Sustainability of energy management of transport sector in Hungary

Katalin TANCZOS, Agnes KOSZTYO, Adam TOROK

Abstract: The high ratio of road transportation in CO_2 emission caused by humanity made the research of relation between the road transportation and climate change reasonable. There is a justifiable demand by the society to moderate the environmental impacts caused by road transportation. Our aim is in this article to monetarise the impact caused by the road transport sector in Hungary. First we analysed the fuel consumption in Hungary then tried to estimate the carbon dioxide emission from these time series. According to the recent finalised EC founded research projects we tried to monetarise the impact of the transport sector on the climate. This is the monetarised value which has been paid by the society and not by the sector.

Keywords

Fuel consumption, transportation, carbon dioxide emission, climate change.

1. Introduction

There is a strong relation between economical activity and motorization. Although until now it has been unclear, weather the increase of economical activity affects motorization or the increase transport demand induces the economical activity. One effect is clear, the increase of motorization affects our environment, and there is a loop back, our environment has an effect on transportation. I have analysed the relation between the environment, the economy and motorization. I have begun with Simon Kuznets' (1901-1985) work:

$$\ln(Y_t) = \alpha_0 + \alpha_1 \left(\ln\left(\frac{GDP}{LAK}\right)_t\right)^2 + \alpha_2 \ln\left(\left(\frac{GDP}{LAK}\right)_t\right) + \varepsilon_0 \quad (1)$$

where:

Y: environmental pollution [CO_2 kg/person],
t: years,
GDP: Gross Domestic Product,
LAK: inhabitants,
α_i: weights, $a_1<0$ and $a_2>0$ and $a_3\geq 0$,
ε_0: error.

I have added the degree of motorisation to provide a link between environmental pollution, economical activity and motorization:

$$\ln(Y_t) = \alpha_0 + \alpha_1 \left(\ln\left(\frac{GDP}{LAK}\right)_t\right)^2 + \alpha_2 \ln\left(\left(\frac{GDP}{LAK}\right)_t\right) + \alpha_3 \ln\left(\left(\frac{MOT}{LAK}\right)_t\right) + \varepsilon_1 \quad (2)$$

where:

Y: environmental pollution [CO_2 kg/person],
t: years,
GDP: Gross Domestic Product,
LAK: inhabitants,
α_i: weights, assumeing that $a_1<0$ and $a_2>0$ and $a_3\geq 0$,
MOT: number of private cars,
ε_1: error.

I could prove with the extended Kuznets model that the dramatically increasing motorisation is a determining part of environmental pollution. I have compared the results of the extended Kuznets model with a multi-linear model:

$$(Y)_t = \beta_0 + \beta_1 \cdot \left(\frac{GDP}{LAK}\right)_t + \beta_2 \cdot \left(\frac{MOT}{LAK}\right)_t + \varepsilon_2 \quad (3)$$

where:

Y: environmental pollution [CO_2 kg/person],
t: years,
β_i : weights, assuming that $\beta_0 \neq 0$,
GDP: Gross Domestic Product,
LAK: inhabitants,
MOT: number of private cars,
ε_2: error.

Having linearised the problem the effect of motorisation on environmental pollution became more significant.

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When examining the possibility of adaptation of EKC (Environmental Kuznets Curve) the problem arises how effectively GDP reflects the real evolution of society and economy. This problem led me to exchange the GDP to HDI (Human Development Index) and test the modified Kuznets model and the multi-linear model as well.

$$\ln(Y)_t = \alpha'_o + \alpha'_1 \cdot (\ln(HDI)_t)^2 + \alpha'_2 \cdot \ln(HDI_t) + \alpha'_3 \cdot \ln\left(\left(\frac{MOT}{LAK}\right)_t\right) + \varepsilon'_1 \quad (4)$$

where:

Y: environmental pollution [CO_2 kg/person],
t: years,
α'_i: weights assuming that $a_1<0$ and $a_2>0$ and $a_3\geq 0$,
HDI: Human Development Index,
LAK: inhabitants,
MOT: number of private cars,
ε'_i: error.

The model that has been extended with motorisation and modified with HDI has remained of an upside-down U shape, as the original one. That means the environmental pollution depends not only on social development, but on the development of motorization as well.

Finally I have analysed the connection between the development of society, motorization and environmental pollution with a multi-linear model.

$$\left(\frac{Y}{LAK}\right)_t = \beta'_0 + \beta'_1 \cdot (HDI)_t + \beta'_2 \cdot \left(\frac{MOT}{LAK}\right)_t + \varepsilon'_2 \quad (5)$$

where:

Y: environmental pollution [CO_2 kg/person],
t: years,
β_i : weights, assuming that $\beta'_o \neq 0$,
HDI: Human Development Index,
LAK: inhabitants,
MOT: number of private cars,
ε'_2: error.

After we have proved the necessity of the examination of emission in transport sector, we try in this article is to estimate the CO_2 emission of the transport section in Hungary. We have to clarify the emission of the transport sector in order to get information on externalities, for a further step to sustainable society. 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 standardized, the effectiveness of transportation service must be increased, while the environmental pollution must be decreased or prevented. 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. 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 the production chain. Societies are horizontally and vertically differential. The manpower, the stock, the semi finished and finished products must be transported.

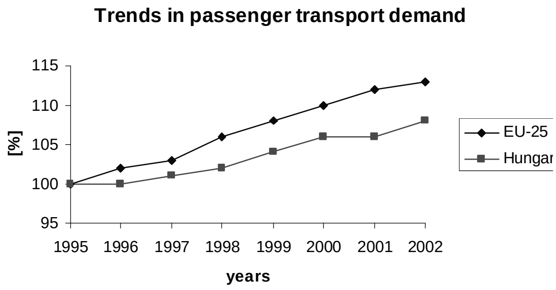

Fig. 1. Trends in passenger transport demand

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. Externalities according to the EU guideline should be internalised and indicated in the cost of transportation [3].

2. Fuel consumption of the transport sector of Hungary

The majority of the energy we use in the transport sector in Hungary is based on oil, a non–renewable fossil fuel. The base of estimation method is that we assume that there is perfect burning, although we know that in reality just less CO_2 can be produced, because there is no perfect burning. In our model we assume that for the C and H ratio of petrol we can use octane:

$$C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O \quad (6)$$

For the C and H ratio of gasoline we can use:

$$C_{14}H_{30} + \frac{43}{2}O_2 \rightarrow 14CO_2 + 15H_2O \quad (7)$$

That means, from 1 mol that is 114 g of petrol there will be after perfect burning 8 mol that is 352g carbon dioxide. From 1 mol, that is 198g of gasoline there will be after perfect burning 14 mol that is 616g carbon dioxide. If we take into account the density of petrol and gasoline we can calculate the maximum amount of CO2 when 1 litter of petrol or gasoline has been burnt.

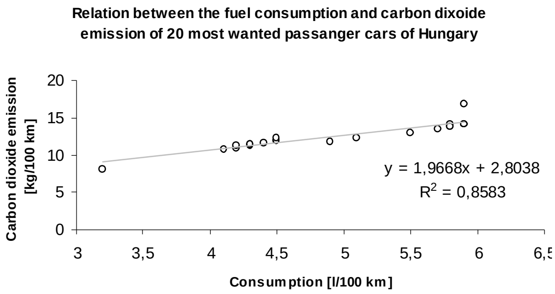

Fig. 2. Relation between the fuel consumption and carbon dioxide emission

3. External costs of climate change of transport sector in Hungary

As it can be seen from **Fig. 3** the number of Hungarian vehicles has slightly increased both in the case of petrol and gasoline driven vehicles. There was a slight increase in gasoline and petrol consumption as well, but the gasoline usage was nearly 50% higher because of the higher consumption level of HGVs. As it can be seen there had been a slight increase in CO_2 emission as well.

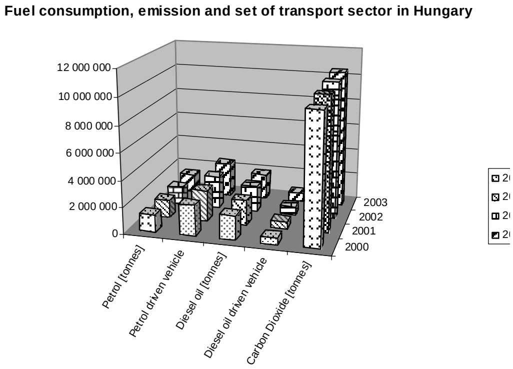

Fig. 3. Fuel consumption, emission and set of transport sector in Hungary

We calculated the external cost of transport sector of Hungary according to EU climate researches. The method of calculating costs due to the emission of greenhouse gases (usually expressed as CO_2 equivalents) basically consists of multiplying the amount of CO_2 equivalents emitted by a cost factor. Due to the global scale of the damage caused, there is no difference how and where in Europe the emissions of greenhouse gases take place.

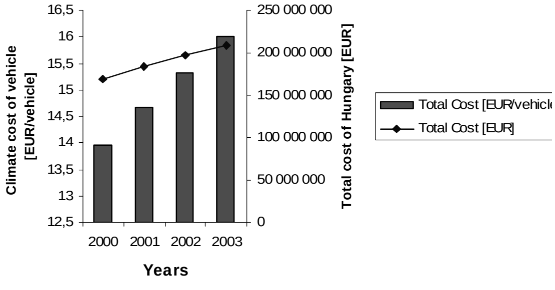

Fig. 4. Carbon dioxide emission in Hungary

As it can be seen from **Fig. 4** there is a slight increase in the cost of emitted carbon dioxide in Hungary. It can be explained by the increasing cost factor, and the increasing emitted gas, due to the increase of number of vehicles in Hungary.

As we are using more cars, and even more fuel to satisfy our higher requirements of mobility. Although there are nearly the same amount of people „moving" in the country with nearly the same old cars.

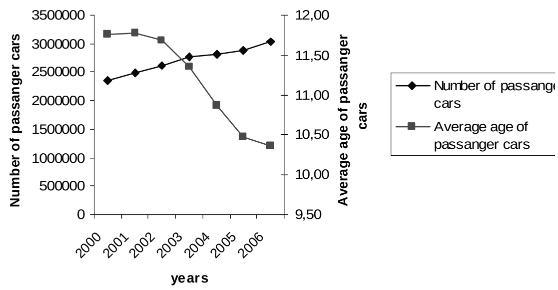

Fig. 5. Average age and number of passenger cars in Hungary

Now that we have monetarised the cost of the effect, there should be the identification of the emitters. As it is caused by the road transportation, by using and burning fuel, the cost should be allocated to the fuel. In an economical sense that could be special taxation for the environment, with a common, social and political will to protect the nature.

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 scientifical approaches, EU funded research and development projects that clearly describes that solution [2]. Even in Hungary we started a national research and development project about climate change and about national climate change strategy.

There should be an equitable system for fuel using. That not only includes the parameter of used fuel, but the efficiency of burning as well. In road transport sector, this two parameter can be described by the EURO environmental group (the higher group means higher efficiency, as have lower limits of emission) and engine displacement as relevant parameter of fuel usage (There is a high correlation between engine displacement and fuel consumption, R^2=0,62). Generally C matrix with this assumption would be:

$$\underline{\underline{C}} = \begin{vmatrix} c_{11} & c_{1j} & c_{1n} \\ c_{i1} & c_{ij} & c_{in} \\ c_{m1} & c_{mj} & c_{mn} \end{vmatrix} \quad (8)$$

Where c_{ij} is the number of thousands of passenger cars in EURO i category and in category j in engine displacement (Based on

EUROSTAT categories:[until 1399 cm^3; 1400-1999 cm^3; from 2000 cm^3]). For Hungary, that C matrix would be in 2005:

$$\underline{\underline{C}}\Big|_{Hungary,2005} = \begin{vmatrix} 620 & 360 & 53 \\ 705 & 410 & 60 \\ 80 & 47 & 7 \\ 285 & 166 & 25 \\ 39 & 23 & 3 \end{vmatrix} \quad (9)$$

This could be bases of an equitable system, and it is in synchrony with the latest EU researches.

Our paper aims to identify the macro economical cost of sector of road transportation in Hungary.

4. Conclusion

There is a common, social will to protect the Earth and the environment. Climate change causes the crescendo of climate extremity in Hungary. 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. Transport energy is a major cause of environmental pollution adding to the Greenhouse effect with about 25% of total CO_2 emissions resulting from fossil fuel use.

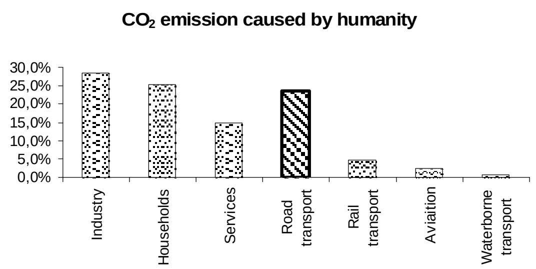

Fig. 6 Carbon dioxide emission caused by humanity

As there are so many international and national scientific hard and soft solution for decrease the emitted gases, yet even in Europe there are only 1-2 solution staring to work (carsharing, carpooling).

Vehicle emissions also cause increased levels of photochemical smog and carbon monoxide. The keys to substantially reducing the damaging effect of greenhouse gas emissions in the transport sector are [1]:

- choosing to minimise our petrol consumption and reliance on private vehicle use
- the widespread use of alternative transport fuels

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