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THE ANALYSIS AND EVALUATION OF THE RELATION BETWEEN ROAD TRANSPORTATION AND CLIMATE CHANGE

Ádám TÖRÖK

Department of Transport Economics
Budapest University of Technology and Economics
H-1111 Budapest, Bertalan L. u. 2., Hungary
Tel.:463-1061,
Fax.: 463-3268,
e-mail: atorok@kgazd.bme.hu

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Abstract

The target of this article is to analyse and evaluate the relation between road transportation and climate change, through the long time series of average CO_2 concentration in the atmosphere and global average temperature of Earth. This article is built on data from the age before the human impact on Earth. It can be clearly seen from the research that the human impact on air quality has different tendency than it had before. The trend of time-series was nearly independent from time: it was constant. It can be identified from the data that the increase of temperature was usually faster than the decrease in decreasing periods. There is a strong correlation between the average CO_2 concentration in air and the average temperature of the Earth. The CO_2 emitted into the environment increases the global temperature of the Earth. A huge part of the CO_2 emitted by mankind into the atmosphere comes from transportation, mainly from the sector of road transportation.

Keywords: CO_2 emission, climate change, transportation.

1. Introduction

This research aims to analyse and evaluate the relation between transportation and climate change, through the long time series of average CO_2 concentration in the air and average temperature of Earth. The historical, 400 000 years old data [1] start before the environmental human impact. This is the basis of the extrapolated data for nowadays. It can be seen from the analysis that change caused by the human impact, is diversed from the average. ppppon the overview of the database – focused on the size of sample and the heterogenety – I managed to put them on a common timeline. Now it is a great opportunity to analyse and evaluate the relation between climate change and road transportation.

2. Trends in Average Temperature of Earth and Concentration of CO_2 in Air

With common statistical tools the hypothetical trend can be discovered with the elimination of cycle effects. This means that we can apprehend not the individual

short phenomenon, but the long-ranged, complex effects. Examining the Glass-house effect I assumed that I do not need to examine the whole atmosphere, but only the relevant CO_2 component. That is why I have examined only the average CO_2 concentration in air and the average temperature of Earth. The graphical analysis shows that the time series can be divided into growing and falling periods *Fig. 1.* shows the long waves of the Earth average temperature and it can be clearly identified that the CO_2 emission shows similar waves (*Fig. 2*).

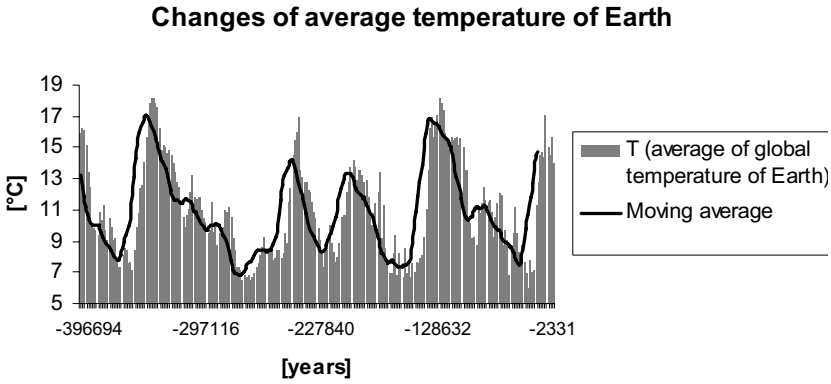

Fig. 1. Time series of the global average temperature of Earth and the moving average

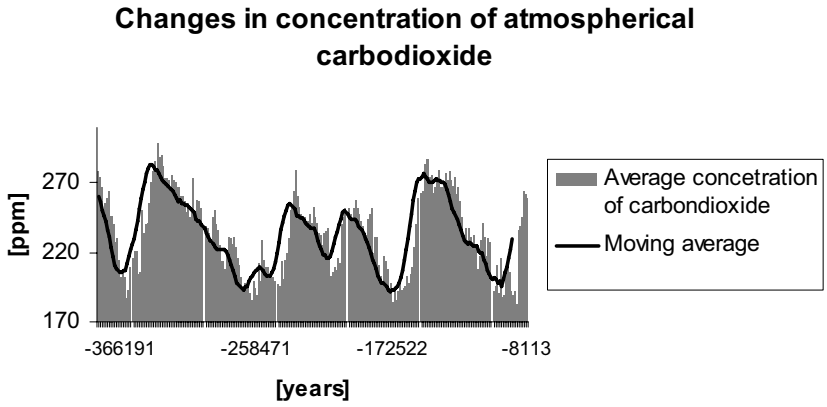

Fig. 2. Time series of atmospherical carbon dioxide and moving average

It can be seen that the moving averages represent the process and uncrease the deflection of certain terms, that is why I assume to use the moving averages. I have examined the long trends of the CO_2 concentration at the atmosphere and the long trends of average temperature of Earth. It is clarified that there were no important changes in trends in the time on none of them.

3. The Periodic Analysis of Average Temperature of Earth

In this issue I am going to analyse the decrease and increase of average temperature of Earth. The total time series can be separated into 4 periods. All of them can be separated into rising and falling part. They can be compared (*Fig. 3*).

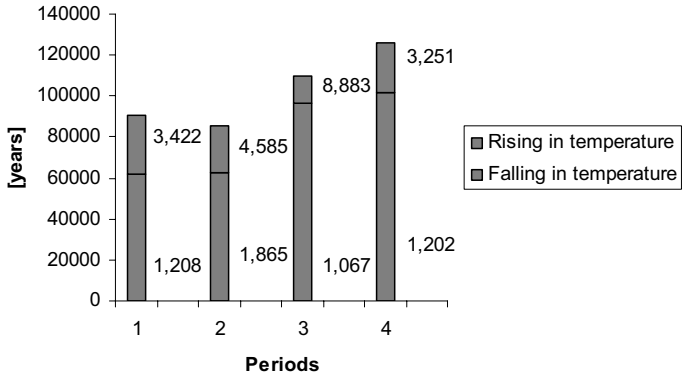

Fig. 3. The bars of risings and fallings in temperature

From the results the increase of the periodic time can be estimated but because of the small amount of data rising and falling periods cannot be compared further more. Next to the bar chart the gradient of the risings and fallings can be seen in [˚C/10 000 years]. (*Table 1*)

Table 1. Gradient of risings and fallings in temperature [˚C/10 000 years]

	Rising	**Falling**
Maximum	1.865	8.883
Minimum	1.067	3.251
Average	1.336	5.035
Deviation	0.359	2.633

From the data it can be seen that the risings of temperature before the human impact were 3 to 5 times faster than the fallings.

4. Correlation between CO_2 in Atmosphere and Average Temperature of Earth

To analyse the correlation of global average temperature and CO_2 concentration in the atmosphere I have normalized both time series.

$$u_i = \frac{x_i - \overline{x}}{\sigma} \tag{1}$$

where

u_i : a normalized value
x_i : actual value of time series
$\overline{x}_i$: average of x_i values
σ : deviation of x_i values

$\overline{x}$ average of x_i values:

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{2}$$

σ: deviation of x_i values [2]:

$$\sigma = \sqrt{\frac{(x_i - \overline{x})^2}{n}} \tag{3}$$

The normalized graph can be seen at *Fig. 4*.

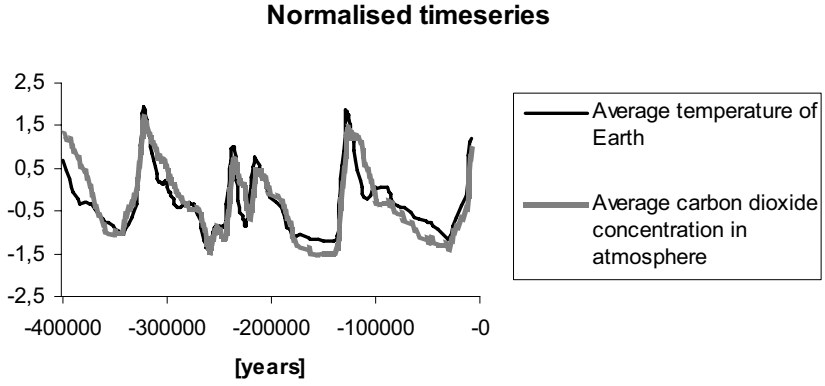

Fig. 4. Normalized time series of CO_2 and temperature before human impact

My hypothesis is that there is relation between the concentration of CO_2 and the average temperature of Earth. I will justify the acceptability of my hypothesis by χ^2 test.

My H_0 hypothesis: There is a relation between atmospherical CO_2 concentration and average temperature of Earth.

My H_1 anti-hypothesis: There is no relation between atmospherical CO_2 concentration and average temperature of Earth.

With χ^2test I tested the normalized values, I got that:

$$\chi^2 = \sum_{i=1}^{m} \frac{(f_i - f_{ti})^2}{f_{ti}} = 118.67 \tag{4}$$

$$\chi^2_{crit(0,05;238)} = 247.98 \tag{5}$$

where

f_i: normalized values of atmospheric CO_2 concentration

f_{ti}: normalized values of average temperature of Earth [2]

The value of χ^2 is less than the $\chi^2_{crit(0,05;238)}$ (significancy level of α=5 %, freedom of 238), (the probability of false reject of the null hypothesis is exactly 0,05). It can be declared that there is relation between the normalized values of atmospheric CO_2 concentration and the normalized values of average temperature of Earth.

It was a great opportunity to analyse large time series, 238 data of atmospheric CO_2 concentration and average temperature of Earth. I have considered the fact that my hypothesis can be accepted only when the value of χ^2 less than the $\chi^2_{crit(0,05;238)}$. I have analysed the fact that my hypothesis would be correct if I had only 95 data of atmospheric CO_2 concentration and average temperature of Earth instead of 238 with the same level significancy (the probability of false reject of the null hypothesis).

As I have continued my analysis I looked for the correlation between CO_2 in atmosphere and global average temperature. Be x and y the two examined criteria. Let $x_1, x_2, \ldots x_i$ and $y_1, y_2, \ldots y_i$ be the sample of the two criteria. At that moment the correlation between them is:

$$r = \frac{n \cdot \sum_{i=1}^{n} x_i \cdot y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left(n \cdot \sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right)\left(n \cdot \sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2\right)}} = \frac{\sum_{i=1}^{n} (x_i - \overline{x})\,(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \overline{x})^2 \sum_{i=1}^{n} (y_i - \overline{y})^2}} \tag{6}$$

where:

$\overline{x}_i$: average of x_i values

$\overline{y}_i$: average of y_i values

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{7}$$

$$\overline{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{8}$$

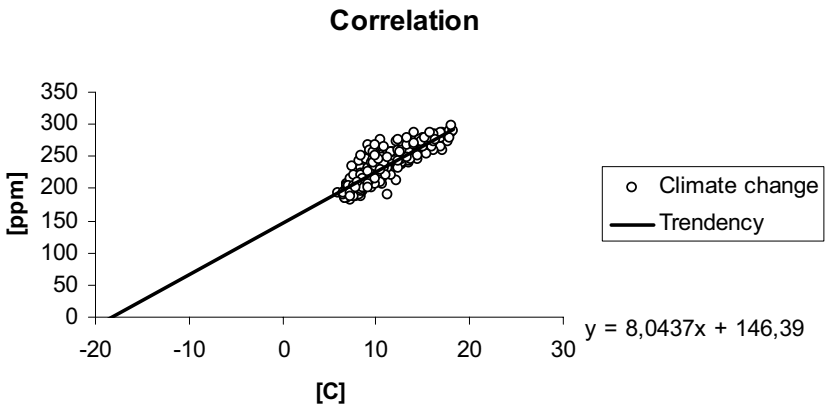

Fig. 5. Atmospheric CO_2 concentration in the relation of average temperature of Earth

So there is a strong correlation between Atmospheric CO_2 concentration and the average temperature of Earth (r=0.8657).

Nowadays with the great human impact, that is considerable to the size of atmosphere, the relation can be changed. The CO_2 emission caused by humanity raises the global temperature. More than quarter of the total emission of CO_2 caused by humanity is produced by road transportation [3]. So the road transportation contributes to climate change (*Fig. 6*). There is a common, social will to protect the

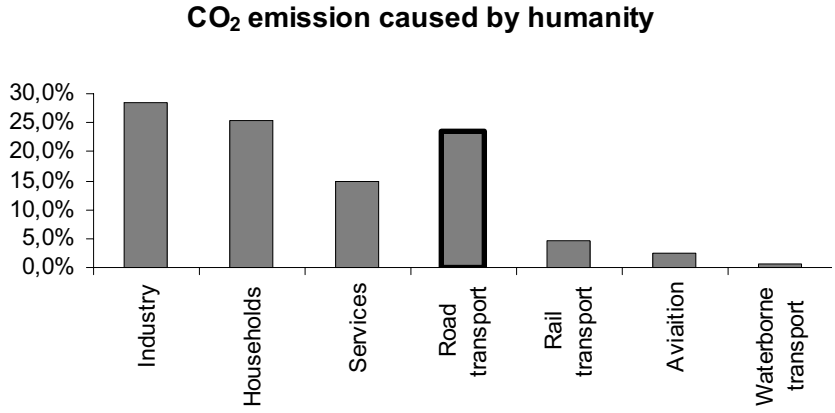

Fig. 6. The road transportation contributes to climate change

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 has effect on environment by emitting pollu-

tants and greenhouse gases, but environment has also effect on road transportation through climate change. In this point of view transportation has to hold on in this dynamic space. It has to fulfil the challenge of environment, society and economy.

5. Summary

The high ratio of road transportation in CO_2 emission caused by humanity made reasonable the research of the relation between road transportation and climate change. There is a justifiable demand by the society to moderate the environmental impacts caused by road transportation. Before human impact on atmosphere there was a balanced relation between the concentration of atmospherical CO_2 and global average temperature. Nowadays with the human impact to the atmosphere the relation can be modified.

References

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