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Expenditure from provincial environmental protection and water management funds vs. pollution reduction

Abstract: The aim of this study is to examine the factors influencing changes in the emission of gaseous pollutants in the voivodeships in Poland in the years 2014–2023. The work uses the logarithmic mean method of the Divisia index, also referred to as the LMDI (Logarithmic Mean Divisia Index). The research carried out showed that increase in expenditure from provincial funds for environmental protection and water management for atmospheric air and climate protection results in a reduction of gaseous pollutant emissions in a given voivodship.

Keywords: environmental expenditure, pollutant emissions, air protection

Introduction

The main effect of humanity's increasingly intensive economic activity around the world is the emission of greenhouse gases, chemical pollutants and fertilizers, which in turn causes the degradation of ecosystems (Linnenluecke 2016, p. 124–125). Therefore, various types of actions are taken as part of environmental protection policies around the world. It should be emphasized that significant changes have been noticeable in this respect over the last few decades. In the 1960s and 1970s, the tendency in this policy was to use tools based on command and control. However, in the 1990s and early 21st century, the situation in this respect changed dramatically, as incentive-based policy instruments became more and more common (Oates, Portney 2001, p. 25–27).

In recent years, due to noticeable climate changes, there has been a general change in the approach to environmental protection, with intensified efforts to reduce the negative impact on the climate and the environment. There is a noticeable spread of the concept of sustainable development around the world. The

implementation of the principles of this concept resulted in the need to revise the approach to both the development of effective solutions supporting pro-environmental initiatives and the financing of sustainable investments (Sobik 2023, p. 289). An important role in this respect is played by properly conducted fiscal policy, which may contribute to an increase in the rate of return on green projects and an increase in the share of the private sector in investments in these projects (Sachs et al. 2019, p. 6).

Therefore, as part of the implementation of the concept presented above, various tasks in the field of environmental protection are carried out, requiring the provision of appropriate sources of financing. Extremely important in this respect are projects aimed at reducing pollutant emissions, improving energy efficiency, developing low-emission technologies and renewable energy sources, popularizing ecological public transport, as well as promoting new consumption patterns (Kozera et al. 2022, p. 1–2). It should be emphasized that the implementation of this policy limits the adverse impact of business activities on natural resources by reducing greenhouse gas emissions, leading to a reduction in the level of environmental pollution (Liu et al. 2022, p. 1). Intensifying the process of implementing environmental protection policy reduces the energy intensity of the economy and promotes energy efficiency by reducing specific energy consumption and limiting resource waste (Yang 2021, p. 1).

Based on international research, studies by numerous authors (including Islam, Lopez 2014, Huang 2018, Yang 2021, Donkor et. al. 2022) emphasize that the increase in public spending on environmental protection reduces air pollutant emissions. Research by other authors (including Nath, Madhoo 2022, Li et. al. 2023, Wei et al. 2023) also shows that fiscal expenditure on research and development has positive impact on the development of green technological innovations, which are related to, among others, with devices contributing to the reduction of atmospheric pollutant emissions. This type of research is very popular, including: in the USA, China, but also in Northern Africa and Southern Africa.

The instruments that can be implemented to reduce pollutant emissions include end-of-pipe technologies (e.g. catalytic converters, filter systems, etc.) or regulatory and financial instruments (e.g. low emission zones, subsidies, etc.) through legislative acts (Maione 2021, p. 1150). For the proper implementation of tasks in this area, it is necessary to systematically identify the appropriate organizations along with defining the sources and principles of financing this type of projects. In accordance with Polish legal regulations, the National Fund for Environmental Protection and Water Management, together with funds at the provincial level, plays a key role in this respect (Sikorski 2015, p. 149).

When conducting financial policy in the field of environmental protection, Poland is based mainly on the “polluter pays” principle. According to this principle, the obligation to finance environmental protection projects rests with the entity using environmental resources and making changes to it. However, this does not mean a complete abandonment of external financial support. It occurs when there is difficulty in identifying a specific entity causing environmental

damage – then part of the financing burden may be taken over by central or local authorities (Kožuch 2018, p. 75).

The Polish system of financing environmental protection is based on the expenditure of funds obtained, among others, from: from fees for the use of the environment, administrative penalties and taxes and other public levies in the field of environmental protection. These funds are allocated to investment projects aimed at reducing the level of environmental pollution. The previously mentioned fees and penalties are transferred to both the National Fund for Environmental Protection and Water Management presented at the beginning of this part of the work and the provincial funds for environmental protection and water management, as well as to the budgets of local governments (Sękulski, Żuchowski 2018, p. 2).

The aim of this study is to examine the factors influencing changes in the emission of gaseous pollutants in the voivodeships in Poland in the years 2014–2023. The data used in the study come from the Local Data Bank of the Central Statistical Office. The work uses the logarithmic mean method of the Divisia index, also referred to as the LMDI (Logarithmic Mean Divisia Index).

The essence of ecological funds in Poland

One of the most important and inevitable challenges for highly developed and developing countries is the transition to a low-emission economy (Kiuila, Lewczuk 2021, p. 249). Poland is one of the countries where electricity generation is largely dependent on the availability of fossil fuels. The large-scale use of conventional energy sources inevitably leads to environmental pollution. Due to the above, it is necessary to take various types of actions aimed at broadly understood protection of the natural environment.

Conducting effective and efficient environmental protection activities requires guaranteeing appropriate sources of financing, especially when infrastructure investments are carried out that are characterized by high capital intensity. The environmental protection system in Poland is financed using numerous instruments and institutions, as well as legal provisions specifying the principles of obtaining and using financial resources in order to improve the quality of the natural environment (Burchard-Dziubińska, Burzyńska 2023, p. 121). The institutions operating within the above-mentioned system in Poland include primarily ecological funds.

There is no legal definition of the term “ecological fund” in the current legislation. Despite this, this concept is often used by various institutions in their official documents and publications. Moreover, related terms such as “environmental fund” or “environmental protection fund” are often used within this concept. However, it is important to emphasize the apparent lack of consistency in the use of the above terms (Barczak, Kowalewska 2014, p. 42–43).

The literature on the subject points out that ecological funds are created to guarantee the independence of the sources of financing for pro-ecological projects

from the state budget. They are characterized by specialization, manifested in the financing of precisely defined tasks based on public resources collected from specific sources. The proceeds of these funds come from, among others: from ecological fees paid by economic entities or financial penalties imposed for excessive environmental pollution. These funds finance environmental protection projects in the form of grants and preferential loans (Toruński, Wyrębek 2010, p. 19).

The most important ecological funds in Poland include:

- National Fund for Environmental Protection and Water Management,
- provincial funds for environmental protection and water management,
- Forest Fund (Toruński, Wyrębek 2010, p. 19).

Tasks carried out by provincial funds for environmental protection and water management in Poland and sources of their financing

The effective implementation of measures aimed at increasing air protection depends to a large extent on the structure of the system. The entities covered by the air protection system against pollution operate at the level of central administration and regional and local administration. Considering the central level, the Ministry of Climate and Environment is responsible for national legal regulations in the field of air protection. The Ministry of State Assets deals with energy policy, while the Chief Inspectorate for Environmental Protection is primarily responsible for informing the public about the state of the environment. In the Polish air protection system, the important role of the Environmental Protection and Water Management Funds should be emphasized, both at the central level (National Fund for Environmental Protection and Water Management) and regional level (Provincial Funds for Environmental Protection and Water Management).

The main task of the Provincial Funds for Environmental Protection and Water Management is to financially support activities aimed at environmental protection. The institution's mission, i.e. supporting projects implemented for the natural economy, is fulfilled through, among others, active participation in fulfilling the ecological obligations that Poland accepted when joining the European Union. The most important task of the Fund is not only to co-finance investments, but also to properly manage the Fund's finances. The organization's individual tasks are included in the business plan and on the list of priority projects, which are updated every year (WFOŚiGW – Jakie ma zadania? Czym się różni od NFOŚiGW?).

Provincial funds for environmental protection and water management carry out tasks in the field of:

- atmosphere protection,
- protection of the earth's surface,
- water protection,
- water management,

- ecological education,
- nature conservation,
- monitoring,
- preventing environmental threats (Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej w Warszawie 2023, p. 14).

It is worth paying special attention here to aspects related to the sources of financing for the above-mentioned tasks. The basis for the financial management of provincial funds for environmental protection and water management is the annual financial plan, and the method of its management must ensure full use of funds from the European Union budget, which are non-refundable and intended for environmental protection and water management (Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska, 2023, art. 400q, ust. 2, 3). Provincial funds for environmental protection and water management may receive subsidies from the state budget within the scope specified by law, and they also have the right to take out loans and credits (Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska, 2023, art. 401, ust. 4, 6). The sources of income of these units also include, among others:

- revenues from environmental fees and administrative fines,
- voluntary contributions, donations, bequests, receipts and benefits in kind from foundations, as well as proceeds from initiatives and projects for environmental protection and water management,
- funds from the EU budget and other funds from foreign sources, non-repayable,
- revenues from the issue of own bonds (Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska, 2023, art. 401, ust. 1, 2, 3, 5).

The role of provincial funds for environmental protection and water management in Poland in reducing atmospheric pollutant emissions

When discussing the role of provincial funds for environmental protection and water management in Poland in reducing the emission of atmospheric pollutants, it is worth taking a look at the structure of the subsidy granted based on the own funds of selected provincial funds for environmental protection and water management, paid in 2022. The structure includes separate funding for water protection and water and sewage management, air protection, land surface protection and waste management, as well as other areas, which include, among others: nature protection, ecological education, and prevention of serious accidents and environmental threats. The structure of co-financing granted from the provincial funds for environmental protection and water management in Poznań, Kraków, Warszawa and Katowice was analyzed in detail on the Figure 1. These structures show a significant advantage of co-financing in the field of water protection, water and sewage management, and air protection, which significantly contributes to the reduction of atmospheric pollutant emissions in a given voivodship.

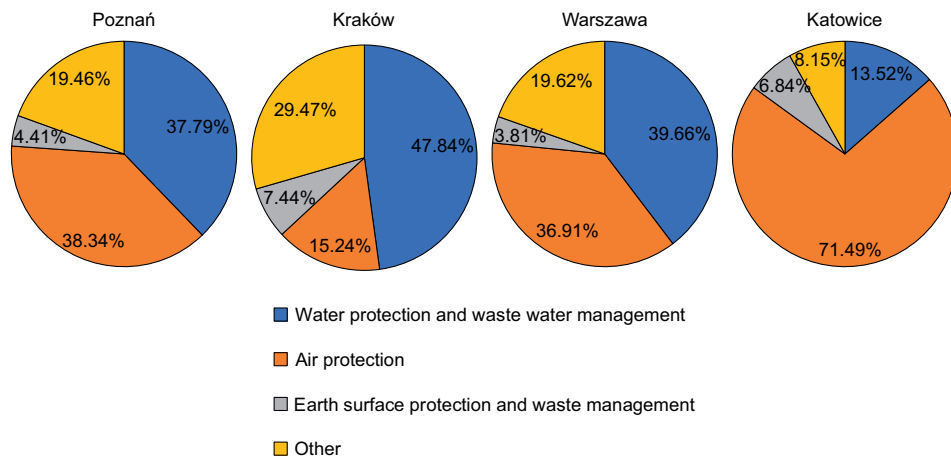


Fig. 1. Structure of the subsidy granted based on own funds of selected provincial funds for environmental protection and water management paid in 2022

Source: own study based on the Reports on the activities of the provincial funds for environmental protection and water management in Poznań, Kraków, Warszawa and Katowice for 2022.

Purpose and research method

The aim of this paper is to examine the factors influencing changes in the emission of gaseous pollutants in the voivodeships in Poland in the years 2014–2023. The data used in the study come from the Local Data Bank of the Central Statistical Office (GUS, Bank Danych Lokalnych). The work uses the logarithmic mean method of the Divisia index, also referred to as the LMDI (Logarithmic Mean Divisia Index). The starting point for this method is very often the Kaya identity, which is used to analyze phenomena related to emissions. It allows for the decomposition of a given phenomenon into established causal factors, thanks to which it is possible to analyze a number of scenarios in detail and compare them. It should be noted that the discussed identity does not describe the cause-and-effect relationship, and the identified causal factors are characterized by mutual interconnection (Piontek, Sidorczuk-Pietraszko 2008).

The LMDI method was proposed by Ang et al. (1998) and has many advantages that distinguish it from other decomposition methods. It is relatively simple to use and allows for obtaining a perfect decomposition, i.e. it does not leave a residual factor, which would significantly complicate the interpretation of results (Ang 2004, p. 1135). It should also be noted that the decomposition formulas always take the same forms, regardless of the number of factors considered in the study (Ang 2015, p. 237). This method is also consistent in aggregation, which means that the estimates of effects at the subgroup level can be aggregated to obtain the appropriate effect at the group level (Ang 2005, p. 870).

The LMDI method can be divided into two types: LMDI-I decomposition (Ang et al. 1998, Ang, Liu 2001) and LMDI-II decomposition (Ang, Choi 1997). For both of the above-mentioned approaches, both additive and multiplicative

models are used. In additive decomposition analysis, the arithmetic (or differential) change of the aggregate indicator is decomposed, and the aggregate change and decomposition results are given in physical units. In the case of multiplicative decomposition analysis, the change of the aggregate indicator is decomposed. In this approach, the aggregate change and decomposition results are expressed in indices (Ang 2015, p. 234).

The additive model of LMDI-I decomposition was used in this research. By making appropriate modifications and adjustments to the needs of the research, an equation was created illustrating the relationship between the emission of gaseous pollutants in a given voivodeship and individual factors that may affect the change in the emission level of these pollutants on an annual basis. This equation takes the following form:

$$EmP_g = \frac{EmP_g}{APE} \times \frac{APE}{GDP} \times \frac{GDP}{Pop} \times Pop$$

where:

- EmP_g – annual emission of gaseous pollutants in a given voivodship,
- APE – annual expenditure on air and climate protection from a given provincial funds for environmental protection and water management,
- GDP – annual gross domestic product in a given voivodship,
- Pop – population in a given year in a given voivodship.

In the LMDI-I method, explanatory variables are also factors that affect a given explained variable. By using this method, it is possible to estimate the strength and direction of the impact of individual factors on the examined explained variable. In order to achieve greater clarity in the notation of subsequent formulas used in the method selected for research, individual factors will be recorded with appropriate symbols:

$$\frac{EmP_g}{APE} - \text{emission factor } (x_1)$$

$$\frac{APE}{GDP} - \text{expenditure factor } (x_2)$$

$$\frac{GDP}{Pop} - \text{GDP per capita factor } (x_3)$$

$$Pop - \text{population factor } (x_4)$$

The strength and direction of the impact of individual factors ($X_{n-effect}$) on the explained variable, i.e. the change in the level of annual emission of gaseous pollutants in a given voivodship, can be estimated using the following formulas:

$$X_{1-effect} = \frac{EmP_g^t - EmP_g^0}{\ln \frac{EmP_g^t}{EmP_g^0}} \times \ln \frac{x_{1t}}{x_{10}}$$

$$X_{2-effect} = \frac{EmP_g^t - EmP_g^0}{\ln \frac{EmP_g^t}{EmP_g^0}} \times \ln \frac{x_{2t}}{x_{20}}$$

$$X_{3-effect} = \frac{EmP_g^t - EmP_g^0}{\ln \frac{EmP_g^t}{EmP_g^0}} \times \ln \frac{x_{3t}}{x_{30}}$$

$$X_{4-effect} = \frac{EmP_g^t - EmP_g^0}{\ln \frac{EmP_g^t}{EmP_g^0}} \times \ln \frac{x_{4t}}{x_{40}}$$

where:

- $X_{n-effect}$ – the impact of the n-factor on the annual emission of gaseous pollutants in a given voivodship
- EmP_g^t – annual emission of gaseous pollutants in a given voivodship in year t
- EmP_g^0 – annual emission of gaseous pollutants in a given voivodship in the previous year, i.e. $t-1$
- x_{nt} – the n-factor in year t
- x_{n0} – the n-factor in the previous year, i.e. $t-1$

Based on a review of the literature on the subject (Islam, Lopez 2014, Huang 2018, Yang 2021, Donkor et al. 2022, Nath, Madhoo 2022, Li et al. 2023, Wei et al. 2023) the following research hypothesis was formulated in the study:

An increase in expenditure from provincial funds for environmental protection and water management for atmospheric air and climate protection results in a reduction of gaseous pollutant emissions in a given voivodship.

Results of the conducted research

The applied calculation method enables the decomposition of the studied emission value of gaseous pollutants by isolating individual factors influencing its changes and determining their value (positive or negative). For the purposes of the study, the following factors were distinguished: emission, expenditure, GDP per capita and population.

Figure 2 presents the results of the decomposition analysis, illustrating the accumulated effects of the identified factors influencing the changes in the

emission of gaseous pollutants in individual voivodships. For greater clarity of the obtained results, the graph is presented in percentage terms. At the beginning it should be noted that in most voivodships there was a decrease in the level of gaseous pollutant emissions in the period under review. The exceptions are kujawsko-pomorskie, lubuskie, opolskie and świętokrzyskie voivodships.

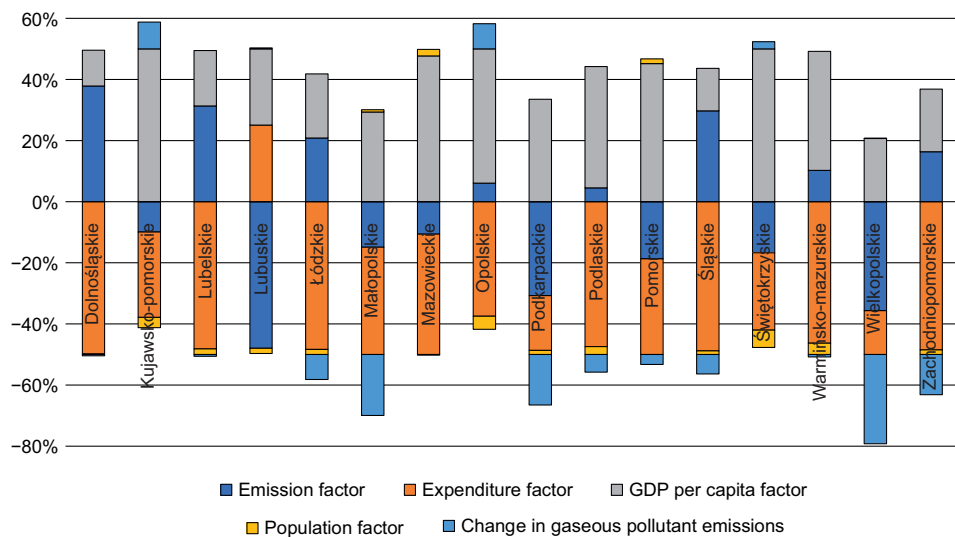


Fig. 2. Accumulated effects of the identified factors influencing the changes in the emission of gaseous pollutants in individual voivodships of Poland in 2014–2023
Source: own study.

For this study, it is crucial to observe the results of the expenditure factor ($X_{2-effect}$). In all voivodships (except for lubuskie voivodship), this factor has a negative effect, which means that it contributed to reducing the level of greenhouse gas emissions in a given voivodship. This factor has the strongest negative effect in zachodniopomorskie, śląskie and łódzkie voivodships.

The emission factor ($X_{1-effect}$) is characterized by a wide range in terms of the strength and direction of the impact on the level of gaseous pollutant emissions in all provinces. In eight of them, this impact is positive (the strongest in dolnośląskie and lubelskie voivodships), contributing to an increase in the level of gaseous pollutant emissions, while in another eight, this impact is negative (the strongest in lubuskie and wielkopolskie voivodships), contributing to a decrease in the level of gaseous pollutant emissions.

The impact of the GDP per capita factor ($X_{3-effect}$) can be assessed unequivocally. A positive impact was noted in all voivodships, which means that this factor causes an increase in the level of gaseous pollutant emissions. This factor had the strongest impact in świętokrzyskie, kujawsko-pomorskie and mazowieckie voivodships. The population factor ($X_{4-effect}$) had the weakest impact on the level

of gaseous pollutant emissions in a given voivodeship out of all the factors studied, and this impact was mainly negative.

Conclusion

The aim of this paper was to examine the factors influencing changes in the emission of gaseous pollutants in the voivodeships in Poland in the years 2014–2023. Particular attention was paid to the relationship between expenditure on air and climate protection from provincial funds for environmental protection and water management and the emission of gaseous pollutants. Based on the conducted research, the following research hypothesis were verified:

An increase in expenditure from provincial funds for environmental protection and water management for atmospheric air and climate protection results in a reduction of gaseous pollutant emissions in a given voivodeship – was confirmed. With the increase in the value of the expenditure factor (x_2), i.e. expenditure from provincial funds for environmental protection and water management on air and climate protection in relation to the GDP of a given voivodeship, the emission of gaseous pollutants decreases.

The only exception is the lubuskie voivodeship, where the above-mentioned regularities do not apply.

It should be mentioned here that the conducted study has certain limitations. It focuses only on selected factors, while the emission of gaseous and particulate pollutants also depends on other factors, e.g. the energy intensity of a given voivodeship. Another significant limitation was the limited availability of quantitative data that could potentially be used to construct factors influencing the studied explanatory variable.

The presented research does not fully exhaust the research area covered. They constitute a prelude to further, in-depth analyses. A proposed direction for further research in this area may be to check, how specific financial support programs from provincial funds for environmental protection and water management (e.g. “Clean Air Program” or “My Electricity”) affect the quality of atmospheric air in individual voivodeships. Another aspect that should be taken into account in future research is to take into account other important factors affecting the level of environmental pollution, such as: EU subsidies, regulations and expenses on research and development.

Conflict of interest

The author declares no conflicts of interest and assures that the work is the result of his own creation.

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Wydatki z wojewódzkich funduszy ochrony środowiska i gospodarki wodnej a redukcja zanieczyszczeń

Zarys treści: Celem opracowania jest zbadanie czynników wpływających na zmiany emisji zanieczyszczeń gazowych i pyłowych w województwach w Polsce w latach 2014–2023. W pracy wykorzystano metodę średniej logarytmicznej wskaźnika Divisia, zwanego również LMDI (Logarithmic Mean Divisia Index). Badania wykazały, że zwiększenie wydatków z wojewódzkich funduszy ochrony środowiska i gospodarki wodnej na ochronę powietrza atmosferycznego i klimatu skutkuje zmniejszeniem emisji zanieczyszczeń gazowych i pyłowych w danym województwie.

Słowa kluczowe: wydatki na ochronę środowiska, emisja zanieczyszczeń, ochrona powietrza