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CASE STUDY OF THE IMPACT OF THE CO_2 EMISSIONS TREND FROM TRANSPORT ON THE EXTERNAL COSTS IN SLOVAKIA AND SLOVENIA

Abstract. Transport is one of the human activities that increases the amount of greenhouse gases in the air. CO_2 is the main cause of global warming and contribute for around 80 % of all greenhouse gas emissions. The paper presents CO_2 production based on the amount of sold fuel in Slovakia and Slovenia. Based on the obtained data, the calculations about the production of CO_2 according to the type of fuel was made. The conducted research has focused on the issue of traffic congestion and to reduce CO_2 emissions by 15 % in total by 2030, as Slovakia and Slovenia concluded an agreement with other EU members in 2009. External costs calculation was made with average price of 1 tonne emission credit in 2016 and with presumed average price in 2019. The case study takes into account the consumption of the gasoline and diesel in transport throughout all Slovakia and in Slovenia.
Keywords: CO_2 emissions, the cost of CO_2 from transport, traffic congestions, traffic management

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Introduction

Globalization is the main reason for increasing mobility in the world, thus also result in significant costs. Next to all the impacts on the environment and human health, that was the main reason for the formation of this article.

The increase in transport has many negative impacts on the environment like air pollution problems that are caused by Burning of Fossil Fuels, Agricultural activities, Exhaust from factories and industries and some other activities. Global climate changing has become a severe problem in the world nowadays. The temperature of the atmosphere is increasing because the heat waves are becoming more intense and more frequent. Global warming and air pollution are largely caused by greenhouse gas emissions from traffic and Fossil Fuels (Kakouei et. al., 2012).

A Stanford scientist details how each increase of 1 degree Celsius caused by CO_2 would annually lead up to upward of 20 000 air-pollution-related deaths (Whitty, 2008). GHG include Fluorinated gases, Nitrous oxide (N_2O), Methane (CH_4) and the most problematic Carbon dioxide (CO_2). Carbon emissions are the most significant of greenhouse gas emissions that cause global warming (Dosio et. al., 2018). Increased concentration of CO_2 can lead to various health problems, these are: headache, dizziness, restlessness, difficulty breathing, sweating, fatigue, high blood pressure, suffocation and other (Department of Health Services). The effects of CO_2 on an individual are dependent on the concentration and duration of exposure. At the same time, other factors have influence on this, those are: age, health, physiological composition, lifestyle and others (Rice, 2003).

Carbon dioxide is a colorless and non-combustible gas at room temperature. It is naturally present in the air, so it is inhaled at a concentration of about 0.037% (Health and Safety Executive).

Levels of CO_2 emissions in the air are:

a) 250-300 ppm - normal amount of exterior spaces;
b) 350-1000 ppm - normal amount of indoor spaces;
c) 1000-2000 ppm - rate associated with fatigue;
d) 2000-5000 ppm - rate associated with headaches, poor concentration and increased heart rate;
e) > 5000 ppm - unusual air conditions (Department of Health Services).

The industrial revolution has caused a significant increase in CO_2 emissions. CO_2 accounts for 72 % of all greenhouse gases. It is the main cause in addition to PM particles for global warming. It takes 100-200 years for CO_2 to decompose from the atmosphere, due to this fact, because of that CO_2 accumulates in the atmosphere, which leads to an increase in surface temperatures and increasing fluctuations in weather. For this reason, the European Union has made a directive that the atmosphere should not be heated by more than 2 degrees Celsius, which on the other hand means a significant reduction in CO_2 emissions. Transport planners and founders of transit and real estate were from the very beginning interested in those markets, which were supportive of transit services, especially in the field of public transport. The expansion

of the automotive industry between and after industrial revolution, almost broke the development of the railways with the comfort and ease of a car (Feigon et.al., 2003)

Many organizations strive for efficient supply chains because of enormous mass production of raw materials, goods and products for the customers' needs. Today's production of goods is formed based on customer satisfaction (Jereb et. al., 2016). To make business processes more effective and efficient we must to reduce time and costs. This is achieved by well-organized transport. Because of this reason, the increase on transport is reflected in all modes of transportation: road, rail, sea and air (Jereb et al., 2017), (Jennings, 2006).

On the other hand, we have a smart traffic management in the transport field, where users can choose new and more clever ways of transport such as public transport, car sharing, hybrid vehicles, electrical vehicles, etc. On the side of the member states of the EU is to regulate the legislation in the field of transport, or just to implement the smart traffic management such as green waves. By implementation of such management we decrease fuel consumption, emissions of CO_2 and the impact on the environment. The correlation is always proportional, as the fuel consumption increases, so do emissions and the impact on the environment (Jereb & Čeh, 2017).

The European Union wants to reduce the amount of greenhouse gas emissions by 20 % (European Commission - 2020 climate & energy package). They want to reach a reduction with the strategy called European 20/20/20 objectives. The strategy was set by EU leaders in 2007 and has three targets to achieve: 20 % increase in energy efficiency, 20 % reduction of CO_2 emissions and 20 % renewables by 2020. Whit this set of binding legislation, they want to ensure improvements on climate and energy sets (Lodi et. al., 2018), (Erixon, 2010).

The first clear EU demand of emission trading was in 2000 when the EU issued a Green Paper on greenhouse gas emissions trading. Such a system of restriction and trading of emission credits (A "cap and trade" system) was established in the EU in 2005, primarily for the achievement of the Kyoto Protocol of 1997 when it was signed (Ellerman A. D. et al., 2015). The Kyoto Protocol was signed by industrialized nations and stipulates that greenhouse gas emissions will be reduced by 5 % between 2008 and 2012 compared to 1990. The second target period was adopted in 2012, known as the modification of the Doha Convention Protocol (CNN Library, 2018).

The objective of establishing an emission trading scheme is to allow market mechanisms to drive industrial and commercial processes towards lower emissions of carbon dioxide and other greenhouse gases, as in the case of processes where the price for discharges is not determined. It is a trading that represents the right to release 1 ton of CO_2 or any other gas of the same weight. Limiting the amount of greenhouse gases is determined by the installations that are covered by the system. Within these limits, such companies may receive or buy these credits. If the company reduces emissions during the year, it can maintain or sell the reserve emission credits (European Commission - EU Emissions Trading System (EU ETS)). This way of an emission trading is then reflected in the prices. We can check it with the financial models, such as the OMEGA, where the basic information about the vehicle such as weight, aerodynamic drag, map engine, etc. It is used to predict fuel consumption and CO_2 emissions within a specific driving cycle. OMEGA was developed to correspond requirements of the manufacturers:

a) cost of the technology paid by the consumer,
b) the value which the consumer is likely this place on improved fuel economy,
c) the degree to which manufacturers are prepared to go to meet the CO_2 emission target (EPA, 2009).

The EU framework by 2030 contains the targets for reducing CO_2 emissions by at least 40 % since 1990, which will allow the EU to take cost-effective steps towards achieving long-term targets (2050) for reducing CO_2 emissions by 80-95 % within the framework of emergency reductions based on the Paris agreement (European Commission - 2030 climate & energy framework). The European Union dictates that CO_2 emissions should be reduced to 20 gigatons of CO_2 by the year 2050 (Rohrer, 2007).

Low carbon economy of the EU suggests:

- the EU must reduce GHG by 80 % of the values measured in 1990 by 2050,
- - 40 % by 2030 and 60 % by 2040,

all sectors must be included, - low-carbon transition is feasible and at the same time accessible (European Commission - 2050 low-carbon economy).

These regulations are covered by the White Paper, which also lists several other measures to reduce traffic in the EU. Among them are introduction of more integrated and efficient transport system, accelerated introduction of modern technologies for vehicles and fuel, promoting the use of cleaner modes of transport (European Commission - Transport: EU transport white paper).

Presumed average price of 1 tonne emission credit in 2019 is up to 25 € (energie-portal).

1. Fuel consumption in transport in Slovakia

The year 2016 was the tenth year when both keys motor fuels - gasoline and diesel were sold in Slovakia with bio-components. In particular, due to the efforts of member companies, SAPPO Slovak Republic has fulfilled the stated goal of the Government of Slovakia in the area of biofuel share of fossil motor fuels

The only producer of motor fuels in Slovakia is Bratislava refinery SLOVNAFT. Compared to previous years, the market position of SLOVNAFT products didn´t changed. Export was dominating with the share of almost 70 % in the total sales of main products (gasoline, diesel, primarily plastics). Most of SLOVNAFT's products end on foreign markets. The products of the Slovak refining industry have found their outlets in particular in the

Czech Republic, Austria, Poland, Germany, Romania, Italy, but also in Serbia, Croatia and the Netherlands.

Last year were processed 5.6 million tons of oil. which dropped 3.2 % year-on-year. As a result of lower oil processing, the production of motor fuels decreased year-on-year by 11 000 tonnes to a total of 4 441 thousand tonnes.

The production of automotive gasoline reached the level of 1 388 thousand tonnes (which was 41 thousand tonnes less than in the previous year), representing a year-on-year decrease of 2.9 %. In 2016, the manufacture of diesel fuel amounted to 3 052 thousand tonnes, (which was about 30 000 tonnes more than year ago), translating into a 1 % year-on-year increase. Table 1 shows domestic refinery and petrochemicals production of Slovakia in 2016 and in 2017. (Výročná správa Slovenskej asociácie petrolejárskeho priemyslu a obchodu, 2017)

Table 1. Domestic refinery and petrochemicals production in Slovakia
(ths.tonnes)

Type of fuel	year 2016	year 2017	17/16
Gasoline	1 430	1 388	-2.90 %
Diesel	3 022	3 952	1.00 %

Source: Výročná správa Slovenskej asociácie petrolejárskeho priemyslu a obchodu, 2017 – edited by the authors

In 2016, 1 855 000 tonnes of diesel and 540 000 tonnes of gasoline were sold in Slovakia, but in 2017, 1 928 000 tonnes of diesel where sold, resulting in an increase of 3.90 % compared to 2016 and 548 000 tonnes of unleaded 95 octane fuel, whose consumption grew by 1.50 %.

From the Slovak Associacion of Petroleum Industry and Trade of the Republic of Slovakia were obtained data on the tonnes of fuel consumed in Slovakia, which are shown in Table 2.

Table 2. Total domestic consumption of selected refinery products in Slovakia (ths.tonnes)

Type of fuel	year 2016	year 2017	17/16
Gasoline	540	548	1.50 %
Diesel	1855	1928	3.90 %

Source: Výročná správa Slovenskej asociácie petrolejárskeho priemyslu a obchodu, 2017 – edited by the authors

Imports to Slovakia jumped 7.8 % in diesel imports and 10.2% in gasoline imports compared to the year 2016. Total of 758 000 tonnes of diesel and 166 000 tonnes of gasoline were imported in 2016. Total values in thousands of tonnes are shown in Table 3.

Table 3. Imports of key motor fuels in Slovakia (ths.tonnes)

Type of fuel	year 2016	year 2017	17/16
Gasoline	166	183	10.20 %
Diesel	758	817	7.80 %

Source: Výročná správa Slovenskej asociácie petrolejárskeho priemyslu a obchodu, 2017 – edited by the authors

2. Fuel consumption in transport Slovenia

Since there are no oil deposits in Slovenia as well as refineries for the processing of crude oil, petroleum products used as energy products, including motor fuels, we import them into the territory of Slovenia or acquisition petroleum products from any country, regardless of whether it is a member of the European Union or a third country. Gasoline and diesel are imported from abroad. Due to the geographical location of Slovenia and especially access to the sea, imports from abroad do not represent major obstacles and related costs. Imports into Slovenia are done through wholesalers selling to different customers who sell motor fuels to end users or other market participants through various sales channels (Javna uprava Republike Slovenije za varstvo konkurence, 2017).

In 2016, 1 651 977 401.13 liters of diesel were sold in Slovenia and 566 994 926.89 liters of unleaded 95 octane fuel, or so-called gasoline in Slovenia (Statistični urad RS: Bilanca trdnih, tekočih in plinastih goriv, Slovenija, letno, 2017).

Subsequently, this data was used in calculating of CO_2 emissions and the related value of CO_2 emissions arising from traffic in Slovenia.

3. Calculation and results

To calculate the emissions of CO_2 from the quantity of sold fuel it is necessary to know the amount of CO_2 emissions that are dropped into the atmosphere when consuming 1 liter of diesel and 1 liter of gasoline. So, if you use a liter of diesel, it will produce 2.67 kg of carbon dioxide. Gasoline has a lower carbon content and thus produces 2.42 kg of CO_2 (EN 16258, 2012).

Calculated in tonnes in 2016, CO_2 emissions from diesel and gasoline together amount 7 709 550 tonnes in Slovakia and 5 782 907 tonnes in Slovenia, where approximately 80 % of emissions are produced by the diesel vehicles and 20 % by gasoline.

The average price of the emission credit in 2016 was about 5,76 € for 1 tonne (Ministrstvo za okolje in proctor: Register emisijskih kuponov, 2017).

External costs from transport according to the amount of CO_2 produced in 2016 were 44 407 008 € in Slovakia and 33 309 547 € in Slovenia (Table 4).

Table 4. External costs from transport according to the amount of CO_2 produced in Slovakia and Slovenia in 2016

	External Costs (€)		
	Gasoline	Diesel	∑
Slovakia	10 108 800	34 298 208	44 407 008
Slovenia	7 903 456	25 406 091	33 309 547

Source: Calculation by the authors

Based on the data from the literature on the reduction of CO_2 emissions by 15 % in Slovakia and Slovenia by year 2030, was calculated what a reduction in external costs would be achieved with implementation of the smart industry and using cleaner energy sources. The costs shown below are external costs from CO_2 emissions and are not tied to individuals.

Calculated in tonnes by 15 % reducing of CO_2 emissions from diesel and gasoline together amount 6 553 118 tonnes in Slovakia and 4 915 471 tonnes in Slovenia.

The external costs for reduced amount of CO_2 emissions calculated by presumed average price of 1 tonne emission credit for 2019 (25 €) are in Table 5 and Fig. 1.

Table 5. External costs of 15 % reduced CO_2 emissions from transport in Slovakia and Slovenia calculated by presumed price for 2019

	CO_2 emissions (tonnes)	External Costs (€)
Slovakia	6 553 118	163 827 938
Slovenia	4 915 471	122 886 782

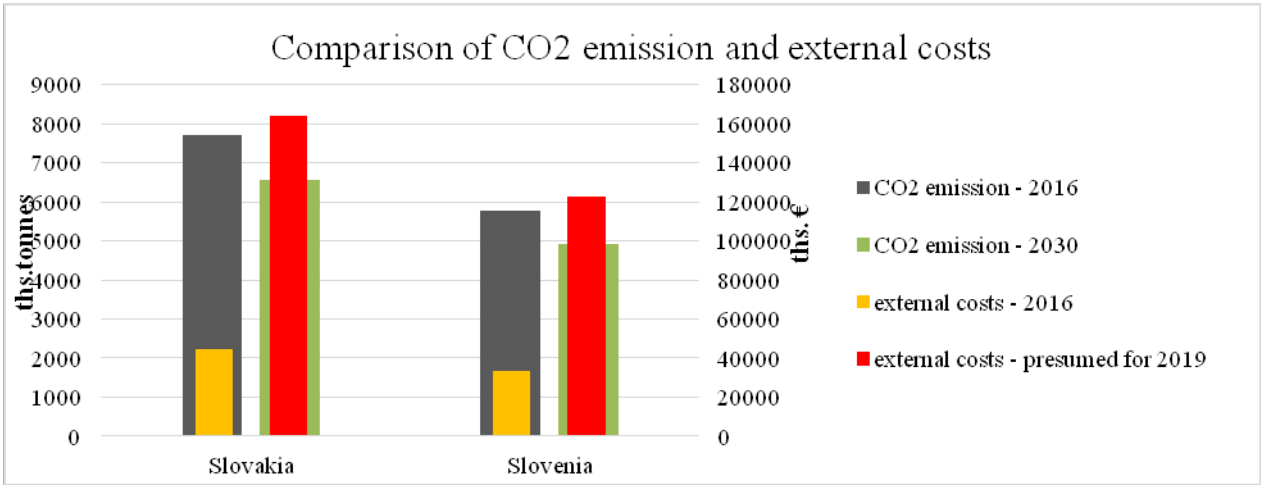

Fig. 1. External costs of 15 % reduced CO_2 emissions from transport in Slovakia and Slovenia calculated by presumed price for 2019

Conclusion

CO_2 is one of the main causes of global warming, which is a major problem in today's world. A substantial proportion of the CO_2 is produced because of exhaust gases in traffic.

It is known that the amount of sold fuel is increasing every year, so the question is, what number of CO_2 production, will be achieved in the next 10 years?

It is known that CO_2 causes many health problems in humans, so it is necessary to be aware of their consequences. How big will these problems be, if the production of CO_2 continues to increase in the coming years.

In the context of the Kyoto Protocol, which was adopted in 1997 with a view to reducing emissions, countries started trading in emission credits. In 2016 the average price of the emission loan was 5,76 €, but it changed drastically from year to year. Presumed average price for 2019 is 25 € for 1 tonne.

Price increasing of 1 tonne of emission credit is faster than reducing of CO_2 emissions in transport, so however emissions of CO_2 by transport decrease, external costs increase.

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