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Astrida Miceikienė[*]
Vytautas Magnus University

Daiva Rimkuvienė[**]
Vytautas Magnus University

Kristina Gesevičienė[***]
Vytautas Magnus University

ASSESSMENT OF THE ENVIRONMENTAL POLLUTION DETERMINANTS IN THE ECONOMY SECTORS OF LITHUANIA

Keywords: environmental pollution, sectors of economic activity, GHG.

J E L Classification: Q52, Q56.

Abstract: The research provides substantiation for the problem of environmental pollution in Lithuania on the basis of the increase in the greenhouse gas (GHG) emissions in the country's individual economy sectors. The research aims at assessing the GHG emissions of individual sectors of economic activities with reference to the key econo-

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[*] Contact information: astrida.miceikiene@vdu.lt, Vytautas Magnus University, Faculty of Bioeconomy Development, Universiteto str.10-428, Akademija, Kaunas distr. LT 53361, Lithuania, phone: +37065680908; ORCID ID: https://orcid.org/0000-0003-1432-7971.

[**] Contact information: daiva.rimkuviene@vdu.lt, Vytautas Magnus University, Faculty of Bioeconomy Development, Universiteto str.10-428, Akademija, Kaunas distr. LT 53361, Lithuania, phone: +37061422787; ORCID ID: https://orcid.org/0000-0003-3145-3697.

[***] Contact information: kristina.geseviciene@vdu.lt, Vytautas Magnus University, Faculty of Bioeconomy Development, Universiteto str.10-428, Akademija, Kaunas distr. LT 53361, Lithuania, phone: +37068552727; ORCID ID: https://orcid.org/0000-0002-1547-858X.

mic indicators of the respective sectors. The performed analysis of the GHG emissions and their determinants in Lithuania has not shown any common trends in GHG emissions and determining factors among the economic activities. The environmental taxes do not perform the goals set for these taxes, while investments into environmental protection have generated a positive effect only in the economic activities of water supply; sewerage, waste management and remediation. The relationship between GDP and GHG emissions is significant for certain economic activities only.

Introduction

In light of the globally increasing environmental pollution and rapid increase in the use of natural resources, environmental protection has been given increasingly greater consideration. The problems of pollution, use of natural resources and climate change are one of the key problems in many developed and developing countries, as their solution determines not only the health of the population, but also economic growth of the entire country. The environmental taxes have been introduced to promote development of the national economy and protect the environment, as such taxes are imposed on the negative environmental impact and, at the same time, promote investments into new environmentally friendly technologies (The 2030 Climate And Energy Framework, 2014).

Global warming is referred to as one of the major consequences of the reckless exploitation of the environment. The battle against global warming and environmental damage have become a universally recognized issue. Climate change puts the key elements of human life, such as access to water, food production, health, and use of land and environment, at risk globally (Stern & Taylor, 2007; Edenhofer, 2015; Kovats, Menne, McMichael, Corvalan & Bertollini, 2000). The Kyoto Protocol was signed to mitigate global warming, committing the countries to reduce the emissions into the atmosphere. In 2015, the Paris Agreement was signed, whereby the developed countries committed to undertaking expedient and effective measures for the shift to low-carbon technologies, and the developing countries committed, to the best of their abilities, to contribute to reduction of the atmospheric pollution (The Paris Agreement, 2015). However, even after two years from the Paris Agreement, the carbon dioxide emissions continue to rise, fossil fuel continues to be the major type of energy used, and the growing demand continues affecting the natural resources, acute ecosystem degradation accelerates, intensity of water stress increases,

and air and water pollution continues to increasingly exert the health impacts (OECD, 2017).

Although Lithuania has reduced the environmental pollution indicators, including the GHG emissions as one of the key indicators, since the restoration of its independence, the problem is particularly relevant at present due to the climate change consequences related to the effect of environmental pollution on these consequences.

Researchers have been analysing the causes, scopes and trends of environmental pollution as a climate change determinant. However, there are very few studies on environmental pollution dedicated to changes in the economic indicators and environmental pollution in individual sectors of economic activity, and they have not been substantiated with empirical data and are focused on identification of prospective common trends. In their research assessing the link between the economic indicators and variation of environmental pollution, the researchers propose taking the GHG amount as the indicator offering the best description of the phenomenon, as this is one of the key pollution indicators globally. The GHG amount includes CO_2, sulphur oxide (SO_2), methane (NH_4), nitrogen oxide (N_2O) and other components according to the base referred to in the Kyoto Protocol (Morley, 2012; Im & Cho, 2010; Jackson, 2009 and others).

The research aim is to assess the GHG emissions by individual sectors of economic activity in Lithuania and their variations compared to variations in the key economic indicators of the sectors.

Research objectives:

1. To provide theoretical substantiation of the relevance of the problem of environmental pollution.
2. To identify the economic determinants of the GHG emissions.
3. To identify the link between the GHG emissions by the individual sectors of economic activity and key economic indicators of these sectors.

To substantiate the research problem, general scientific research methods, such as literature analysis and synthesis, have been used. The empirical study was conducted by using the statistical information and correlation analysis method. The method of graphic imaging was used to visualize the research results.

Research results and discussions

At present, the major share of the global population lives in the countries using more resources than can be provided by the ecosystem present on the territories of the countries. Efforts to reduce environmental pollution are cost-intensive. The financial resources and investments allocated to these efforts are the main prerequisites enabling long-term changes. In the majority of industrial countries, about 1.5-2% of the GDP are spent on reduction of pollution and preservation of the nature. The more the nation spends on preservation of the environment and reduction of pollution, the lower the damage (Patterson III, 2000).

Primary greenhouse gases, carbon dioxide (CO2), methane (CH4) and nitrogen oxide (N2O), are emitted into the atmosphere as a result of various human activities, e.g., power supply, industry, transport, commercial and residential buildings. Moreover, agricultural and forest management activities may have considerable effect on the GHG emissions.

In the recent decade, the pace of growth of the GHG emissions has increased. The anthropogenic GHG emissions have increased by 90 % compared to the period 1970 to 2010. In the last decade of the period, the GHG emissions hit the highest mark in human history. CO2 emissions from fossil fuel and industrial processes accounted for about 78 % of the total GHG emissions in the recent decades (OECD, 2017). Agriculture, deforestation and land use change are other causes of the GHG emissions. Their share in the global GHG emissions reached 24 % in 2010 (OECD, 2010).

It is sought to contain the increasing environmental pollution by various agreements, international documents which are mandatory to Lithuania as well. In December 2012, the Kyoto Protocol countries adopted an amendment to the Kyoto Protocol at the Climate Change Conference in Doha. Under the Doha Amendment to the Kyoto Protocol, the countries committed to reduce the GHG emissions to 80 % of what they were in the base year (mostly 1990) from 1 January 2013 to 31 December 2020. This goal is sought by implementation of the adopted legal acts under the EU's 2020 Climate Change and Energy Package.

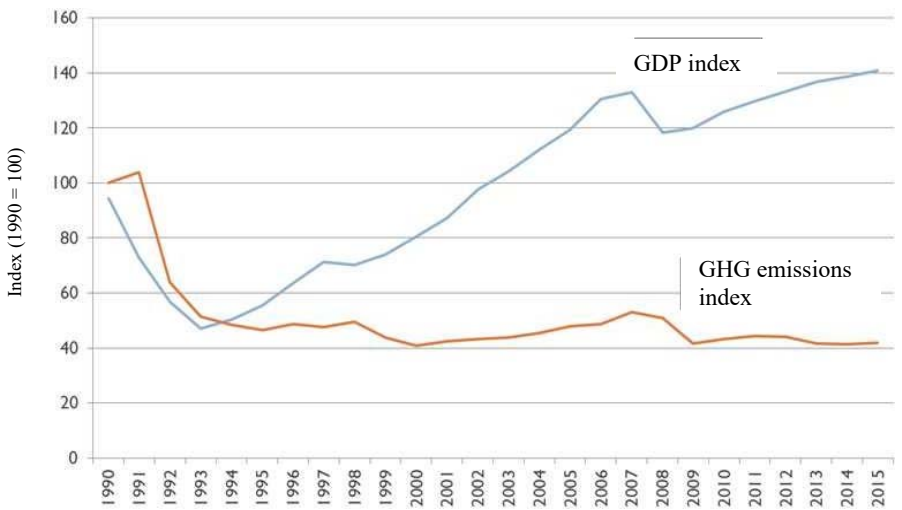
With the view towards the Paris Agreement, the European Council adopted the decision in relation to the EU's 2030 Climate and Energy Policy Framework in 2014. The Framework provides for the mandatory target of the EU to cut the GHG emissions inside of the EU by at least 40 % from the 1990 levels by 2030

(The EU's 2030 Climate and Energy Policy Framework, 2014). Implementation of the target has been planned EU-wide in the economically most efficient way.

The common mandatory target defined in the EU's 2030 Climate and Energy Policy Framework will also create conditions for implementation of the Paris Agreement. In December 2015, the UNFCCC countries agreed on the legally binding climate change agreement which determines the GHG emission reduction commitments from 2021. The countries have agreed to pursue joint efforts to keep the average global temperature rise well below 2°C above pre-industrial levels and limit the further global warming to 1.5°C (The Paris Agreement, 2015). It was planned that the Paris Agreement would enter into force as soon as ratified by at least 55 countries, covering at least 55 % of the global GHG emissions. The threshold was reached on 5 October 2016, and the Paris Agreement entered into force in 2016.

During the independence period, Lithuania decoupled between economic growth and growth of environmental pollution. Nonetheless, the level of GHG emissions continues to be fairly high in Lithuania (figure 1). This supports the relevance of the present research.

Figure 1. Lithuania's GDP and GHG emissions index 1990-2015



Source: information by the Ministry of Environment of the Republic of Lithuania: Policies & Measures and Projections of Greenhouse Gas Emissions in Lithuania.

To assess the effect of the determinants on variation in the GHG emissions, the present research builds on the links proposed by the Intergovernmental Panel on Climate Change and researchers (Edenhofer, 2015; Miceikienė & Čiulevičienė, 2016; Miceikienė, Čiulevičienė, Rauluškevičienė, & Štreimikienė, 2018; Anthony, Misselbrook, Chadwick, Moorby, Crompton, Topp & Williams, 2018 and others), interlinking the GHG emissions, direct factors, main factors and policies as well as measures.

Production and consumption growth per capita are one of the key factors promoting growing global GHG emissions. Average global economic growth expressed in GDP per capita increased by 100% in the period 1970 to 2010 (AR5 Synthesis Report, IPCC, 2014). Despite the decreasing energy intensity in the developed and large developing countries largely stimulated by changes in technology, economic structures, combination of diverse energy sources, global energy consumption per capita in the period 1970 to 2010 still increased by 130 % as a result of the population growth.

Population growth promotes increase in the GHG emissions worldwide. Global population growth was 87 % in the period 1970 to 2010. Ageing, household size and other demographic changes have indirect effect on the amount of emissions, but this effect is lower than the direct effect caused by the change in the population size (OECD, 2017).

Technological innovations and their dissemination promote general economic growth, but also determine economic intensity of production and carbon intensity of energy. Choices for the infrastructure have a long-term effect on emissions, as the infrastructure and technologies chosen by the industrial countries after the World War II continue to influence present global GHG amounts. Robotization transforms human work, new-generation technological innovations are implemented, the number of people occupied in individual sectors of economic activity is decreasing. However, there is the question whether decrease of environmental pollution in the robotization process can be associated with the changes in the number of employed populations.

According to B. Morley (2012), investments into environmental protection are also a very important indicator and should be included into the assessment of environmental pollution. On one hand, the variable of investments into environmental pollution would be expected to have a negative connection, as the increasing investments would facilitate access to more advanced, energy-saving production technologies. On the other hand, with the emissions into the atmosphere increasing, investments into environmental protection should be in-

creased up to a certain breakeven point representing the level, from which the amount of pollutants starts decreasing.

Environmental taxes are considered to be one of the available ways to address the GHG issue (Miceikienė et al., 2018; Cherry, Kallbekken & Kroll, 2012; Čiulevičienė & Kožuch, 2015; Ekins & Speck, 2011; Wu & Tal, 2018). The principles of economics also suggest that reducing the amount of emissions to the degree that the marginal utility of reduction is equal to the marginal costs is the most economically efficient way to reduce the GHG emissions (Gillingham & Stock, 2018).

The research methodology and the course of the research process

When considering the processes taking place in the surrounding environment, it is important to realize the cause-and-effect relationships between the state of the environment and the processes influencing it, have reliable indicators available, and know how apply the environmental measures.

In order to analyse environmental pollution and processes related to the phenomenon and happening around us, it is necessary to understand the cause and effect relationships between the environmental condition and processes acting on it, have reliable indicators, and know how to apply environmental measures. The research methodology builds on the cause-and-effect relationship, where the country's economic indicators determining the changes in the environmental pollution are the cause, and the GHG emission is the effect.

The research deals with the case of Lithuania.

Research period: 2008–2016. The present research analyses the link between the GHG emission and GDP, employment rate, investments, environmental taxes in individual sectors of economic activity. Independent variables were selected on the basis of scientific literature (Čiulevičienė & Kožuch, 2015; Miceikienė et al., 2018; Wu & Tal, 2018).

The research data were taken from the Database of Statistics Lithuania.

To assess the link between the GHG emission and other variables, the pair-correlation method has been employed. In view of the nature of the data used in the study, the pair correlations were subject to assessment based on the Spearman's rank correlation coefficient. The Spearman's correlation coefficient shows the strength of the monotonic relationship, whether linear or not, between the observed variables. In contrast to the Pearson correlation coeffi-

cient, the Spearman's correlation coefficient is recommended for interval variables, for which the assumption of normality is not satisfied. The data were analysed using statistical package R version 3.4.0 (R Core Team, 2017).

Research results

Carbon dioxide is the main GHG in Lithuania. In 2017, the actual CO_2 emissions, excluding the contribution of the land use, purpose change, and forestry sector (LUPCF), was lower compared to 1990 by 63.3 %. Compared to 2014, the CO_2 emissions increased by 2.1 %, including the LUPCF, and by 17.5 % excluding the LUPCF. Energy sector was the major source of the CO_2 emissions and accounts for about 79.3 % share in the total CO_2 emissions. Compared to 2014, the CO_2 emissions by the energy sector increased slightly (by 0.004 %) in 2015, the CO_2 emissions by the energy companies reduced by 0.8 %, while the CO_2 emissions by transport increased by 5.5 %.

Methane was the second GHG by its magnitude, accounting for the 16.8 % share in the country's total GHG emissions (excluding the LUPCF). The major sources of methane emissions were the agricultural sector, accounting for the 56 % share in 2015; waste sector – 29 %, and volatile emissions from petroleum and natural gas activity – 9 %. The CH_4 emissions in agriculture were generated by fermentation in the intestine of livestock and manure management, accounting for the 48 % and 8 % shares respectively in the country's total CH_4 emissions (excluding the LUPCF).

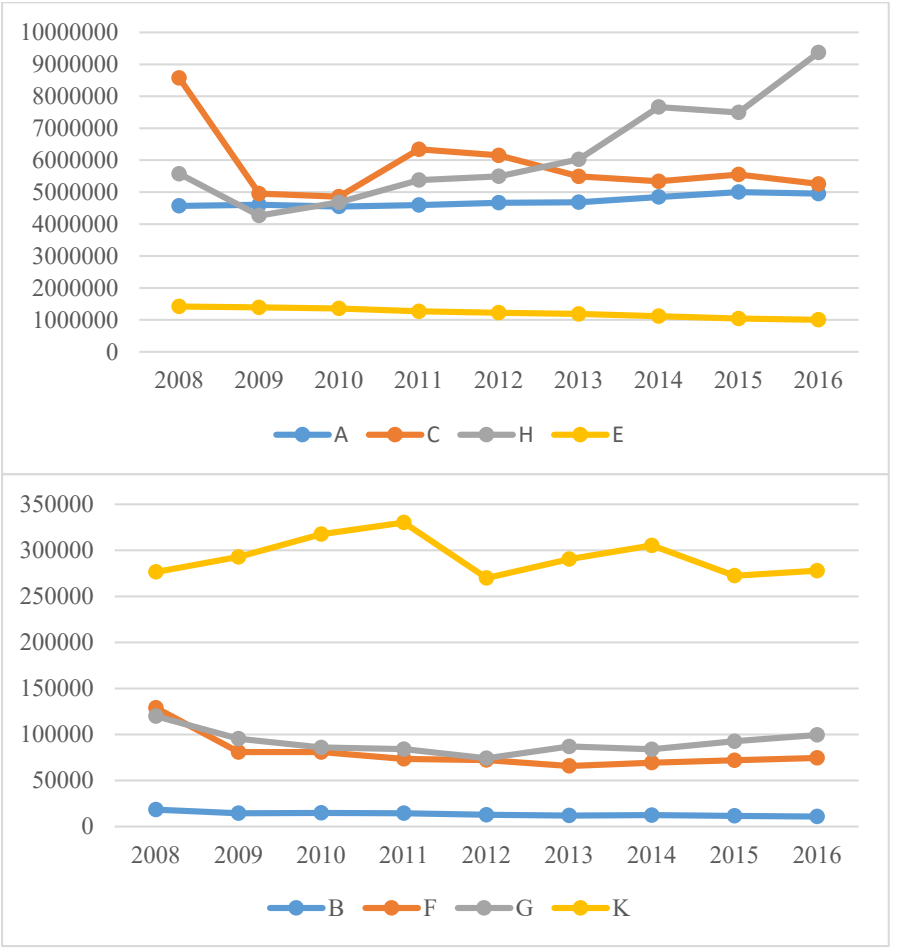
Nitrogen suboxide accounted for the 15.4 % share in the country's total GHG emissions (excluding the LUPCF). Agriculture was the main source of N_2O, accounting for the 85 % share in the total N_2O emissions in 2015. Compared to 2014, N_2O by the agricultural sector increased by 2.4 %. The second major source of N_2O is nitric acid production. It accounted for the 8 % share in the total N_2O emissions (Lietuvos šiltnamio efektą sukeliančių dujų tendencijos Europos Sąjungos (EU-27) kontekste, 2011).

In 2015, the share of fluorinated gases in the country's total GHG emissions was 2.4 %. Within the 1993 –2015 period, the fluorinated gas emissions increased considerably. The main driver of this upward trend was the replacement of the ozone depleting substances (ODS) with fluorinated gases in many areas of application.

In the period analysed, the largest GHG emissions were generated by transportation and storage activities (H), the smallest – mining and quarrying (B). The highest GDP and employment rates were generated in the financial and insurance economic activity (K) branch, the lowest – in the mining and quarrying (B) branch. The largest amounts of environmental taxes are paid by wholesale and retail trade businesses and repair of motor vehicles and motorcycles businesses (G), the smallest – by mining and quarrying businesses (B). It can be noticed that the agriculture, forestry and fishing businesses (A), transportation and storage businesses (H) and manufacturing (C) generated the highest GHG emissions in the period analysed. Moreover, the data analysis has shown that, in the period 2008-2016, generation of the GHG emissions increased in agriculture, forestry and fishing and, in particular, in transportation and storage businesses. Minor downward trends can be noticed in other branches (figure 2).

Analysis of the strength of the relationship between the variables by branches (table 1), in the case of agriculture, forestry and fishing (A), has suggested positive and medium relationship between the GHG and GDP as well as taxes. In the case of water supply; sewerage, waste management and remediation activities (E), statistically significant and strong negative relationship has been registered between the GHG emissions and GDP, and negative relationship between the GHG emissions and investments. In the case of activities of wholesale and retail trade and repair of motor vehicles and motorcycles (G), medium positive relationship between the GHG and employment rates has been registered. In the case of construction (F), there is a negative relationship of medium strength between the GHG emissions and environmental taxes. In the case of transportation and storage activity (H), there is a strong positive relationship between the GHG emissions and GDP, employment rate and investments.

Figure 2. GHG emissions in economic activities (kt $C0_2$ eq)



A – agriculture, forestry and fishing, B – mining and quarrying, C – manufacturing, D – electricity, gas, steam and air conditioning supply, E – water supply; sewerage, waste management and remediation activities, F – construction, G – wholesale and retail trade; repair of motor vehicles and motorcycles, H – transportation and storage, K – financial and insurance activity.

S o u r c e : made by the authors, information by Statistics Lithuania: Official Statistics Portal.

Table 1. The Spearman's correlation coefficients of the GHG emissions and other variables

Economic activity	Correlation coefficient and *p* –value			
	GDP	Employment rate	Investments	Environmental taxes
A	**0.6883** (*0.0424*)	0.3000 (*0.4328*)	0.1333 (*0.7324*)	**0.6833** (*0.0424*)
B	0.0500 (*0.8984*)	0.2167 (*0.5755*)	-0.1833 (*0.6368*)	-0.4770 (*0.1942*)
C	0.1333 (*0.7324*)	0.2333 (*0.5457*)	0.3667 (*0.3317*)	0.3000 (*0.4328*)
E	**-0.9000** (*0.0009*)	-0.5167 (*0.1544*)	**-0.6000** (*0.0876*)	-0.4000 (*0.2861*)
F	-0.1667 (*0.6682*)	0.3500 (*0.3558*)	0.0167 (*0.9661*)	**-0.7667** (*0.0159*)
G	0.0667 (*0.8647*)	**0.7000** (*0.0358*)	---	0.3500 (*0.3558*)
H	**0.8833** (*0.0016*)	**0.8833** (*0.0016*)	**0.8000** (*0.0096*)	-0.4500 (*0.2242*)
K	-0.5167 (*0.1544*)	-0.4667 (*0.2054*)	---	-0.2000 (*0.6059*)

A – agriculture, forestry and fishing, B – mining and quarrying, C – manufacturing, D – electricity, gas, steam and air conditioning supply, E – water supply; sewerage, waste management and remediation activities, F – construction, G – wholesale and retail trade; repair of motor vehicles and motorcycles, H – transportation and storage, K – financial and insurance activity.

S o u r c e : made by the authors, information by Statistics Lithuania: Official Statistics Portal.

The presented results suggest that, in the cases of B, C and K, the correlation coefficients are statistically insignificant.

The correlation analysis has suggested the conclusion that no common trends among all the economic activities have been found for the GHG emissions and their determinants in Lithuania. The environmental taxes do not perform the goals set for these taxes, and positive effect of the investments into environmental protection was generated only in the water supply; sewerage, waste management and remediation activities. Whereas no statistically significant relationship has been found in certain cases, the research needs to be continued, and other determinants of the increasing GHG emissions need to be explored.

Conclusions and recommendations

1. Environmental pollution measured as the GHG emissions has increased by 90 % in the recent decade compared to the period 1970 to 2010 and was the largest in the human history. In Lithuania, the GHG emissions decreased compared to the beginning of the Independence, but the problem of pollution volumes remains relevant. The largest polluters are the transportation, manufacturing and agricultural sectors.
2. The researchers analysing the causes of the increase in the GHG emissions point at the following main economic indicators: GDP, employment rates, investments, and environmental taxes. The present research has analysed the effect of these factors on the GHG emissions in individual sectors of economic activity.
3. The main GHG in Lithuania are carbon dioxide accounting for about 64% share in the total GHG emissions. Methane is the second GHG by magnitude, accounting for % of the country's total GHG emissions. Nitrogen suboxide accounts for 15 % of the country's total GHG emissions. In the period analysed, the highest level of the GHG emissions was generated by the transportation and storage businesses, the lowest – mining and quarrying activities.
4. Comparison of the GHG emissions of the main economic activities in Lithuania to the economic indicators of the respective activities has shown no common trends among the activities for the GHG emissions and their determinants. The existing environmental taxes do not perform the goals set or these taxes, and positive effect of the investments into environmental protection was generated only in the water supply; sewerage, waste management and remediation activities. In the majority of economic activities, no significant relationship between the covered indicators has been found; therefore, further research is needed to identify the factors which determine the increase in the GHG emissions.

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