MODELLING THE IMPACTS OF ROAD PRICING IN BUDAPEST

(by Janos MONIGL - Zsolt BERKI, TRANSMAN Consulting, Budapest)

Scope of the project

EUROPRICE (Energy efficiency of Urban ROad PRicing Investigation in Capitals of Europe) was an EU DGXVII project within the SAVE II programme. It's objectives were as follows:

1. To assess the fuel saving potential of urban road pricing schemes in several European capital cities.
2. To extend and refine the findings of previous SAVE projects and other relevant urban road pricing initiatives by EU member states and the European Commission.
3. To test road use charging equipment in several urban areas, in terms of user response (before and after a field trial), public acceptability, interoperability and energy efficiency implications.
4. To relate energy efficiency to integrated urban transport pricing and associated demand management measures.
5. To disseminate the findings to other capital cities, particularly in Central and Eastern Europe.

Within the framework of the EUROPRICE EU-project, finished in 1999, various charging experiments and modelling calculations have been executed in London, Dublin, Athens and Budapest.

In case of Budapest by applying the TRANSURS model system, with sufficient demand-models (trip generation, distribution and modal split model) and assigning methods, based on the data of the 1994 household survey, the analysis of various charging (access fee) scenarios have been carried out by TRANSMAN. The paper contains the main characteristics of Budapest transport, the scenarios investigated and the main findings.

Transport network structure

Budapest, the 2 million capital city of Hungary is located on both sides of the Danube River. On the right hand side there is the hilly Buda, with the castle district and on the left hand side the plane Pest lays with a concentration of work places and institutions in the city.

The road network on the Pest side shows a ring-radial shape, where besides the Big Ring, the Hungária Ring is the main connecting element and where the back bone of the dense public transport network is outlined by the three metro lines (see Figure 1).

Figure 1: Road transport network wit traffic load volumes

In the road network of Buda the western part of the Big Ring is the only connecting element for the different roads shaped by the moved topography and with more conventional public transport.

Inside the Big Ring there are five out of the seven Danube bridges which are inside the boundaries of Budapest (one more bridge of the M0 motorway is south from the town). This results in a high concentration of road traffic in the inner part of the city. On 2.1% of the area of Budapest concentrates 7.4% of the traffic, 12.0% of time consumption, 9.7% of fuel consumption and 6.4% of air pollution. (See Figure 2)

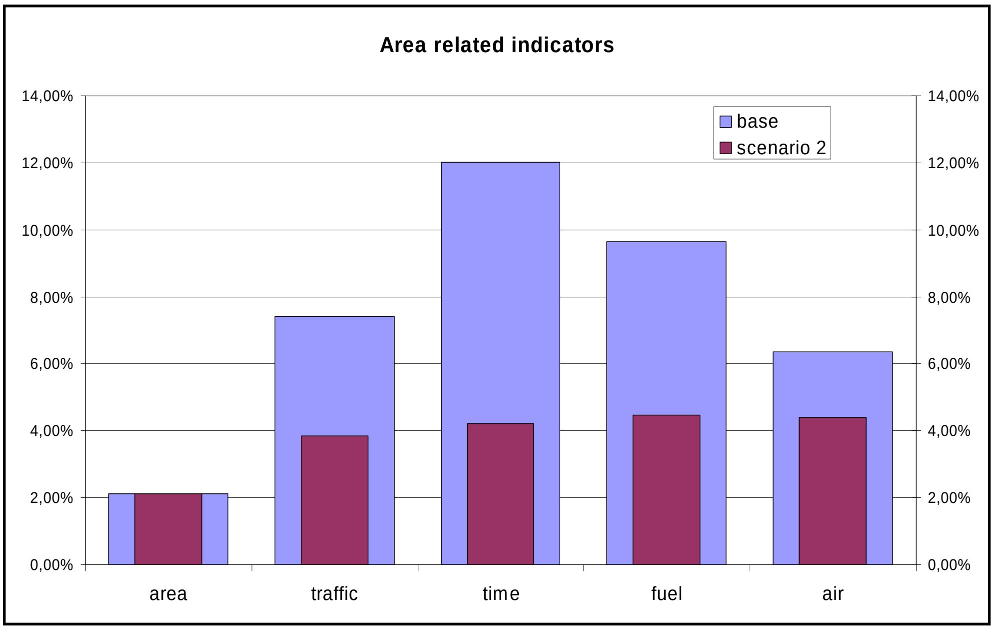

Figure 2: Road transport network wit traffic load volumes

Though the metro line M2 crossing the Danube it is still not able to reduce the congestion of vehicles coming from the middle part of Buda (a further metro line M4 to south-west Buda is just before construction).

Traffic concentration in the city

The inhabitants of Budapest make around 5 million trips a day of which the motorised trips are less then 4 million. The modal split is around 60:40 and is shifting year by year to the disadvantage of public transport, because of the permanently increasing motorization. The motorization rate is around 320 cars/1000 inhabitants.

From the daily 300-350 thousand people who are involved in destination and transit traffic around 60% come with car, which together with the substantial truck traffic cause daily congestions on the radial and outer ring roads.

On the road network in the inner part of the town concentrated on narrow space trucks over 3.5 tons are banned and substantial public transport is also operated.

In destination traffic into the inner part of the city the share of car traffic is lower than the average, but 68% of the car users going from home to work return from the work place directly home again (see Figure 3).

In spite of the fact that among the trips to the city the ratio of the car traffic is lower than at the Danube crossing passenger transport the tendency is worsening if we consider the increasing motorisation. In Figure 4 a shift towards car trips can be observed by increasing car ownership in households. It can also be seen how the season pass ownership influences the daily mode choice, which is a result of a previous decision and important in modelling.

Main parts of the through traffic pass also the inner city and cross one of the five bridges inside the Big Ring causing congestions in most part of the day, hindering also the public transport on the roads.

Transport policy implications

The transport policy of Budapest has changed a lot in the last decades. The environmental issues became more important, so in the latest Transport System Development Plan the following main goals have been formulated:

- Reducing demand for transport by improved land use management;
- Improving traffic organisation and management;
- Mitigating the environmental impacts of transport activity;
- Minimising costs and improving the efficiency of the transport system.

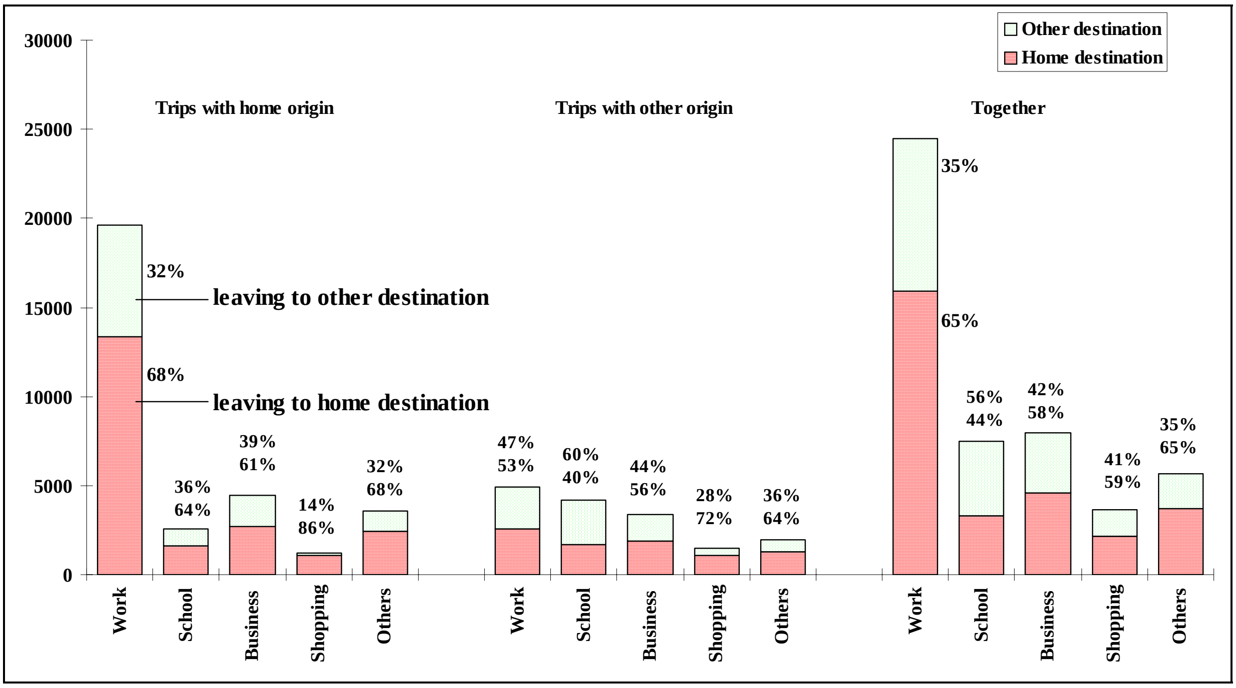

Figure 3: Car trips to the city by trip origin, purpose and leaving trip destination

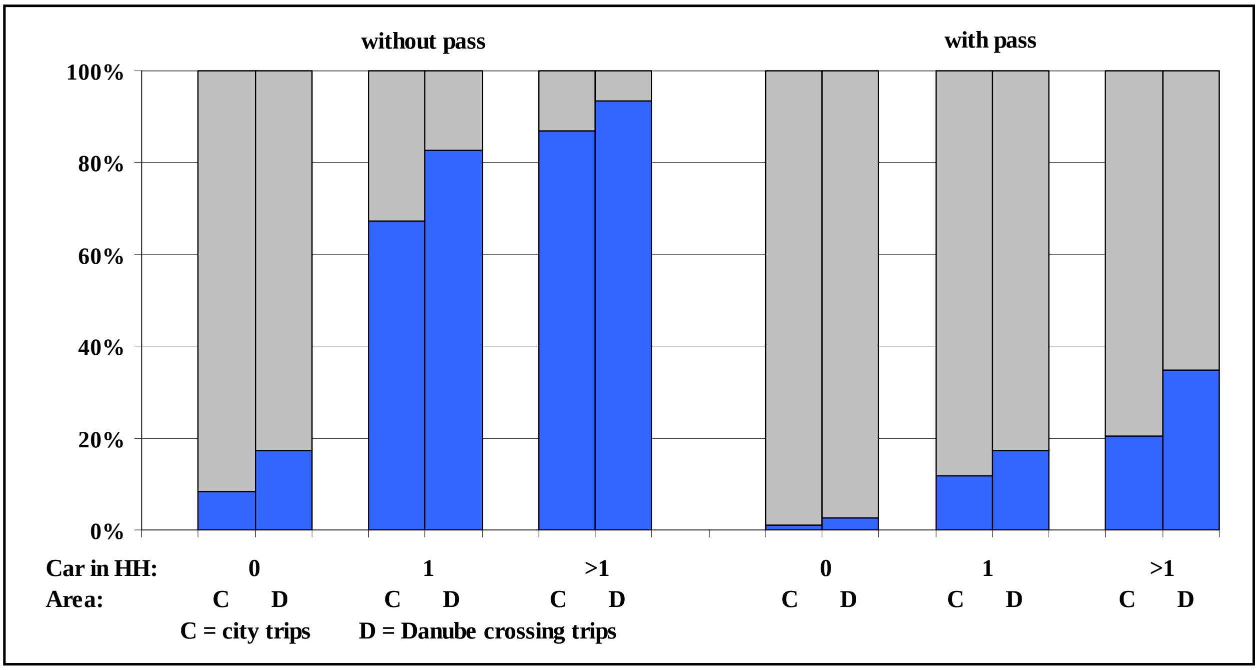

Figure 4: The share of car trips by household car ownership and destining area

With the increasing motorization the congestion and the air pollution became critical especially in the inner part of the city. At the same time within the transport development the public transport is decreasing (see Figure 5), because of disappearance most of the "mass working places" and the declining service provision caused by of financial problems.

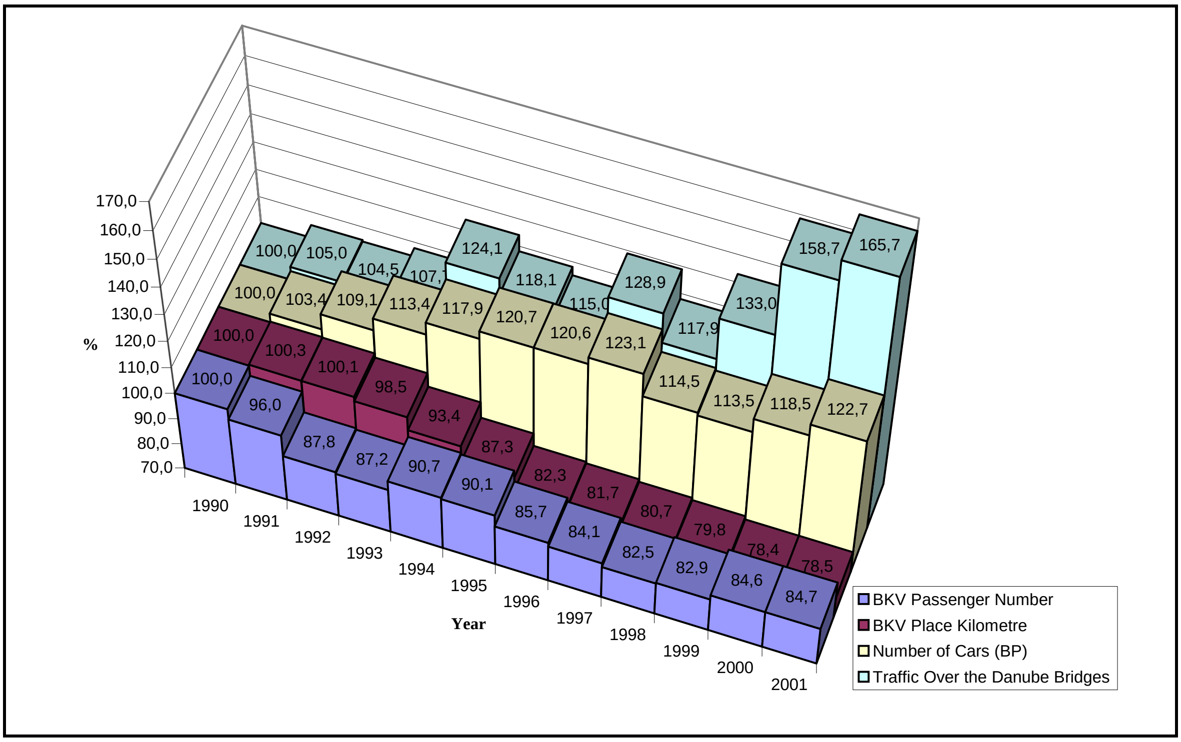

Figure 5. Development tendencies of car traffic and public transport in Budapest

That is obvious that the car traffic problems in the city by parking regulations and fee-measures only cannot be reduced, therefore in later years – similarly to other European cities – the introduction of access fees could be considered. Before this "ultimate" solution other organisational and traffic engineering measures should be utilised.

The kind of the investigated access fees should serve in first line as a measure to influence the behaviour of car drivers, the destination, mode and route choice to reduce congestion, the harmful environmental burdens and other external costs while only in second line to gather revenues.

The model calculations for Budapest in the frame of EUROPRICE can be seen only as theoretical exercises, without any political relations, because at this time the road pricing or access fees were early ideas in Budapest.

Modelling work

The TRANSURS model system for destination choice and mode choice applies logit-models. It became obvious; that simultaneous models are necessary, because models with trip-end or trip interchange mode choice do not deliver realistic results (see Figure 6). The reason for this is that the "holistic" all-mode relational deterrence functions (generalised costs) are not sufficient to calculate realistic zonal and modal shifts in passenger transport, because not all modes are influenced by the access fees.

The scenarios, which are shown in the Figure 7-9, can be characterised as follows:

a) **Reference scenario**:

This represents the "current" (1995) situation. All other cases are evaluated by comparing them to this case.

b) **Scenario 1** - Danube Crossing Tolling: (see Figure 7)

The bridges inside the Big Ring would be tolled, Margit and Petőfi bridges, as part of the ring, with 1 toll unit and the three other inner bridges with 2 units.

c) **Scenario 2** - Inner City Tolling: (see Figure 8)

All entrance road sections in the Inner City Area inside the Big Ring would be tolled with 2 toll units as well as the two bridges on the Ring. The three inner bridges would be tolled with 1 unit only.

d) **Scenario 3** - Pest Side Tolling: (see Figure 9)

To protect more the Pest Side of the city the tolling should considered inside the outer Hungária ring too. In this case the entrance roads and the 5 Danube bridges serve as toll screen lines. The entrance roads of the outer Hungária ring would be tolled with 1 unit. The access fee for the Inner City Area would be an additional 1 toll unit as well as the two Big Ring bridges. The inner bridges would be tolled with two units.

e) **Scenario 4** - Theoretical case:

Same as Scenario1 but in this case we examined also the effects on mobility of road pricing. Because of the distortions in the relationship between the zone potential and specific trip rate derived from the surveys this effect type had to be eliminated from our later evaluations.

The assumed cordon unit fee is relatively high, it equals to 2 public transport tickets (price in 1995: HUF 25/ticket), in case of the inner Danube bridges an additional fee of 2 units has been assumed traffic for a crossing comparison of the fee level: at this time the price for 1 litre of petrol was around 95 HUF).

The introduction of access fees brought change in the generalised costs what influenced trip rates, the destination distribution and the modal shares of the participants of transport and further the routes of the car drivers (the trucks are prohibited from the inner part of the city).

The results of the logit-based traffic flow calculations on the basis of the generalised transport costs (time, fuel, service conditions + access fee) for destination and mode choice in respect of the around 75 passengers and trip purpose groups provided the input for an equilibrium traffic assignment. The results are shown on the load map and load difference map for the most favourite Scenario2 (Figure 10), where the decrease of the traffic in the city and the increase in the less sensitive outer areas can be observed.

To the traffic models different impact modules are connected, which allow the calculation of time, energy (fuel consumption), air pollutions, noise levels and accidents.

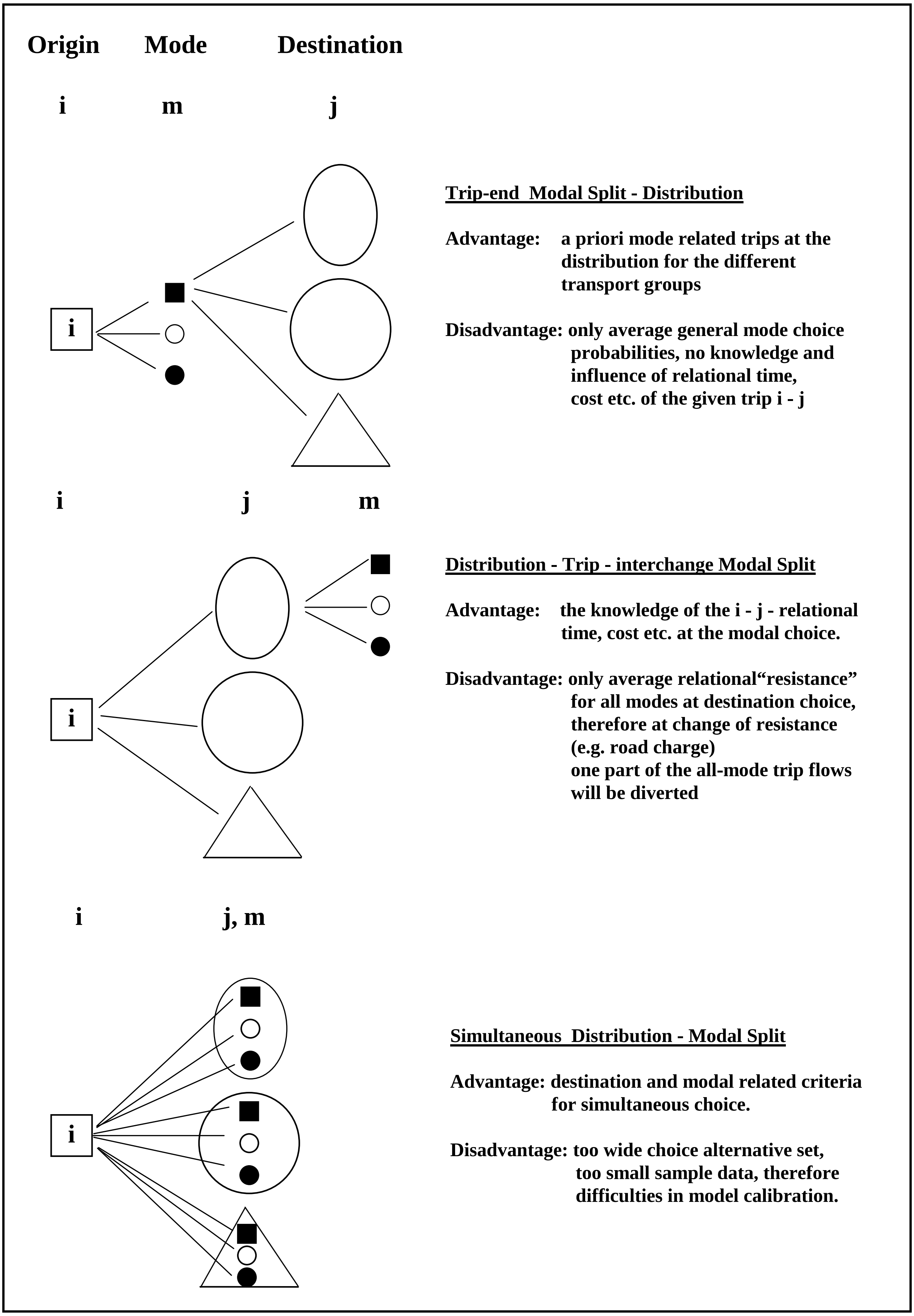

Figure 6: Possible ways of handling trip distribution and modal split

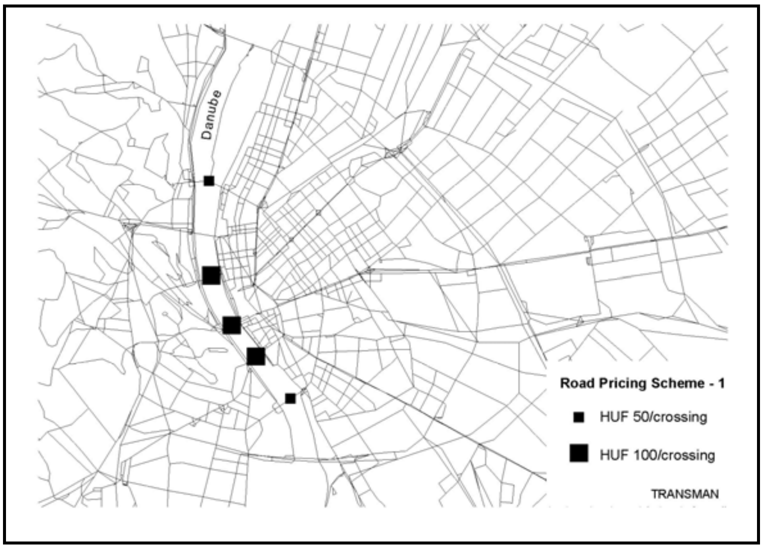

Figure 7: Road pricing scenario-1

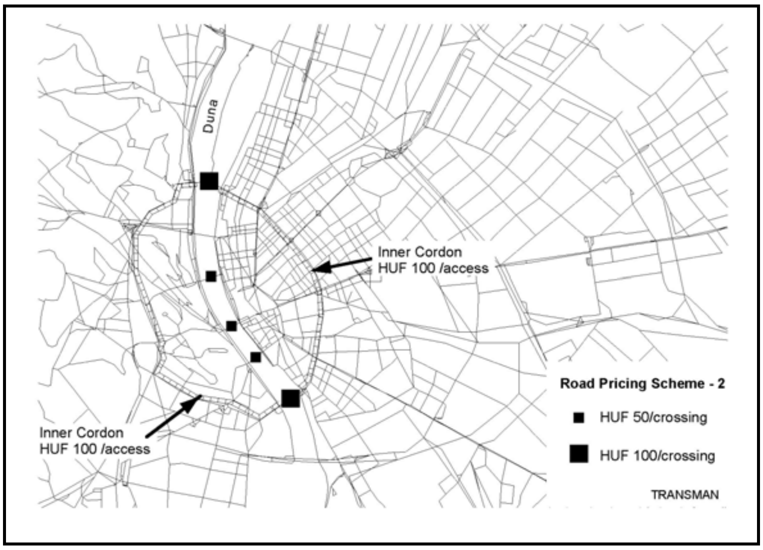

Figure 8: Road pricing scenario - 2

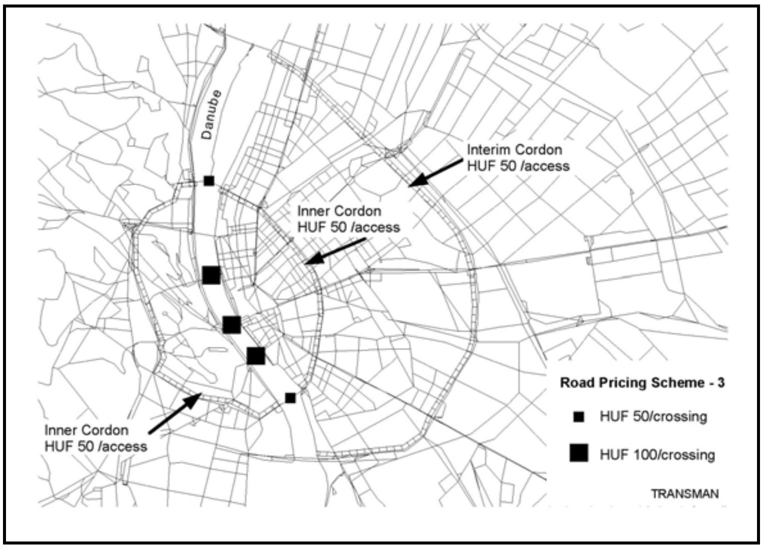

Figure 9: Road pricing scenario - 3

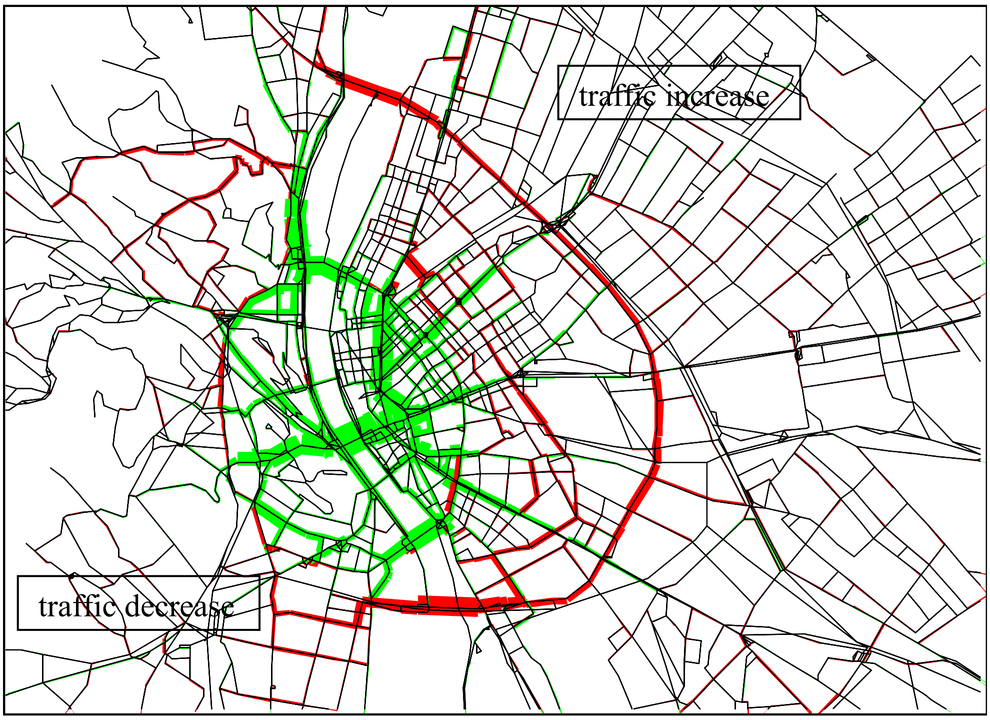

Figure 10: Traffic load difference map of road pricing Scenario2

In the EUROPRICE-project the main aspect was the energy saving, which was extended by us to savings in time consumption and air pollution (represented by NO_x for local pollution).

Main findings

The modelled quantities and indicators have been grouped by the areas of arise; so for the

- inner city (inside the Big Ring)
- interim area (between the Big Ring and Hungária Ring on the Pest side)
- other areas (outside of the inner and interim areas on both parts of the city).

The main results can be summarised as follows (see also Table and Figures11 and 12):

- The departing and destining traffic in the direction to the inner areas would decrease overall by approximately 4% all (in the calculations the differentiation between the inhabitants and other travellers was not possible.).

  The proportion of the transport modes would change as follows: private cars -40%, public transport +8%, bicycles +3%, pedestrians +2%.

- Compared to the base scenario the different modes in the inner districts of Budapest as well as in the whole city would change as follows: destination traffic of private cars (-42/-4%) traffic performance (-48/0%), time spent in the traffic (-65/+1%), fuel used (-54/-1%) emitted nitrogen-oxide (NOx) (-31/+3%) – decrease (-), increase (+).

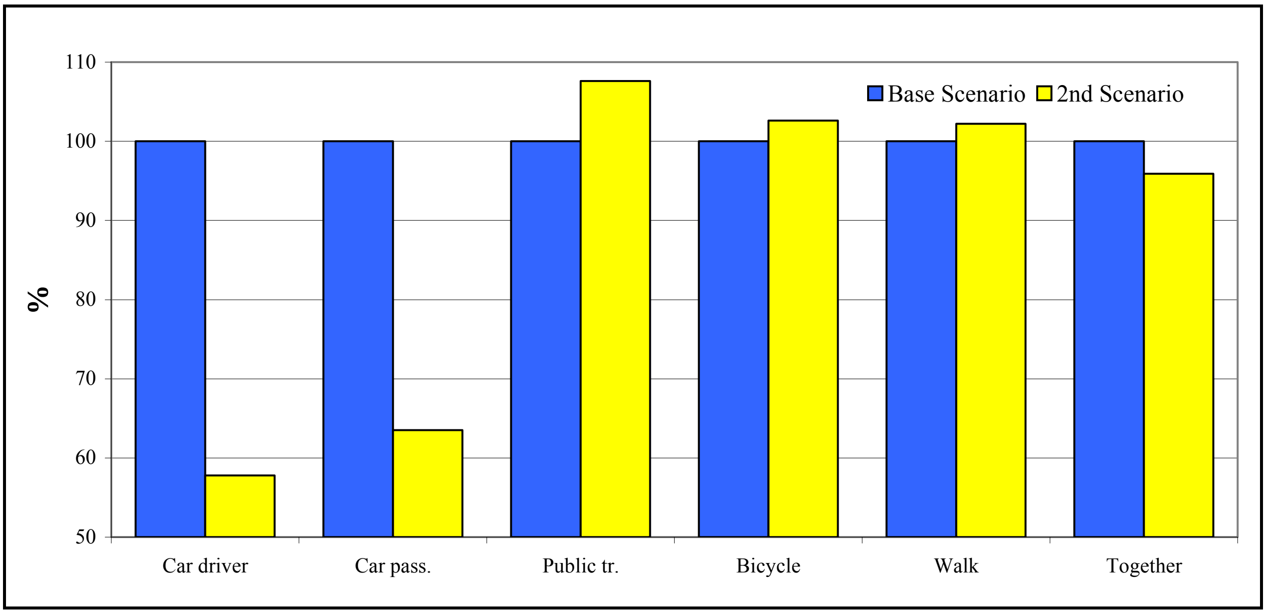

Figure11: Modal shifts because of road pricing in Budapest (2nd Scenario)

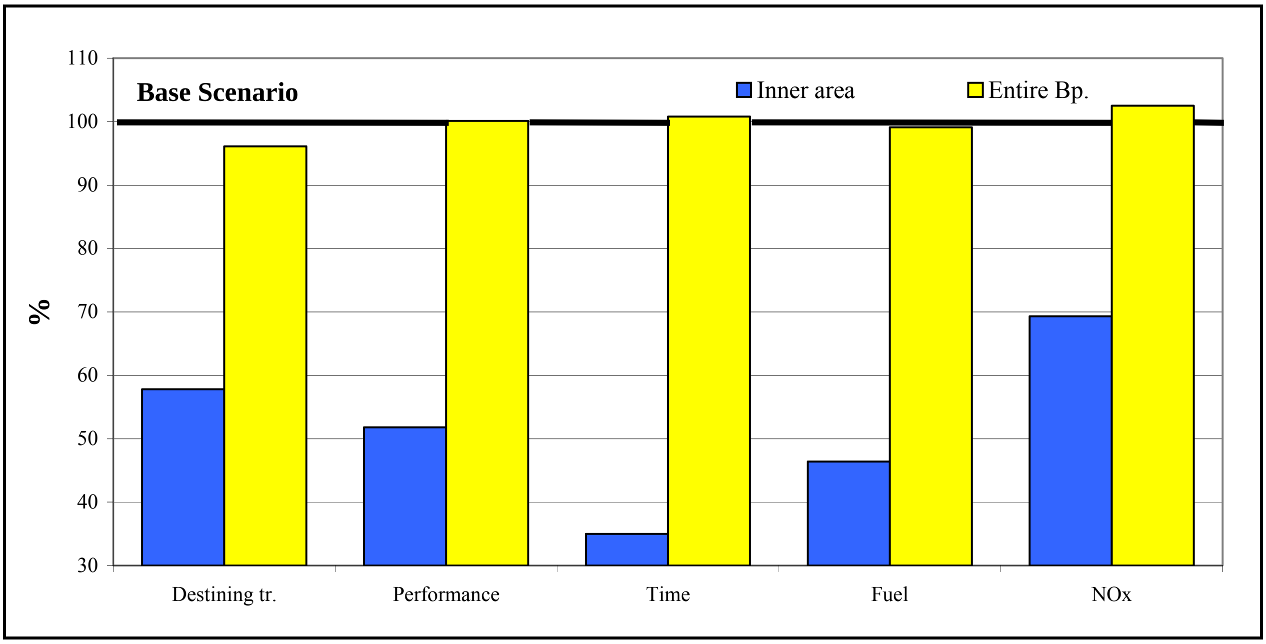

Figure 12: Impacts of road pricing in Budapest (2nd Scenario)

– The traffic loads of the network in the inner areas and on the bridges would considerably decrease; part of the 'edged off' excess traffic would appear on Lágymányosi bridge and Árpád bridge, where this traffic would still cause less additional external costs than in the inner districts.

– The annual fare box revenue – which is not an unimportant aspect – would be HUF 7 billion/year (in case of 1995 prices).

In the course of theoretical modelling we did not deal with the technology of fee collection, investment demands and operational costs. Savings would decrease in case of the beneficence of the inhabitants of the given area, but the consideration of this was not possible due to the given framework and conditions.

	Originating trips		Destinating trips		Modal split (day)		Road traffic	Time consumption	Fuel consumption	Air pollution	Toll revenue
	Morning peak *trip/h*	Daily *trip/d*	Morning peak *trip/h*	Daily *trip/d*	public tr. *%*	car *%*	*carkm/d thousands*	*carhour/day*	*l/day petrol*	*NO_x wkg*/day*	*HUF/day*
Base scenario											
Inner area	72619	695418	122469	699437	70,8	29,2	1162,3	61960	115070	3390	
%	*100*	*100*	*100*	*100*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	
Interim area	98050	734918	113250	738851	65,8	34,2	1782,2	98820	173920	5730	
%	*100*	*100*	*100*	*100*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	
Other area	508836	3175274	443786	3167321	60,6	39,4	12748,1	354580	903060	44230	
%	*100*	*100*	*100*	*100*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	
Budapest Total	679505	4605609	679505	4605609	63,0	37,0	15692,6	515360	1192050	53350	0
%	*100*	*100*	*100*	*100*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	*100,0*	
Scenario 1											
Inner area	72585	696714	122356	700681	72,9	29,1	968,9	48370	94080	3110	
%	*100,0*	*100,2*	*99,9*	*100,2*	*103,0*	*99,7*	*83,4*	*78,1*	*81,8*	*91,7*	
Interim area	97784	730019	112141	733852	66,8	33,2	1785,1	99350	174430	5900	
%	*99,7*	*99,3*	*99,0*	*99,3*	*101,5*	*97,1*	*100,2*	*100,5*	*100,3*	*103,0*	
Other area	508931	3178705	444803	3170904	60,7	39,3	13172,8	386210	940750	46060	
%	*100,0*	*100,1*	*100,2*	*100,1*	*100,2*	*99,7*	*103,3*	*108,9*	*104,2*	*104,1*	
Budapest Total	679300	4605437	679300	4605437	63,6	36,4	15926,8	533930	1209260	55070	9 897 900
%	*100,0*	*100,0*	*100,0*	*100,0*	*101,0*	*98,4*	*101,5*	*103,6*	*101,4*	*103,2*	
Scenario 2											
Inner area	71503	668933	115359	670638	81,6	18,4	602,4	21670	53370	2350	
%	*98,5*	*96,2*	*94,2*	*95,9*	*115,3*	*63,0*	*51,8*	*35,0*	*46,4*	*69,3*	
Interim area	97653	729838	112255	733945	67,1	32,9	1795,0	102840	177590	5970	
%	*99,6*	*99,3*	*99,1*	*99,3*	*102,0*	*96,2*	*100,7*	*104,1*	*102,1*	*104,2*	
Other area	509695	3205913	451237	3200101	60,4	39,6	13313,8	395140	950150	46360	
%	*100,2*	*101,0*	*101,7*	*101,0*	*99,7*	*100,5*	*104,4*	*111,4*	*105,2*	*104,8*	
Budapest Total	678851	4604684	678851	4604684	64,6	35,4	15711,2	519650	1181110	54680	23 859 200
%	*99,9*	*100,0*	*99,9*	*100,0*	*102,5*	*95,7*	*100,1*	*100,8*	*99,1*	*102,5*	
Scenario 3											
Inner area	71834	674491	116885	676867	79,4	20,6	640,9	27850	60020	2410	
%	*98,9*	*97,0*	*95,4*	*96,8*	*112,1*	*70,5*	*55,1*	*44,9*	*52,2*	*71,1*	
Interim area	97738	730753	112365	734396	68,1	31,9	1705,5	95500	167710	5700	
%	*99,7*	*99,4*	*99,2*	*99,4*	*103,5*	*93,3*	*95,7*	*96,6*	*96,4*	*99,5*	
Other area	509337	3199745	449659	3193725	60,8	39,2	13364,2	392870	955650	46250	
%	*100,1*	*100,8*	*101,3*	*100,8*	*100,3*	*99,5*	*104,8*	*110,8*	*105,8*	*104,6*	
Budapest Total	678910	4604989	678910	4604989	64,7	35,3	15710,6	516220	1183380	54360	26 002 350
%	*99,9*	*100,0*	*99,9*	*100,0*	*102,7*	*95,4*	*100,1*	*100,2*	*99,3*	*101,9*	

*Weighting according to imposed area type by network sections

Table 1: Network wide impacts of the road pricing scenarios

The elaborated modelling task showed that TRANSURS model could trace the impact of such measures with an adequate accuracy. The results proved that such pricing measures generate advantageous traffic and environment impacts locally but one should take care on global effects as well. The road pricing measure generates substantial additional fare box revenue; this would be HUF 7 billion/year (1995 prices) in Scenario 2. It must be emphasised that the pricing measures should be used only in the case when all other, conventional traffic management measures has been considered or tried and in the outer area complementary traffic network development measures, e.g. alternative route or mode development, are applied also.

References:

Monigl,J.-Berki,Zs.-Koren,T-Ujhelyi,Z.:

EUROPRICE Energy Efficiency of Urban Road Pricing Investigation in Capitals of Europe
Impact Assessment of Road Pricing in Budapest - a Case Study
(TRANSMAN, April 1999)
(Project leader: Trinity College Dublin; for EC DG XVII - Contract No 1031/SA-114/96)

Monigl,J.-Nagy,E.-Koren,T-Ujhelyi,Z-Berki,Zs.:

Space-time-cost approach in modelling and impact evaluation of the transport in Budapest and its region (TRANSURS Model System)
(TRANSMAN Consulting, Budapest 1998)

- Budapest Transport System Development Plan (2001)
(for the Municipality of Budapest; project leader FÖMTERV Rt, in cooperation with TRANSMAN at al.)