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Influence of Pollutants from Transport on Life Expectancy in the EU Countries

Wpływ zanieczyszczeń pochodzących z transportu na długość życia w krajach UE

Hana Rozehnalová*, Michal Mádr, Lucie Formanová***, Břetislav Andrlík******

Mendel University in Brno, Faculty of Business and Economics,
Zemědělská 1, 613 00 Brno, Czech Republic
**E-mail: xrozehna@mendelu.cz*
***E-mail: xmadr@mendelu.cz, ORCID: 0000-0002-4031-531X*
****E-mail: lucie.formanova@mendelu.cz, ORCID: 0000-0002-8957-8583*
*****E-mail: bretislav.andrlik@mendelu.cz, ORCID: 0000-0002-7352-0774*

Abstract
Road transport has become the major source of environmental pollution and it is also one of the biggest environmental risks in the EU countries. Good air quality is very important for population as pollutants have negative impacts on human health. The paper deals with relationship between air pollutants generated by road transport and the life expectancy in EU countries. At the beginning of the paper the main pollutants from motor vehicles are described and impact on human health is summarized too. We use regression analysis of panel data to analyse the relationship between chosen air pollutants and life expectancy. Our results show negative impacts of nitrogen oxide and sulphur oxide, specifically reduction in life expectancy by 1.49 years for nitrogen oxides and 0.28 years for sulphur oxides with an increase of the pollutant by 1%. So according to our findings economic policy makers should focus primarily on the reduction of nitrogen and sulphur oxides.

Key words: air pollution, life expectancy, human health, NO_x, SO_x

Streszczenie
Transport drogowy stał się głównym źródłem zanieczyszczeń i jednym z największych zagrożeń dla środowiska w krajach UE. Dobra jakość powietrza jest bardzo ważna dla populacji, ponieważ zanieczyszczenia mają negatywny wpływ na zdrowie ludzi. Artykuł dotyczy związku między zanieczyszczeniami powietrza wytwarzanymi przez transport drogowy a oczekiwaną długością życia w krajach UE. Na początku artykułu opisano główne zanieczyszczenia pochodzące z pojazdów samochodowych oraz podsumowano wpływ na zdrowie ludzi. Wykorzystujemy analizę regresji danych panelowych do analizy związku między wybranymi zanieczyszczeniami powietrza a oczekiwaną długością życia. Nasze wyniki pokazują negatywny wpływ tlenku azotu i tlenku siarki na zdrowie, w szczególności na skrócenie oczekiwanej długości życia o 1,49 roku w przypadku zanieczyszczenia tlenkami azotu i 0,28 roku w przypadku zanieczyszczenia tlenkami siarki, przy wzroście zanieczyszczenia o 1%. Zgodnie z naszymi ustaleniami decydenci polityczni powinni skupić się przede wszystkim na redukcji poziomu tych zanieczyszczeń.

Słowa kluczowe: zanieczyszczenia powietrza, długość życia, ludzkie zdrowie, NO_x, SO_x

1. Introduction

Nowadays, air pollution is one of the biggest environmental risks in the Member States of the European Union (EU) and, according to a European Commission opinion poll in the EU-28, it is an area of great concerns and fears after climate change (European Commission, 2017). In the 2019 report, even more than 90% of the world's population lives in an area that does not meet the requirements and recommended values given by the WHO guidelines on air quality (see Air quality guidelines – global update 2005) (HEI, 2019). As a result, particulate air pollution is the thirteenth most common cause of death in the world (Brook, 2008). Awareness of global air pollution is increasing and is a priority on the environmental, political and health agenda (Miller, 2020). The paper provides further arguments, why emissions from road transport should be reduced. The idea of the paper is based on the climate and energy framework, which seeks to strengthen the sustainability of the economy and the energy system in the European countries. This can be achieved by reducing emissions (European Council, 2020).

Regarding the general development of pollutants in the EU-28 in the years 2000 to 2017, it is possible to read the declining trend of pollutant production in all major sectors of the economy – road transport, energy production and distribution, agriculture (EEA, 2019). It is in the transport sector that a decrease in the volume of pollutants generated can be identified, although there has been no decline in the sector, and, conversely, the intensity of passenger, freight and rail transport has increased. This is due to EU regulation, such as stricter EURO emission standards (Commission Regulation (EC) No 692/2008) or requirements concerning the quality of the fuels used (Regulation (EU) 2018/858 of the European Parliament and of the Council) (EEA, 2019). Although there is a decrease in the production of pollutants, transport still accounts for a quarter of greenhouse gas emissions in the EU, and the vast majority of these emissions are caused by road motor transport (European Commission, 2020).

The aim of the paper is to identify the impact of pollutants generated by transport on the life expectancy of the population in EU countries. First, the monitored pollutants are defined and their impact on human health is summarized through empirical literature with an emphasis on economic costs. The methodological part describes the used regression model and the individual variables are justified. The set goal is achieved through regression analysis of panel data using OLS models with fixed effects. The results of the regression analysis are summarized in the Results chapter.

2. Theoretical background

Pollutants are divided into primary and secondary, also depending on the source, the nature of pollutants also differs, they can be substances of natural or anthropogenic origin. Natural sources are considered to be activities that are not under human control and have their origin in nature, such as volcanic activity and the subsequent swirling of dust or forest fires that result in smoke. In connection with transport, anthropogenic sources mean the use of internal combustion engines (EEA, 2019; WHO, 2013; Pöschl, 2005).

Internal combustion engines are the largest consumer of fossil fuels. About 30-40% of the heat in the form of spent fuel is converted into mechanical work and the rest is in the form of exhaust gases (Jadhao and Thombare, 2013).

Emissions of pollutants caused by transport, namely particulate matter (PM), nitrogen oxides (NO_x) and sulphur (SO_x), volatile organic compounds (VOC), ground-level ozone (O_3), carbon monoxide (CO), ammonia (NH_3) and toxic metals are a major contributor to air pollution (European Commission, 2020; EEA, 2019). Together with energy production, these are the main areas with an impact on changes in the composition of the atmosphere and it is the main source of atmospheric aerosols (Kampa and Castanas, 2008; Pöschl, 2005). Specifically, in 2017, in the EU-28, the transport sector contributed the most to NO_x emissions and was also the second largest contributor to these pollutants – black carbon (BC), carbon monoxide (CO), primary fine particulate matter ($PM_{2.5}$) and lead (Pb) (EEA, 2019). Of course, the existence of pollutants also creates negative externalities, i.e. additional costs, and in addition causes damage to buildings, soil, water, the biosphere, and, in addition, damage to human health is an indisputable fact (Maibach et al., 2008).

Air pollution continues to have a lasting impact on the human health of populations across Europe. This fact is confirmed by the EEA (2019) and states that these are mainly urban areas. Air quality is very important for human health, as it can have fatal health consequences leading to premature death. The effects on human health can range from common nausea, difficulty breathing, to the aforementioned premature death. Air pollution manifests itself primarily through cardiovascular or respiratory diseases, as these systems are most susceptible to emerging pollutants (Kampa and Castanas, 2008). Pollutants also lead to exacerbation of pre-existing chronic conditions such as asthma (HEI, 2019; WHO, 2006; Amann, 2008). According to HEI (2019), air pollution is an even more common cause of death than known risk causes, such as malaria, traffic accidents or excessive alcohol consumption.

The most significant pollutants in terms of air quality, human health and its negative impact are PM, NO_2 and O_3 (EEA, 2019; HEI, 2019). Maibach et al. (2008) and U.S. Environmental Protection Agency (2018) in addition to the mentioned substances also lists the remaining oxides of nitrogen, SO_2 and VOC. According to the EEA (2019), exposure to these pollutants in 2016 resulted in a large number of premature deaths – namely $PM_{2.5}$ 374,000 deaths, NO_2 68,000 deaths and O_3 14,000 deaths per year (all in the EU-28). Subsequently, in 2017, air pollution accounted for 4.9 million premature deaths and the loss of 147 million years of healthy life worldwide (HEI, 2019). As for the causes of these 4.9 million premature deaths, the vast majority are chronic non-communicable diseases, such as diabetes, lung cancer or chronic obstructive pulmonary disease. However, air pollution also contributes to the development of communicable diseases such as respiratory infections (HEI, 2019).

The PM consists of a mixture of solid and liquid particles that are held in the air. Of course, particles vary in origin, composition, and size, and are classified according to their aerodynamic properties (Pöschl, 2005; Pope and Dockery, 2006; WHO, 2006). This paper focuses on fine particles ($PM_{2.5}$; particles with an aerodynamic diameter <2.5 μm) and on particles with an aerodynamic diameter <10 μm. The 2.5 μm limit for the determination of fine particles is based on the WHO methodology (2006; 2013).

As mentioned above, cardiovascular disease is very often associated with air pollution. Exposure to air pollutants leads to increasing cardiovascular mortality, mainly due to myocardial infarction, stroke and heart failure (Bourdrel et al., 2017; Shah et al., 2013). Inhalation of pollutants may also promote thrombosis and thus increase the risk of cardiovascular death (Miller, 2020). There is also a direct relationship, with higher and longer exposure to pollution increasing the risk of disease (Bourdrel et al., 2017; Shah et al., 2013). A meta-analysis examining 195 studies concluded that heart failure or death was associated with increasing amounts of CO, SO_2, NO_2, and PM, and did not confirm this relationship in O_3 (Shah et al., 2013).

According to analyses, $PM_{2.5}$ particles are a very risky pollutant, as exposure to high average concentrations of $PM_{2.5}$ over several years is the strongest indicator of mortality, so it is a riskier pollutant than PM_{10} – especially in connection with premature death and cardiovascular or respiratory disease (HEI, 2019; WHO, 2013).

Exposure to PM is ubiquitous and, most importantly, involuntary. These particles are so small that they can penetrate the airways in the chest area. Particle size is crucial for this penetration into the respiratory system. Larger particles such as PM_{10} remain mainly in the upper respiratory tract, and fine or ultra-fine particles have the ability to transport to the alveoli (Kampa and Castanas, 2008).

Taking into account all sources of $PM_{2.5}$, these particles contributed to almost three million premature deaths in 2017. The largest number of deaths was in the world's most populous countries, namely China and India (HEI, 2019). Compared to NO_2 and O_3, it is the largest contributor to premature death in all of Europe. The highest number of deaths due to exposure to $PM_{2.5}$ is related to population, as a large number of deaths are found in the countries with the highest population – Germany, Italy, France, Great Britain (EEA, 2019). In addition to premature death, these fine particles ($PM_{2.5}$) are associated with other diseases – ischemic heart disease, stroke, lung cancer, respiratory infections (e.g. pneumonia) and chronic obstructive pulmonary disease (HEI, 2019; Bourdrel et al., 2017; WHO, 2013). These substances also have an impact on cognitive thinking and disorders, as well as on neurological disorders such as Alzheimer's disease (HEI, 2019).

Differences in human health impacts also differ in terms of exposure to these particles over time. In terms of mortality, short-term exposure is not a large number of deaths. However, estimates of these short-term exposures are subject to concerns about the accuracy and correctness of the estimates. In this case, these are short-term effects, in contrast to long-term exposure, where the effects are cumulative and more permanent (Bourdrel et al., 2017; WHO, 2013; Pope and Dockery, 2006). In any case, a key component, such as the number of particulate matters, their surface area or size, has not yet been discovered to explain the causes of deteriorating health and the effects of PM on human health (Kampa and Castanas, 2008).

Similar effects and impacts on human health are also found for NO_x and SO_x and VOC. It is these gaseous substances, and especially VOC, that are very strongly related to road transport, as they are the main anthropogenic source of these pollutants (Brunekreef and Holgate, 2002; Kampa and Castanas, 2008). All the mentioned gaseous pollutants mainly affect the respiratory system (Kampa and Castanas, 2008). They manifest themselves in the form of emerging symptoms of bronchitis, affecting the function of the respiratory system and lung function, inflammation and a higher susceptibility to respiratory infections or asthma (Chen et al., 2007; Kurt et al., 2016; WHO, 2018). In the cardiovascular field, there is a higher number of hospitalizations and a higher mortality or worsening of pre-existing cardiovascular disease (Ghorani-Azam et al., 2016; WHO, 2018). In addition, eye irritation or cancer may occur (Kampa and Castanas, 2008; WHO, 2018).

Ammonia (NH_3) could be considered as a specific element. It reacts strongly to form aerosols as it is dispersed and incorporated into these aerosols and then makes up 30% to 50% of the total weight of $PM_{2.5}$ and PM_{10} (Anderson et al., 2003; Seinfeld and

Pandis, 2016; Skjøth and Geels, 2013). It therefore manifests itself through PM and can be considered a substance that affects human health. Thus, although NO_x and SO_x are reduced, PM is still formed due to the existence of NH_3 (Aneja et al., 2009). Although the main source of NH_3 is agriculture – livestock and domestic animals, fertilizers, soil, forest fires (Anderson et al., 2003; Bouwman et al., 1997; Skjøth and Geels, 2013), transport is also one of the sources of this gas (Anderson et al., 2003; Kean et al., 2009).

In addition to health impacts, air pollution also has economic impacts, which, however, are closely related to health status. On the one hand, there is increasing expenditure on the necessary medical care, it also leads to a shortening of lives, reduced labour productivity, which will be reflected in the performance of the whole economy or costs associated with efforts to reduce emissions (EEA, 2019; Korzhenevych et al., 2014). Health care expenditure should be spent as efficiently as possible. Increasing life expectancy leads to both improvement in the quality of life and declining health care costs. Thus, there is an improvement in health as important indicator of life quality (social aspect of sustainability) and an increase in the robustness of the health care system (economic aspect of sustainability). For more details see Drastichová and Filzmoser (2020).

In terms of the economic cost of air pollution worldwide, the amount is estimated at $ 2.9 trillion, representing 3.3% of world GDP (McCarthy, 2020). In the EU-28, the total cost of pollution is estimated at € 33.36 billion – € 24.79 billion for diesel cars and € 8.58 billion for petrol-powered cars. Following the withdrawal of the United Kingdom from the EU, the values changed to € 23.1 (diesel) and € 7.9 (petrol) billion (van Essen et al., 2019).

Furthermore, in particular, the costs of damage caused by the main pollutants from transport are on average for EU countries for $PM_{2.5}$ from € 28,108 tonne (rural areas) to € 270,178/tonne (urban areas), € 10,640/tonne for NO_x and € 10,241/tonne for SO_2. The values are certainly not negligible, and a way should be found to reduce these pollutants (Korzhenevych et al., 2014).

Despite increasing urbanization, problematic lifestyle changes or the complexity of policy decisions, anthropogenic sources of pollutants should be reduced, and this reduction should be a key goal in reducing the burden of disease (Miller, 2020).

3. Research objective and methodology

Regression analysis of panel data is used to fulfil the objective of this paper. Specifically, the impact of individual pollutants caused by transport on human health is analysed. The explained variable representing human health is life expectancy at birth (*L_E*). This variable expresses the number of years a newborn should live if the prevailing mortality patterns remain the same throughout his life, according to the World Bank methodology (The World Bank, 2020a). This indicator is one of the most common expressions of human health in the empirical literature, namely Bayati et al. (2013), Brunekreef (1997), Fotourehchi (2016), Krewski (2009).

The explanatory variables are pollutants that appear in the air as a result of the use of motor vehicles. Pollutants are divided into particulate matters according to size and gases (O'Neill et al., 2003). Specifically, we distinguish between particulate matters with a diameter of up to 2.5 μm (variable *PM25*) and particulate matters with a diameter of up to 10 μm (variable *PM10*). In the case of compounds with oxygen, oxides of sulphur (variable *S_O*) and nitrogen (variable *N_O*), ammonia (variable *A*) and volatile organic compounds (variable *VOC*) are monitored. This breakdown is based on Eurostat's methodology according to the Nomenclature for Reporting (NFR 14) classification (Eurostat, 2020a) and the European Environment Agency (EEA, 2019). All indicators are measured in tonnes per calendar year and the source of pollution is road transport. Monitoring the impact of individual pollutants is the main benefit of this paper, as many papers focus only on total air pollution (e.g. Bayatti et al., 2013), distinguish between PM_{10} and CO_2 (Fotourehchi, 2016) or analyse only one factor (e.g., $PM_{2.5}$; Apte et al., 2018; Hill et al., 2019; Pope et al., Ezzati a Dockery, 2009). We assume that pollutants reduce life expectancy and thus negatively affect human life expectancy. In regression models, individual pollutants are tested separately. Separate modelling of pollutants in individual equations is given by a large dependence between individual pollutants, i.e. the risk of multicollinearity (the correlation coefficients range from 0.66 to 0.96).

The following socio-economic factors are selected as control variables – median age (*MEDIAN_AGE*), gender (*SEX*), level of education (*EDUC_X*), GDP per capita (*GDP_p_c*), size of health care expenditure (*E_GDP*). All variables were selected based on a literature review of modelling air pollution and health dependence and their determinants (see Bayati et al., 2013; Blazquez-Fernández et al., 2017; Brunekreef, 1997; Fotourehchi, 2016; Hill et al., 2019; Kabir, 2008; Krewski, 2009; Mondal and Shitan, 2014).

The distribution of population by age and sex is a basic demographic breakdown that should not be omitted (Bilas et al., 2014; Brunekreef, 1997; Fotourehchi, 2016; Hill et al., 2019; Krewski, 2009; Mondal and Shitan, 2014). This variable is represented by two variables, the median age of the population (*MEDIAN_AGE*) and the relative proportion of men in the population (*SEX*). We expect a positive effect at the median age, while a higher proportion of the male population should have a negative effect. These variables are obtained from Eurostat (Eurostat, 2020b).

Another important factor influencing life expectancy is the level of educational attainment (for more details see Bayati et al., 2013; Blazquez-Fernández et al., 2017; Brunekreef, 1997; Brunekreef and Holgate, 2002; Hill et al., 2019; Kabir, 2008). The authors work with basic and university education, because here we can assume different impacts on human health in accordance with the literature. Specifically, people with a basic education live to a younger age than people with a university degree. At the same time, let us add that secondary education is omitted due to multicollinearity. Education indicators are expressed as the relative share of persons with primary (ISCED level 0-2; *EDUC_1*) and higher education (ISCED level 5-8; *EDUC_3*) in the age group 15 to 64 according to the Eurostat methodology (Eurostat, 2020c).

Another selected factor is the level of GDP per capita expressed in purchasing power parity by conversion to the international dollar with a base period in 2017 according to the methodology of the World Bank (The World Bank, 2020b). The Eurostat database is not used in this case due to the unavailability of data for Romania from 1995 to 2001. According to the results of a study on life expectancy in EU countries (EU 28) from 2001 to 2011, GDP per capita and educational attainment explained over 70% of the differences in life expectancy at birth (Bilas et al., 2014). According to Kabir (2008), there is also a connection that countries with a low level of GDP per capita have a lower life expectancy. This variable is one of the most commonly used control variables (for more details, see Bayati et al., 2013; Bilas et al., 2014; Blazquez-Fernández et al., 2017; Fotourehchi, 2016; Chaabouni et al., 2016; Sufian, 1989).

The last control change is the size of public expenditure on health care using the Eurostat methodology (Eurostat, 2020d) – National Accounts Indicator (ESA 2010) and also the specific classification of government functions (COFOG 1999). To enable comparison, this variable is expressed as a share of gross domestic product (*E_GDP*). For this variable, we assume that life expectancy will be higher in countries with higher health expenditures (e.g. Bayati et al., 2013; Blazquez-Fernández et al., 2017; Fotourehchi, 2016; Chaabouni et al., 2016). According to Kabir, this is even one of the key factors (Kabir, 2008).

The basic method is regression analysis of panel data. The examined set contains 28 cross-sectional units (EU Member States) and 23 time periods (1995–2017). For panel data, a model with fixed or random effects can be used. The Hausman test was used to decide which method was more appropriate. The test indicated the suitability of the model with fixed effects (the Chi square is 50.47 with a p-value of 0.00).

The preference for a model with fixed effects also has a theoretical rationale, because we can assume individual fixed effects across countries. As part of the econometric verification, stationarity was gradually tested (Levin-Lin-Chu test, IPS and Fisher test), homoscedasticity (Wald test) and autocorrelation (Wooldridge test). The problem of nonstationarity was solved by including the first differences in non-stationary variables. Non-stationary variables were gender, median age, and VOC. Both models of fixed effects contain heteroscedasticity (Wald test) and serial autocorrelation (Wooldridge test), i.e. violation of the assumptions of the classical linear model. Since there are more cross-sectional units than time units, the clustering condition seems to be a suitable tool, as stated by Hoechle (2007). After these modifications, the models no longer contain any shortcomings. For a better interpretation of the values, the variables showing the pollution were converted to a logarithm. The final regression model can be expressed by the following equation:

$$LE_{i,t} = \beta_0 + \beta_1 logX_{i,t} + \sum(\beta_k Controls)_{i,t} + \omega_{i,t} + \varphi_{i,t} + \varepsilon_{i,t}$$

where *i* represents individual EU member states, *t* denotes individual years, $LE_{i,t}$ is life expectancy at birth, $logX_{i,t}$ is set of variables representing individual pollutants ($PM_{2,5}$, PM_{10}, N_O, S_O, A, VOC; logarithmic functional form); $\sum(Controls)_{i,t}$ is set of control proxies (Median age of the population in first difference; Proportion of men in the population in first difference; GDP per capita; Proportion of people with primary education; Proportion of people with tertiary education; Proportion of public health expenditures in GDP), $\omega_{i,t}$ captures year fixed effects, $\varphi_{i,t}$ captures country fixed effects, and $\varepsilon_{i,t}$ is an unobserved error term.

4. Results and discussion

The following chapter presents the results of regression analysis and compares these outputs with the current empirical literature.

Looking at the control variables, we can consider the economic level (gross domestic product per capita), higher education and the size of public expenditure on health care as the main factors influencing life expectancy. All three variables have the expected positive effect, i.e. people in more developed countries live to an older age (Blazquez-Fernández et al., 2017), while people with a university degree have a healthier lifestyle, greater awareness of their health and preventive ways to improve it (Fotourehchi, 2016) as well as higher public health spending increases life expectancy through better available care (Blazquez-Fernández et al., 2017; Fotourehchi, 2016). On the contrary, we can consider the median age of the population and the proportion of men as statistically insignificant factors, which may be due to the fact that we work with data at the macroeconomic level that insufficiently capture the variability of men's behaviour in relation to their health.

Table 1. Influence of individual pollutants on life expectancy in EU countries, *source:* Authors' calculation.

Life Expectancy	(1)	(2)	(3)	(4)	(5)	(6)
const	72.33 *** (20.33)	88.42 *** (26.36)	87.26 *** (14.08)	71.68 *** (37.59)	70.64 *** (21.11)	69.9 *** (29.72)
d_SEX	−0.55 (-0.68)	-0.54 (-0.67)	-0.2 (-0.23)	0.21 (0.24)	-0.56 (-0.69)	-0.49 (-0.55)
d_MEDIAN_AGE	0.39 (1.45)	0.37 (1.4)	0,54 ** (2.28)	0,45 ** (2.35)	0.33 (1.38)	0.34 (1.34)
GDP_p_c	0.09 *** (3.15)	0.09 *** (2.88)	0.1 *** (4.22)	0.08 *** (3.60)	0.08 *** (3.28)	0.09 *** (3.53)
EDUC_1	0.04 (-1.26)	-0.21 *** (-6.64)	-0.03 (-1.19)	-0.01 (-0.36)	-0.05 (-1.54)	-0.05 (-1.52)
EDUC_3	0.16 *** (4.47)	-0.17 *** (-4.67)	0.12 *** (4.5)	0.15 *** (6.14)	0.17 *** (3.99)	0.16 *** (4.95)
E_GDP	0.34 *** (2.99)	0.35 *** (3.08)	0.26 ** (2.24)	0.28 ** (2.37)	0.36 *** (3.16)	0.4 *** (3.22)
logPM25	-0.26 (-0.6)					
logPM10		-0.17 (-0.36)				
logN_O			-1.49 ** (-2.66)			
logS_O				-0.28 *** (-2.86)		
logA					-0.04 (-0.14)	
d_logVOC						0.34 (1.07)
R^2 (within)	0.84	0.84	0.87	0.87	0.84	0.84
Number of observations	578	578	556	556	556	578

Notes: (.) denotes t-statistic, */**/*** means a significance level at 10 %/5 %/1 %; R2 means an adjusted (within) R-squared

The results indicate a statistically insignificant effect of particulate matters of both sizes (*PM25, PM10*), ammonia (*A*) and volatile organic compounds (*VOC*). This means that we have not been able to prove that these substances have a negative effect on human health. These results differ us from Apte et al. (2018) and Fotourehchi (2016), which may be due to the fact that their research was focused on developing countries, i.e. greater (statistically significant) impacts may be due to lower socio-economic levels of the countries (Fotourehchi, 2016) or because these countries is among the most polluted (Apte et al., 2018). Another reason may be a different concept of pollution, as this paper analyses the level of pollution, while, for example, Pope et al., Ezzati and Dockery (2009) identified a positive effect of reducing pollution.

On the other hand, our results show that we can observe negative impacts in the case of nitrogen oxide (*N_O*) and sulphur oxide (*S_O*). For nitrogen oxides, this is the impact in the form of a reduction in life expectancy by 1.49 years with an increase of the pollutant by 1% and for sulphur oxides by 0.28 years with an increase of the pollutant also by 1%. These substances therefore confirmed the assumption that pollutants from transport reduce the life expectancy, but only in the case of the mentioned gaseous substances. These findings also complement the research of Koolen and Rothenberg (2019), according to which efforts to reduce nitrogen oxides should be the main goal in reducing emissions. The reduction of nitrogen oxides is also one of the six goals of environmentally sustainable transport, since reducing these emissions has positive effects on both the environment and the life quality (Wiederkehr et al., 2004). Darçın (2017) also makes claims about the better subjective well-being of individuals in society and a better quality of life as a result of policies based on the reduction of nitrogen and sulphur oxides. So, we can see direct link between reducing nitrogen and sulphur oxides and environmental and health sustainability.

Conclusion

The aim of the paper was to identify the impact of pollutants generated by transport on the life expectancy of the population in EU countries. The paper focuses on the 28 EU Member States from 1995 to 2017. The set goal was achieved through regression analysis of panel data (OLS with fixed effects).

The results indicate that the negative impact of pollutants on human health has not been confirmed in the form of reduced life expectancy for all pollutants, however, models involving nitrogen and sulphur oxides have confirmed this negative relationship. Therefore, it is not possible to conclude from the results of the performed testing whether air pollutants adversely affect human health or not. The knowledge gained from these models can therefore only be evaluated in such a way that nitrogen oxides and sulphur oxides reduce the expected lifetime and the remaining pollutants (both particulate matter sizes, ammonia, volatile organic compounds) do not confirm this relationship. While in the case of particulate matter this paper differs from the existing literature, in the case of nitrogen oxides our findings point to the need to reduce these emissions (for more details see Koolen and Rothenberg, 2019).

As transport is a very important contributor to air pollution, the actions of economic policy makers should lead to the reduction of this pollution, for example through the introduction of environmental elements in the construction of taxes and charges related to motor vehicle operation or legislation in this area. Existing legislation on the greening of transport in the EU and its strategies should continue to be harmonized in order to achieve the most effective result that promotes greater greening of road transport. However, in line with the findings of the above-mentioned research in our paper, economic policy makers should focus primarily on the reduction of nitrogen and sulphur oxides. These statements are consistent with the idea of sustainable transport in the context of economic, social, and environmental development (Mihyeon and Amekudzi, 2005), in which transport should not cause damage to human health or the environment. There are several ways in which economic policy makers can influence the level of pollutants emitted.

Technically, the amount of nitrogen oxides could be reduced by adjusting the conditions of combustion, such as design modifications or changes in combustion technology and sulphur oxides would be changes in the quality of fuel used. These requirements would be feasible on the part of the EU in the form of directives or regulations. A possible solution would be to include sulphur oxides in the emission EURO standards, so it would be possible to influence the amount of these harmful gases in a direct way.

Another way to reduce the production of nitrogen and sulphur oxides is in the field of alternative propulsion. This may involve supporting car manufacturers or regulating them or providing incentives to transport users. It also offers support for electromobility as such.

State support for fleet renewal is also one of the options. According to Andrlík (2013), the possibility supporting the start of fleet renewal is a significant restriction of vehicles that have above-average production of pollutants, in the form of tax and fee instruments. The level of emissions is related to the renewal of the vehicle fleet, as newly manufactured cars meet the latest established EURO emission standards. This fact is also confirmed in his paper by Andrlík (2012; 2014), who focuses on the element of CO_2 emissions caused by transport and the possibilities of eliminating this negative externality of transport. Furthermore, the tightening of conditions for technical inspections.

In the area of taxes and regulations, one of the appropriate solutions is to affect people who pollute the air as a result of the operation of motor vehicles, by charging for the use of motor vehicles and infrastructure in the form of appropriate taxes or fees. Polluters should therefore pay for these externalities, and fees or taxes are one way of internalising negative externalities. A concrete example could be the introduction of a toll for the use of all types of roads for all types of vehicles or the differentiation of road taxes and tolls (for more details see Andrlík and Zborovská, 2019). Furthermore, the inclusion of emissions in the tax base, such as carbon dioxide emissions from passenger cars in the United Kingdom, Sweden and Germany, which shows signs of environmental taxation and takes into account the impact on the environment (ACEA, 2019).

The main limitation of the paper can be considered the fact that the analysis is performed at the macroeconomic level and thus, the individual variables are aggregated. As part of further research, the issue could be extended to conditional effects, such as income inequality (Hill et al., 2019; Kampa and Castanas, 2008) or different effects in urban and rural areas (Sadorsky, 2014; Sufian, 1989).

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