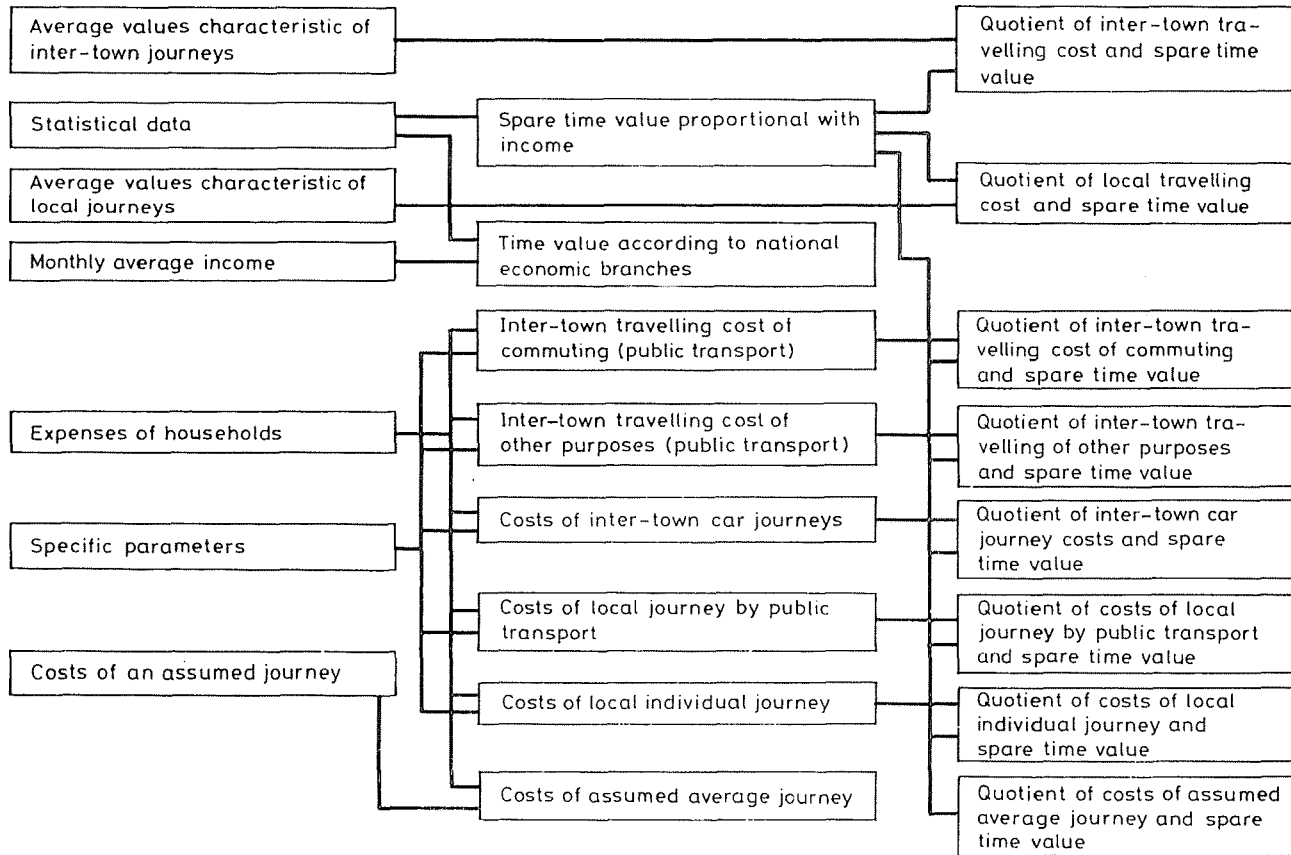


Fig. 1. Flow diagram to the computer analysis of the effects of the time factor

Table 4
Quotient of local travelling expenses and spare time in average households
 daily two hour surplus work

	Annual personal income per capita (Ft/year, capita)							on the average
	below 21600	21601—31200	31201—40800	40801—50400	50401—60000	60001—69600	above 69600	
Average fare of one journey: 2.00 Ft	.57	.34	.26	.21	.17	.15	.1	.2
Average fare of one journey: 2.25 Ft	.64	.38	.29	.23	.19	.16	.12	.22
Average fare of one journey: 2.50 Ft	.71	.43	.32	.26	.21	.18	.13	.25
Average fare of one journey: 2.75 Ft	.78	.47	.36	.28	.23	.2	.14	.27
Average fare of one journey: 3.00 Ft	.85	.51	.39	.31	.26	.22	.15	.3
Car 15 Ft/journey 1 person	15.979	9.569	7.27	5.77	4.780	4.090	2.900	5.58
Car 15 Ft/journey 2 persons	7.989	4.79	3.630	2.890	2.390	2.039	1.450	2.79
Car 15 Ft/journey 3 persons	5.329	3.190	2.420	1.919	1.590	1.36	.97	1.86
Car 20 Ft/journey 1 person	21.299	12.760	9.689	7.699	6.380	5.449	3.869	.449
Car 20 Ft/journey 2 persons	10.649	6.380	4.840	3.849	3.190	2.73	1.929	3.72
Car 20 Ft/journey 3 persons	7.099	4.25	3.23	2.57	2.130	1.820	1.29	2.48
Car 25 Ft/journey 1 person	26.629	15.960	12.109	9.619	7.969	6.81	4.83	9.310
Car 25 Ft/journey 2 persons	13.310	7.98	6.050	4.81	3.99	3.410	2.420	4.650
Car 25 Ft/journey 3 persons	8.880	5.320	4.039	3.210	2.660	2.27	1.61	3.099

Table 5
Quotient of average expenses of public transport (inter-town) to work, school and the corrected spare time
 daily two hour surplus work 86% reductions

	Annual personal income per capita (Ft/year, capita)							on the average
	below 21600	21601—31200	31201—40800	40801—50400	50401—60000	60001—69600	above 69600	
Average household	2.167	1.987	1.559	1.318	1.075	1.042	.674	1.247
Active household	2.55	2.313	1.788	1.571	1.342	1.292	.863	1.471
Inactive household	—	.069	.188	.198	.213	.247	.225	.193
Active urban household	.959	.575	.56	.545	.396	.568	.279	.464
Active village household	2.926	3.568	3.198	2.868	2.732	2.451	2.072	2.834
Inactive urban household	—	—	.156	.107	.021	—	.041	.063
Inactive village household	—	.11	.231	.298	.523	.58	.67	.354

Table 6

Quotient of average expenses of public transport (inter-town) for other purposes and the corrected spare time

daily two hour surplus work

	Annual personal income per capita (Ft/year, capita)							
	below 21600	21601— 31200	31201— 40800	40801— 50400	50401— 60000	60001— 69600	above 69600	on the average
Average household	3.206	2.385	2.115	2.155	1.845	1.726	2.509	2.107
Active household	2.868	2.48	2.160	2.141	1.721	1.609	2.342	2.079
Inactive household	5.110	1.837	1.852	2.221	2.254	2.099	2.905	2.239
Active urban household	2.969	2.066	1.919	2.145	1.711	1.638	2.809	2.117
Active village household	2.819	2.789	2.431	2.131	1.733	1.568	1.382	2.036
Inactive urban household	1.498	1.117	1.56	2.035	2.275	1.947	3.253	2.160
Inactive village household	7.532	2.277	2.198	2.450	2.227	2.313	2.072	2.342

Table 7

Quotient of the expenses of an average long distance journey by car and the corrected spare time

daily two hour surplus work

	Annual personal income per capita (Ft/year, capita)							
	below 21600	21601— 31200	31201— 40800	40801— 50400	50401— 60000	60001— 69600	above 69600	on the average
Average household	.953	.689	.946	1.266	1.373	1.644	2.189	1.338
Active household	.863	.584	.834	1.284	1.478	1.766	2.403	1.293
Inactive household	.738	.275	.273	.357	.752	.928	1.646	.657
Active urban household	1	.531	.782	1.112	1.227	1.554	2.144	1.192
Active village household	1.131	.782	1.01	1.736	2.104	2.271	2.895	1.595
Inactive urban household	.355	.363	.244	.335	.717	1.045	1.49	.676
Inactive village household	1.382	.244	.354	.428	.818	.728	1.851	.649

Table 8

Quotient of the expenses of an average local journey by public transport and the value of the correlated spare time

daily two hour surplus work

	Annual personal income per capita (Ft/year, capita)							
	below 21600	21601— 31200	31201— 40800	40801— 50400	50401— 60000	60001— 69600	above 69600	on the average
Average household	.045	.082	.105	.115	.12	.115	.103	.11
Active household	.036	.086	.109	.122	.132	.129	.115	.117
Inactive household	.099	.053	.081	.082	.081	.069	.077	.077
Active urban household	.088	.12	.124	.136	.137	.134	.112	.127
Active village household	.038	.056	.071	.067	.081	.06	.038	.064
Inactive urban household	.164	.087	.097.	.098	.090	.077	.073	.088
Inactive village household	.013	.018	.027	.018	.007	.028	.015	.019

Table 9

Quotient of the expenses of an average local journey by car and the value of the corrected spare time

daily two hour surplus work

	Annual personal income per capita (Ft/year, capita)							
	below 21600	21601— 31200	31201— 49800	49801— 50400	50401— 60000	60001— 69600	above 69600	on the average
Average household	.634	.458	.629	.841	.912	1.093	1.454	.889
Active household	.574	.388	.554	.853	.982	1.173	1.596	.859
Inactive household	.491	.182	.181	.237	.499	.617	1.094	.437
Active urban household	.637	.338	.498	.709	.782	.99	1.366	.759
Active village household	.687	.475	.613	1.054	1.277	1.379	1.758	.968
Inactive urban household	.226	.231	.156	.213	.457	.666	.95	.431
Inactive village household	.839	.148	.215	.26	.497	.442	1.124	.394

The time value of each journey and the surplus expenses to be spent on time saving for the same journey may be determined for both local and inter-town networks from the relations of the travelling time and costs of certain transport branches. The sum paid for a one minute profit significantly differs between local and inter-town transport (Tables 10., 11., 12.).

Our tests were based on the 1985 figures of the Central Statistical Office (household statistics, employment and transport statistics) and the timetables and fares of that time. On the basis of the statistical figures the number of cars per household for that year is shown in Table 13. The statements do not

Table 10

Cost difference by one member of an active household referring to one minute of time saving in an intertown journey in the case of joint travelling considering local delivery to and from

Travel ing distance (km)	Surplus cost (+) and cost saving (—) (Ft/minute, head)										
	car express train		car stopping train		car bus	express train stopping train		express train bus		stopping train bus	
	1. class	2. class	1. class	2. class		1. class	2. class	1. class	2. class	1. class	2. class
20	-0.02	-0.01	+0.03	+0.04	+0	+0.70	+0.66	+0.16	+0.07	-0.37	-0.53
40	+0.02	+0.06	+0.06	+0.09	+0.02	+0.16	+0.16	+0.02	-0.05	-0.27	-0.50
60	+0.02	+0.06	+0.09	+0.13	+0.04	+0.21	+0.21	+0.06	+0.01	-0.17	-0.30
80	+0.09	+0.17	+0.12	+0.17	+0.05	+0.18	+0.18	+0.01	-0.05	-0.18	-0.32
100	+0.14	+0.23	+0.15	+0.20	+0.06	+0.16	+0.17	-0.	-0.07	-0.18	-0.34
120	+0.14	+0.25	+0.17	+0.23	+0.07	+0.21	+0.21	+0.03	-0.04	-0.20	-0.36
140	+0.20	+0.36	+0.19	+0.26	+0.07	+0.18	+0.18	+0.01	-0.05	-0.18	-0.32
160	+0.29	+0.45	+0.22	+0.29	+0.08	+0.16	+0.16	-0.01	-0.07	-0.18	-0.35
180	+0.34	+0.53	+0.22	+0.30	+0.08	+0.14	+0.14	-0.01	-0.08	-0.18	-0.33
200	+0.42	+0.63	+0.24	+0.31	+0.09	+0.12	+0.12	-0.02	-0.09	-0.20	-0.35
220	+0.44	+0.66	+0.26	+0.34	+0.09	+0.16	+0.16	-0.02	-0.08	-0.23	-0.38
240	+0.55	+0.77	+0.29	+0.37	+0.09	+0.15	+0.15	-0.03	-0.10	-0.25	-0.38
260	+0.74	+1.00	+0.32	+0.40	+0.10	+0.14	+0.14	-0.05	-0.11	-0.26	-0.38
280	+0.86	+1.14	+0.33	+0.41	+0.10	+0.13	+0.13	-0.06	-0.12	-0.28	-0.40
300	+1.09	+1.41	+0.35	+0.43	+0.10	+0.12	+0.12	-0.07	-0.12	-0.28	-0.40
320	+1.16	+1.51	+0.36	+0.44	+0.10	+0.11	+0.11	-0.07	-0.12	-0.26	-0.38
340	+1.50	+1.89	+0.39	+0.47	+0.10	+0.10	+0.10	-0.08	-0.13	-0.28	-0.38

contain the change of the supply-demand functions due to changes in the national income and household incomes and that of the transport expenses within the total expenses. A differentiated consideration of the consumption units does not appear. We have referred to certain effect studies (increase of working hours, increase of expenses in transport) but in this phase of our research our aim is to establish a model for the evaluation of the time factor.

Table 11

Cost difference by one member of an inactive household referring to one minute of time saving in an intertown journey in the case of joint travelling considering local delivery and away

Travel- ing distance (km)	Surplus cost (+) and cost saving (-) (Ft/minute, head)										
	car		car		car	express		express train		stopping train	
	express	train	stopping	train	bus	stopping	train	bus	1. class	2. class	1. class
20	+0.16	+0.20	+0.27	+0.30	+0.20	+1.15	+1.15	+0.42	+0.21	-0.52	-0.83
40	+0.50	+0.59	+0.47	+0.54	+0.37	+0.38	+0.8	+0.08	-0.07	-0.49	-1.01
60	+0.71	+0.84	+0.64	+0.73	+0.45	+0.58	+0.58	+0.17	+0.01	-0.33	-0.73
80	+1.09	+1.26	+0.84	+0.94	+0.55	+0.43	+0.43	+0.07	-0.08	-0.32	-0.63
100	+1.42	+1.64	+0.97	+1.11	+0.63	+0.35	+0.35	+0.04	-0.12	-0.33	-0.70
120	+1.63	+1.89	+1.09	+1.23	+0.70	+0.48	+0.48	+0.10	-0.06	-0.36	-0.72
140	+2.21	+2.56	+1.23	+1.39	+0.39	+0.74	+0.40	+0.07	-0.09	-0.33	-0.67
160	+2.71	+3.03	+1.35	+1.52	+0.78	+0.37	+0.37	+0.03	-0.13	-0.35	-0.67
180	+3.01	+3.46	+1.40	+1.58	+0.80	+0.32	+0.32	+0.02	-0.14	-0.33	-0.67
200	+3.45	+3.93	+1.46	+1.64	+0.84	+0.29	+0.29	-0.01	-0.17	-0.38	-0.73
220	+3.74	+4.28	+1.57	+1.75	+0.87	+0.37	+0.37	0	-0.16	-0.44	-0.78
240	+4.23	+4.75	+1.71	+1.89	+0.89	+0.36	+0.36	-0.04	-0.18	-0.48	-0.79
260	+5.40	+6.01	+1.80	+1.98	+0.91	+0.33	+0.33	-0.07	-0.19	-0.51	-0.80
280	+5.96	+6.59	+1.85	+2.02	+0.92	+0.29	+0.29	-0.10	-0.22	-0.54	-0.82
300	+7.02	+7.72	+1.92	+2.10	+0.94	+0.27	+0.27	-0.12	-0.24	-0.56	-0.83
320	+7.48	+8.26	+2.00	+2.19	+0.95	+0.26	+0.26	-0.11	-0.24	-0.52	-0.79
340	+9.63	+10.58	+2.08	+2.27	+0.95	+0.25	+0.25	-0.14	-0.26	-0.56	-0.80

Table 12

The value of time saving in the choice of individual and public transport means in the case of average network characteristics (speed of individual means is 35 km/h, speed of public transport means is 20 km/h, time allowance is 20')

Travelling distance (km)	Journey by car (per head)	Fare of journey by public trans- port Ft/journey		Fare of indi- vidual journey Ft/journey (If 4.2 Ft/km by car)	Value of time saving Ft/minute, head a	Value of time saving (Ft/minute, head) b
		a	b			
3	1	2	3	12.6	0.44	0.4
	2	2	3	6.3	0.18	0.14
4	1	2	3	16.8	0.58	0.55
	2	2	3	8.4	0.25	0.21
5	1	2	3	21	0.72	0.68
	2	2	3	10.5	0.32	0.28
6	1	2	3	25.2	0.83	0.8
	2	2	3	12.6	0.38	0.35
7	1	2	3	29.4	0.94	0.91
	2	2	3	14.7	0.43	0.4

Table 13
Number of vehicles per 100 households

		Income by categories (Ft/year, capita)							
Type of household	Type of vehicle	below 21600	21601— 31200	31201— 40800	40801— 50400	50401— 60000	60001— 69600	above 69600	average
Active	car	18	24	33	43	49	57	62	44
Househ.	motor cycle	21	19	23	22	24	26	19	22
Inact.	car	8	2	3	6	14	17	22	8
Househ.	motor cycle	9	4	4	8	8	7	9	6
Active	car	29	29	39	47	50	57	66	49
Urban	motor cycle	35	13	17	15	17	16	11	15
Active	car	16	20	26	39	46	56	55	37
Village	motor cycle	18	24	30	32	35	42	37	31
Inact.	car	9	4	4	8	18	23	25	11
Urban	motor cycle	10	2	4	8	5	6	6	5
Inact.	car	7	2	3	3	9	8	13	4
Village	motor cycle	8	5	5	9	13	9	17	8

This research has been based on statistics that are continually at our disposal and without requiring further transport surveys and can be made suitable for transport purposes with the aid of a computer program.

The access to statistical data listed in the references ensures repeatability. The processing program of the model was made for an IBM XT. In a further phase of research it may be expedient to process further statistical data as also a dynamical handling of the time factor instead of the statistical view.

The time factor can be used as a decision parameter in comparison of transport development plans, to refine the traffic division modelling in the preparation of transport development plans and to evaluate the effect of different transport measures (fares, networks in space and time).

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