Harmonization of road price regimes in Europe

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INTRODUCTION

Nature gave humanity a stable base of living and gave almost infinite supply to reserve on Earth. In early ages humanity made changes to the environment with early technology, but globally it was not detectable. In the last three hundred years an enormous invention explosion was detected in the sector of industry and technology, which gave people a multiplied set of tools to destroy nature. The motorisation has been developed so dynamically that the air, soil, water pollutions are considerable to the amounts of air, soil, water of Earth. Transportation cannot be degenerated, as a part of production chain. Societies are horizontally and vertically differential. The manpower, the stock, the semi finished and finished products must be transported.

One of the most emphasized goals of the transport policy of the European Union is sustainable mobility. For this reason transportation systems must be developed and standardised, the effectiveness of transportation service must be increased, while the environmental pollution must be decreased or prevented.

SCIENTIFIC BASE OF ROAD PRICE REGIMES BASED ON MARGINAL SOCIAL COST

Externalities according to the EU guideline: „Users should pay the bill" should be internalised and indicated in the cost of transportation. There are several EU funded research projects that aim to have a common – at least for the EU – way of monetarising of externalities. It is the first step to get the total cost of transportation shifted to the users [Tan04].

The base of internalised cost is the marginal cost. So let us see the Total Social Cost as a base of the method of internalisation.

$$TSC = TSC_{infra} + TSC_{service} + TSC_{user} + TSC_{accident} + TSC_{env} \quad (1)$$

where

TSC: Total Social Costs
TSC_{infra} : Total Social Costs of Infrastructure
$TSC_{service}$: Total Social Costs of Service
TSC_{user}: Total Social Costs of Users
$TSC_{accident}$:Total Social Costs of Accidents
TSC_{env}: Total Social Costs of Environmental pollution

Total Social Cost of Users is nearly equal to the External Costs of Users, and Total Social Cost of Accidents is nearly equal to the External Costs of Accidents

$$TSC = TSC_{infra} + TSC_{service} + EC_{user} + EC_{accident} + TSC_{env} \quad / \frac{d}{dx} \tag{2}$$

$$MSC = TSC_{infra} + MSC_{service} + MEC_{user} + MEC_{accident} + MSC_{env} \tag{3}$$

The above mentioned components can be grouped to comprise of two components:

- the time and vehicle operating resource costs directly associated with driving the length of the link in prevailing traffic conditions (the marginal private resource cost), and
- the costs imposed on society, i.e. the change in the total delay caused to all others on the link, and *total* change in vehicle operating resource costs faced by others on the link (the marginal external resource cost) by a marginal vehicle.

$$MSC_i^u = MC_i^u + MEC^u \text{ [HUF]} \tag{4}$$

where

i:	is the vehicle type (passenger, truck, bus, etc.)
u:	the link
MSC_i^u:	is the marginal social cost for vehicle of type i using link u [HUF]
MC_i^u:	is the marginal private resource costs incurred by vehicle type i usink link u [HUF]
MEC^u:	is the marginal external costs imposed by society by the marginal vehicle using link u [HUF]

The marginal private resource cost represents those costs directly falling to the traveller, measured in terms of the resources consumed.

$$MC_i^u = t_i^u \tilde{v}_i^u \tilde{o}_i^u + c_i^u \text{ [HUF]} \tag{5}$$

where

t_i^u:	is the congested time taken for vehicle type i to travel along on link u [min]
$\tilde{v}_i^u$:	is average value of time per traveller in vehicle type i on link u [HUF/min]
$\tilde{o}_i^u$:	is the average occupancy of vehicle type i on link u [Person/PCU]
c_i^u:	is the vehicle operating resources costs for vehicle type i on link u [HUF]

Where different traveller types (user classes) are distinguished to represent different trip purposes or income groups and/or where information on varying vehicle occupancies is available, Equation (5) can be rewritten as:

$$MC_i^u = t_i^u \left(\frac{\sum_g v_g P_{ig}^u}{V_i^u} \right) + c_i^u \text{ [HUF]} \tag{6}$$

where

v_g: is the value of time of travellers of group g [Ft/min]

P_{ig}^{u}: is the number of people of group g using vehicle type i on the link u [Person]

V_i^u: is the number of vehicles of type i on link u

MARGINAL EXTERNAL COSTS

The marginal external costs can be broken down into three parts:

- the rise in the time spent travelling by other link users (X(T));
- the change in the vehicle operating costs of other link users (X(C));
- and other changes in external costs such as environmental externalities (X(O));

External cost of congestion

The marginal external cost associated with the additional congestion and time delays on a link, X(T) is calculated from:

- the rate of change of time from a unit increase in traffic volume;
- the volume and type of trips affected.

$$X(T)^u = \sum_{ig}\left(\frac{\partial t_i^u}{\partial Q^u} P_{ig}^u v_g\right) \text{[HUF]} \qquad (7)$$

where

$\left(\frac{\partial t_i^u}{\partial Q^u}\right)$: is the the rate of change of travel time t for vehicle type i per equivalent (PCU) Q on link u [min/PCU]

Q: Volume of traffic flow [PCU]

External cost of fuel consumption

The marginal external cost associated with changed fuel consumption due to changed link speeds, X(C), is calculated from:

- rate of change of vehicle operating resource cost from a unit increase in traffic volume;
- volume of vehicles by vehicle type affected.

$$X(F)^u = \sum_i\left(V_i^u \frac{\partial c_i}{\partial Q^u}\right) = \sum_i V_i^u\left(\frac{\partial c_i^u}{\partial t_i^u}\right)\left(\frac{\partial t_i^u}{\partial Q^u}\right) \text{[Ft]} \qquad (8)$$

where

$\frac{\partial c_i^u}{\partial t_i^u}$ Is the rate of change in vehicles operating resources for vehicles type i on link u [HUF/min]

External cost of environment pollution

The marginal external costs associated with environmental / other externalities can be complex to calculate. For the purposes of modelling they could be approximated as an external cost per vehicle kilometre.

$$X(N)^u = \sum_i\left(e_i^u d^u\right) \text{[Ft]} \qquad (9)$$

where

e_i^u : is the environmental cost per kilometre imposed by a vehicle of type i on link u [HUF/km]

d^u : is the length of link u [km]

$$e_i^u = \sum_{g=1}^{p} g(i) \cdot l_g(i) \cdot k_g(i) \text{ [HUF/km]} \tag{10}$$

where

g(i): number of vehicles type i [db]

l_g(i): limit of pollutant g in the vehicle type i [g/km]

k_g(i): Cost of pollutant g [HUF/g]

4. ROAD PRICING

$$MC_i^u = t_i^u \left(\frac{\sum_g v_g P_{ig}^u}{V_i^u} \right) + c_i^u$$

The terms in equations (5), [HUF] , (7), (8), (9), can be drawn together to give the full marginal social cost of a vehicle using a link. The ultimate aim of the price setting process should be to determine a set of link prices such that the 'average perceived private cost' for a vehicle of a given type is equal to the marginal social cost of it using the link.

$$MSC_i^u = t_i^u \tilde{v}_i^u \tilde{o}_i^u + c_i^u + \sum_{ig} \left(\frac{\partial t_i^u}{\partial Q^u} P_{ig}^u v_g \right) + \sum_i V_i^u \left(\frac{\partial c_i^u}{\partial t_i^u} \right) \left(\frac{\partial t_i^u}{\partial Q^u} \right) + \sum_i \left(e_i^u d^u \right) \tag{11}$$

From that the total cost can be derived:

$$\tilde{P}_i^u = t_i^u \sum_g \left(\frac{P_{ig}^u v_g}{V_i^u} \right) + p_i^u + t_i^u \tag{12}$$

where

$\tilde{P}_i^u$: is the average private cost for vehicle type i using the link u

p_i^u : is the perceived vehicle operating costs for vehicle type i using link u

t_i^u : is the toll (if exists) for vehicle type i in link u

The perceived vehicle operating costs should vary by vehicle type depending on whether non-fuel costs and VAT are perceived

TO= $MSC_i^u - \tilde{P}_i^u =$

$$= (MC_i^u + EC^u) - \tilde{P}_i^u =$$

$$= \left(\left[t_i^u \tilde{v}_i^u \tilde{o}_i^u + c_i^u \right] + \left[\sum_{ig} \left(\frac{\partial t_i^u}{\partial Q^u} P_{ig}^u v_g \right) + \sum_i V_i^u \left(\frac{\partial c_i^u}{\partial t_i^u} \right) \left(\frac{\partial t_i^u}{\partial Q^u} \right) + \sum_i \left(e_i^u d^u \right) \right] \right) - \tag{13}$$

$$- \left(t_i^u \sum_g \left(\frac{P_{ig}^u v_g}{V_i^u} \right) + p_i^u + t_i^u \right)$$

And at the end:

$$\text{TO} = EC^u + (c_i^u - p_i^u) - t_i^u \quad (14)$$

Once a price has been levied, the demand for use of the link will change, as will the private and social costs. Consequently the price calculation problem needs to be solved iteratively. This analysis assumes that fuel duty will continue to be levied as now and thus the resultant equilibrium prices may be positive or negative. In congested conditions, where the marginal external costs are large, prices will be positive. In un-congested conditions, where the marginal external costs are minimal, the prices will be negative.

5. CONCLUSION

Nowadays there are approved scientifical techniques to calculate social marginal cost of road transportation and to bring equilibrium between transport modes. However the most flexible way of transportation is the road transportation, the marginal social cost of road transportation is high and needs to be monetarised in a harmonised way and shifted to the users. But nowadays even the European taxation regimes that are connected to the fuel usage are not support the sustainable transportation or the maintenance of nature. There is a strong connection between environment and road transportation. Road transportation affects environment by emitting pollutants and greenhouse gases, but environment also affects road transportation through climate change. In this point of view transportation has to meet many challenges. It has to fulfil the challenge of environment, society and economy.

6. REFERENCES

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