FORECASTING OF PASSENGER TRAFFIC FLOWS BETWEEN WEST AND EAST EUROPE

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Paper Presented to the 5th World Conference on Transport Research in Lyon, June 29 - July 3, 1992

INTRODUCTION

The breakdown of the Communist systems in the countries of Eastern Europe will induce dramatic changes of the economic structures and of the communication patterns. People in Europe can now move freely between East and West, a new dimension of mobility has emerged which has not been anticipated by the planners. Therefore the infrastructure on the East-West corridors is under-developed and has to be improved and extended as soon as possible..

To prepare a basis for planning and evaluation of the transport infrastructure a forecast of traffic flows is necessary. The institutes which were in charge of the German Ministry of Transport to forecast the passenger traffic flows in Germany including the effects of opening of the East-West borders, applied a systems approach which derives travel activities from the main influencing factors (Figure 1):

(1) Population and Economy (E)
(2) Technology and Infrastructure (T)
(3) Spatial Structure and Land Use (S)
(4) Public Policy, Government Intervention and Regulation (G).

In a consistent forecasting scenario all these factors have to be predicted. Their influence on the travel patterns has to be modelled on the base of field data such as questionings and observations. In the case of Germany a large data base on individual travel behavior is available in form of the "continuous questionings on people`s travel behaviour (KONTIV)". A second analytical base is the 1985 matrix of travel flows which has been constructed using data on ticket sales (railway, air travel), traffic counts and statistics on border crossing traffic.

By means of this data base a rich set of models can be calibrated which is appropriate for the forecasting of traffic flows. These models are sensitive with respect to the social, economic, technological and political environment such that they can be used for constructing scenarios. This includes "synthetic" scenarios for the development of traffic in East Germany and Eastern Europe. The "synthetic" approach seems to be the only feasible way of forecasting in these countries, because the structural changes in social life and the economic or political environment will be so dramatic that other ways of forecasting such as trend extrapolation methods must fail.

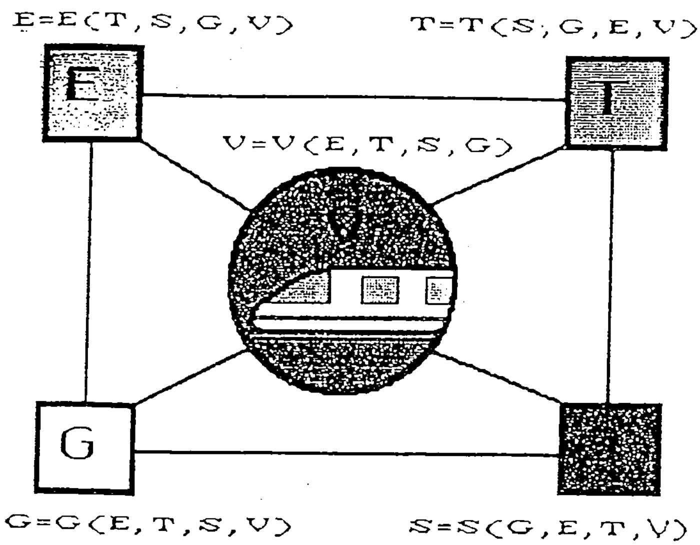

Figure 1: Influencing Factors for the Development of Travel Activities

In this paper an overview on the "synthetic" modelling approach is given. The methods applied for preparing the first German Transport Master Plan ("BVWP") after the unification are referred and possible extensions for the forecasting of East-West transport flows are discussed. Emphasis is laid upon the modal split approach which is used to forecast the role of public transport in the former COMECON-countries under a changed regime of public interventions and regulations. This results in the discussion whether the transition process in the former socialist countries will be a copy of the development of the transport sector in the countries of the Western world. It is shown that it will be very hard to avoid policy failures which have been made in the West with respect to the protection of the environment in the process of economic recovery after the second world war.

1. FORECASTING OF INFLUENCING FACTORS

According to the systems approach shown by Figure 1 it is necessary to forecast the development of the main influencing factors for the West and East European countries. In the case of the East European countries this turns out to be extremely difficult because the political changes have effected a total breakdown of the trade relationships of the COMECON, a considerable decline of the production level, and in the former USSR even a breakdown of the industrial and agricultural organisation. So it is hard to estimate how long the transition process will take. At present the chances of Hungary and Czechoslovakia, to a lower degree also Poland and Bulgaria, seem to be good to recover in the medium and lo catch up with Western threshold countries (e. g.: Spain) in the long run. The prospects for the countries of the former USSR, of Romania or the major part of Yugoslavia however look much worse.

The German case shows the unexpectedly high dimension of the economic problems: East Germany being the country with the highest production per capita of the Comecon countries presently contributes less than 6 % to the German GDP although more than 25 % of the German population is living there.

Because of these difficulties the prospects for the East European countries cannot be derived from sophisticated growth models rather than from a set of plausible hypotheses:

H1: The economic transition processes run at different speeds but are finally successful.

H2: The economies will converge to the structures of West European countries. It is possible to draw parallels between the future development of East and the historical development of West European countries.

H3: There is no major difference between the preferences of people of East and West European countries (exemption: the Asiatic part of the former USSR).

From these basic assumptions, the analysis of the present conditions and a set of detailled figures specifying the type of the transition process the states of the influencing factors for a year of the future (we chose the year 2010) can be derived.

2. FORECASTING CAR OWNERSHIP

In the past the development of car ownership was systematically underestimated in the industrialized countries of Western Europe. In the old West German Federal Master Plan (BVWP) of 1985 for instance the car stock for the year 2000 was estimated to reach 30.5 mill. cars. This forecast however is already reality since the end of 1991. The reasons for the modelling failure are

1) underestimating the "saturation level" for car ownership, and
2) underestimating the speed of demand adjustment.

For the new BVWP a revised model was applied which was calibrated for the parameters

- number and structure of households,
- net income of households, and
- number of driver`s licences.

As a result the number of cars for W. Germany was estimated to reach 34.5 Mill. in the year 2000 and 37.3 Mill. in the year 2010. For East Germany the figures are 6.6 Mill. (2000) and 8.2 Mill. (2010). More recently the IWW has developed an "epidemic" model which in addition to the above mentioned parameters also includes characteristics of the supply side, such as fuel prices, length of the road network and its quality. The heart of the model is a diffusion term which simulates a biological diffusion process:

$$\ln\left(\frac{\Delta S_t}{1 - S_{t-1}}\right) = a_0 + a_1 \ln(P_{t-i}) + a_2 \ln(YD_{t-j}) + a_3 (R_{t-k}) + \ln(q + (S_{t-1})^{\sigma}) + U_t \quad (2.1)$$

S : car stock
P : price

YD : disposable income
R : interest rate
q : proportion of customers who have not adapted at time t
t : time
i, j : time lags
a_k, σ : coefficients
U : stochastic term

First tests with the model support the hypothesis that the new BVWP-forecast is still an underestimation. The new model suggests a figure of at least 38.5 Mill. cars for W. Germany in the year 2010 if no restrictive policy is taken towards cars. This indicates that there will be no saturation of motorization in West Europe in the next two decades. For the countries of East Europe a dramatic growth of car ownership can be expected for those countries which recover fastly from the economic shock. So car stock might double in the CSFR and in Hungary within the next 20 years.

3. TRAFFIC GENERATION/DISTRIBUTION

Traffic generation is derived from a four dimensional matrix comprising the population segmented by

- age,
- sex,
- employment, and
- car ownership.

The key relationships are estimated on the base of field data ("KONTIV") from W. Germany.

The traffic distribution can be modeled by the relationships (see ITP/IVT, 1991):

(3.1) $F_{ij} = f(Q_i, O_j, d)$

(for every travel purpose)

(3.2) $O_j = g(k_{ij}, S_j, r_j)$

F_{ij} : trips from i to j
Q_i : originating trips in i
O_j : Opportunity index for j
k_{ij} : generalized costs for a trip from i to j
S_j : relevant socioeconomic variable for the travel purpose
d : reaction coefficient, related to travel purpose
r_j : index for the spatial characteristic of the region j.

The travel demand between origins i and destinations j is segmented by 15 sociodemographic clusters and 6 travel purposes. The balance between originating and destinating traffic is established by applying the FRATAR-method.

This combined gravitation/opportunity-model can be extended by BOX COX or BOX TUKEY-transformation which provide a better goodness of fit and help to reduce the distance bias (Wells, 1989).

4. MODAL SPLIT

For the BVWP a three stage model has been developed (ITP/IVT, 1991) which successively solves two-mode split problems:

(1) IC/ICE-train - other train travel
(2) train travel - car travel
(3) air travel - train + car travel

While the first and the third stage models are based on simple linear regressions for the parameters like travel time, cost, frequency of service and distance the second stage model is a linear logit approach of the type

$$(4.1) \qquad P_R = \frac{e^{U_R}}{e^{U_R} + e^{U_C}} * s$$

$$(4.2) \qquad P_C = 1 - P_R$$

$$(4.3) \qquad U_R = a_0 + a_1 x_1 + ... + a_n x_n$$

$$(4.4) \qquad U_C = b_0 + b_1 y_1 + ... + b_n y_n$$

P_R: probability to choose rail
P_C: probability to choose car
s: upper limit for rail share, dependent on travel purpose and group characteristic
x_i: supply characteristic of rail
y_i: supply characteristic of car.

The model is applied for each travel purpose and travel group. This way of modeling creates a base for policy sensitive analyses and is widely applied in Germany for investigating the demand impacts of new transport infrastructure investments (high speed rail, maglev trains). The model is very flexible and can easily be adjusted to new observations, just like the INRETS-model which is applied to estimate the demand impacts of the SNCF in France (Morelet, 1988). But the successive modeling is inconsistent from the theoretical point of view (excluding the feedback mechanisms in the customers decision making) and the linear approach doesn`t allow for a good representation of actual behaviour. Consequently the economic interpretation of the model is rather poor. Gaudry, Mandel and Rothengatter (1992) have developed a nonlinear approach by applying BOX-COX transformation and have estimated a number of variants on the base of the KONTIFERN field data which allow for disaggregate modeling. The basic characteristics of the new nonlinear model are:

(1) A change of the supply characteristics of a transport mode will only result in a major change of the modal split if the time or cost differences to the competitors change considerably (nonlinearity).
(2) 10 minutes time savings induce a greater change of the modal split on a 100 km distance than on a 1000 km distance (asymmetry).

(3) The marginal rates of substitution between the influencing factors of the modal split (time, costs) are different for every transport mode.

The model is presented in the paper of Gaudry, Mandel and Rothengatter in session JS01 of the WCTR.

5 RESULTS OF THE FORECASTS FOR THE FIRST GERMAN TRANSPORT MASTER PLAN

The first Transport Master Plan for the Unified Germany is based on a traffic forecast which considers every traffic activity which touches the German network. This means that

(1) East Germany is completely included with respect to domestic, originating, destinating and transit traffic, and

(2) Traffic between East and West Europe is included in terms of activities originating or destinating in West or East Germany and transit between East and West Europe

Germany in the heart of Europe and supplying best facilities for transit travel will be impacted by the major part of East-West travel such that the originating/destinating traffic related to East European countries and the transit traffic give a good figure of East-West traffic which Europe as a whole has to expect for the future. For the case of Germany three policy scenarios have been worked out alternatively:

(1) Scenario F: No major change of relative user costs. No government interventions. No capacity restraints in the network.

(2) Scenario G: Capacity restraints in the road network, reduction of average speed by 5 km/h. Parking restrictions and higher parking fees dependent on the spatial density. Doubling of car user costs by taxation and road pricing. Public interventions and higher costs for air transport.

(3) Scenario H: Reduction of average speed by 5 km/h. Parking restrictions and higher parking fees dependent on the spatial density. Increase of the costs of gasoline by 30 %.

The reasoning for working out three scenarios instead of one (in the past only "F-type" scenarios had been prepared) is the discusion about public interventions towards a reduction of environmental risk. The W. German government has decided to lower the CO_2-emissions by 25 % in the time range from 1987 to 2005 overall economic sectors. Although it is not clear until now whether the transport sector is expected to meet this requirement of - 25 % despite its most dynamic development and the East-West integration problems there is no doubt that at least a major improvement of the environmental situation compared with the trend development is required. Scenario H describes the environmental "minimum level" and has been defined as the reference scenario for the master plan.

The results of the forecasts are summarized in Tables 1 and 2.

	1988	2010 Scenario F	Index 1988 = 100	2010 Scenario G	Index 1988 = 100	2010 Scenario H	Index 1988 = 100
Germany total							
car	2.518,4	3.450,2	137	2.942,8	117	3.189,5	127
rail	353,3	249,6	71	405,5	115	326,1	92
air	48,6	103,6	213	89,3	184	111,5	229
sum	2.920,3	3.803,4	130	3.427,6	118	3.627,1	124
Domestic and originating Traffic West Germany (without Berlin)							
car	2.194,2	2.491,8	114	2.112,8	96	2.299,7	105
rail	124,8	176,3	141	288,8	231	232,8	187
air	24,6	41,9	170	36,2	147	46,7	190
sum	2.343,6	2.710,0	116	2.437,8	104	2.579,2	110
Domestic and originating Traffic East Germany							
car	191,6	733,1	383	622,4	325	673,3	351
rail	217,6	52,2	24	86,7	40	69,7	32
air	4,4	17,5	398	14,1	320	18,9	430
sum	413,6	802,8	194	723,1	175	761,8	184
Originating Traffic Rest of the World and Transit							
car	132,6	225,2	170	207,6	157	216,4	163
rail	10,9	21,1	194	30,0	275	23,6	217
air	19,7	44,2	224	38,9	197	46,0	234
sum	163,2	290,5	178	276,5	169	286,0	175

Table 1: Volume of Passenger Transport in the Year 2010 [Mill. Trips per Year]

Source: ITP/IVT, 1991

	1988	2010 Scenario F	Index 1988 = 100	2010 Scenario G	Index 1988 = 100	2010 Scenario H	Index 1988 = 100
Pass. Km traveled in Germany							
car	268,2	377,9	141	312,4	116	346,8	129
rail	44,4	58,6	132	90,2	203	69,4	156
air	13,7	33,0	241	28,2	206	35,2	257
sum	326,3	469,5	144	430,8	132	451,4	138
Pass. Km traveled in West Germany							
car	244,2	288,4	118	238,0	97	265,2	109
rail	27,5	47,4	172	71,9	261	55,2	200
air	13,1	23,8	182	20,6	157	25,6	196
sum	284,8	359,6	126	330,5	116	345,9	121
Pass. Km traveled in East Germany							
car	24,0	89,5	373	74,4	310	81,6	340
rail	16,9	11,2	66	18,3	108	14,2	84
air	0,6	9,2	1530	7,6	1266	9,6	1603
sum	41,5	109,9	265	100,3	242	105,4	254
Pass. Km traveled by Foreigners in Germany							
car	42,3	80,7	191	74,3	176	76,1	180
rail	5,4	16,1	300	22,5	417	18,9	352
air	44,2	185,4	420	183,2	415	186,3	422
sum	91,8	282,3	307	280,0	305	281,4	306

Table 2: Volume of Passenger Transport in the Year 2010 [Bill. Pass. Km per Year, excluding Km Traveled Abroad]

Source: ITP/IVT, 1991

From the Tables 1 and 2 can be derived that the total volume of passenger transport will rise from 1988 to 2010 by 30/18/24 % (Scenario F/G/H). The biggest percentual change is expected to occur in air traffic which grows by 113/84/129 % (Scenario F/G/H). Car travel will rise by 37/17/27 % while rail travel may decline (-29/+15/-8 %, Scenario F/G/H) because the high market share (more than 40 %) which the rail mode used to have in the former GDR will drop dramatically and converge to the West German value (about 6,5 % in scenario F).

For evaluating the future change of traffic loads on the road network it is necessary to estimate the car Km traveled. These will grow faster than the passenger Km in the F-scenario because it is highly probable that car occupancy rates will continue to fall under free market conditions. This trend can be stopped however by government interventions as it is assumed in scenarios G and H. Such the institutes forecast a growth of car Km traveled in Germany by 41/16/29 % (Scenario F/G/H).

Figure 1 exhibits the development of car km in the different scenarios. It should be noticed that this traffic growth affects the Eastern part of Germany much more than the Western part. East Germany is facing a growth of car Km by about 80 %.

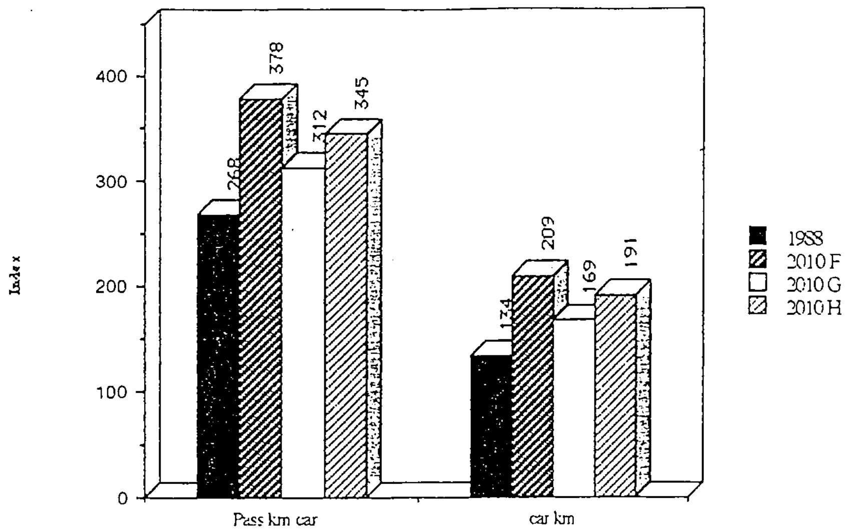

Figure 1: Development of Car Km traveled in Different Scenarios

Source: ITP/IVT, 1991

to / from		West Germany (without Berlin)	Index 1988 = 100	East Germany (with Berlin)	Index 1988 = 100	West Europe	Index 1988 = 100	East Europe	Index 1988 = 100	Rest of the World	Index 1988 = 100	Sum	Index 1988 = 100
W. Germany (without Berlin)	car	2.054,9	99	93,7	852	142,8	127	8,1	979	0,2	124	2.299,7	105
	rail	200,9	174	16,7	717	14,2	205	1,1	306	0,0	183	232,8	186
	air	6,8	133	6,3	302	20,4	182	3,0	441	10,2	184	46,7	190
	sum	2.262,5	103	116,8	757	177,3	136	12,1	656	10,4	182	2.579,2	110
E. Germany (with Berlin)	car	93,7	852	551,3	314	5,9	871	22,2	489	0,1	700	673,3	351
	rail	16,7	717	50,0	24	1,4	810	1,6	63	0,0	400	69,7	32
	air	6,3	302	0,1	4450	7,3	1032	2,3	164	2,9	1446	18,9	430
	sum	116,8	757	601,4	155	14,5	938	26,1	306	3,1	1381	761,8	184
West Europe	car	142,8	127	5,9	871	23,4	175	6,6	2756	0,1	94	178,8	141
	rail	14,2	205	1,4	810	1,8	239	1,8	3375	0,0	180	19,1	242
	air	20,4	182	7,3	1032	0,0	0	0,0	0	0,0	0	27,6	232
	sum	177,3	136	14,5	938	25,2	178	8,4	2866	0,2	96	225,5	154
East Europe	car	8,1	979	22,2	489	6,6	2756	0,2	11300	0,0	0	37,1	663
	rail	1,1	306	1,6	63	1,8	3375	0,0	1200	0,0	0	4,5	148
	air	3,0	441	2,3	164	0,0	0	0,0	0	0,0	0	5,3	256
	sum	12,1	656	26,1	306	8,4	2866	0,2	7933	0,0	0	46,9	439
Rest of the World	car	0,2	124	0,1	700	0,1	94	0,0	0	0,0	0	0,5	139
	rail	0,0	183	0,0	400	0,0	180	0,0	0	0,0	0	0,0	194
	air	10,2	184	2,9	1446	0,0	0	0,0	0	0,0	0	13,1	229
	sum	10,4	182	3,1	1381	0,2	96	0,0	0	0,0	0	13,6	223
Sum Total	car	2.299,7	105	673,3	351	178,8	141	37,1	663	0,5	139	3.189,5	127
	rail	232,8	186	69,7	32	19,1	242	4,5	148	0,0	194	326,1	92
	air	46,7	190	18,9	430	27,6	232	5,3	256	13,1	229	111,5	229
	sum	2.579,2	110	761,8	184	225,5	154	46,9	439	13,6	223	3.627,1	124

Table 3: Aggregate Matrix of Transport Flows 2010 in Germany; Scenario H

Source: ITP/IVT, 1991

While the total growth of traffic in Germany seems to be strong but not dramatic a closer look to the single segments shows that Germany is facing an explosion of East West transport due to the integration of the former GDR and the expected closer relationships between East and West Europe (see Table 3). As can be seen from the Table the traffic between East and West Germany is expected to grow by the factor 7,6. The transit between West and European countries crossing German borders will even increase by the factor 29. This underlines that a world of free foreign exchange and free mobility of people in Europe will be associated with a traffic explosion in the East-West direction.

6 CONCLUSION

Regarding the results of the first integrated German traffic forecasting an explosion of East-West traffic flows can be expected if the former COMECON-countries overcome the present economic crisis. Hungary, the CSFR and Poland have the best chances to catch up and reach the level of the "poorer" EC-countries within 10 - 15 years.

As to the model choice a clear tendency towards individual car travel is expected in Middle and East Europe. The model shares of the railways which nowadays are between 45 and 60 % will drop drastically under free market conditions. This also holds if the quality of the railway infrastructure will be improved. The only way to slow down the growth of individual car traffic is to impose restrictions by costs (road procing) or regulation. As the main concern of public transport policy in the nect future will consist in supporting the economic upturn and to stabilize private market forces there is littel chance for a rigorous environmental transport policy. Therefore the pattern of travel activities will converge to the patterns in West European countries with growing domestic products and disposable incomes. It is probable that transport policy will develop as a staged process in which the environmental components will gain importance in the later stages.

References

1 ITP/IVT, 1991: Personenverkehrsprognose 2010 für Deutschland. München and Heilbronn.

2 IWW, 1991: Strukturdatenprognose für die Bundesverkehrswegeplanung 1991. Karlsruhe.

3 Kessel + Partner and Rothengatter, Werner, 1990: Szenario zur Verkehrsentwicklung mit der DDR und mit Osteuropa. Freiburg and Karlsruhe.

4 Kessel + Partner, Verkehrsconsultants, 1991: Güterverkehrsprognose 2010 für Deutschland. Freiburg.

5 Kowalski, Jan and Rothengatter, Werner, 1991: Prospects on Passenger Transport. In: ECMT (ed.), Prospects for East-West European Transport . Paris.