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DETERMINANTS OF THE EXPENDITURE SIDE OF ENVIRONMENTAL FEDERALISM – PANEL DATA RESEARCH ON COUNTRIES IN EUROPE

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ABSTRACT: The purpose of the article is to examine the influence of financial, socio-economic, and environmental degradation factors on the expenditure scope of environmental federalism. The panel data models were estimated based on 26 European countries for the period between 2007 and 2020. The research hypothesis of the article posits that the sound fiscal position of the local government and the financial sustainability stemming from it deepens the expenditure side of environmental federalism, especially when considering the population and its structure, the size of the economy, population, and the pollution generated by it. The article reveals that local government avoidance of both deficits and excessive indebtedness ends up promoting a higher scope of expenditure side of environmental federalism. In addition, in European countries, the significance of expenditures on environmental protection visible in local budgets is increased for smaller economies that are less environmentally degraded.

KEYWORDS: expenditures, environmental protection, environmental federalism, local government, Europe

Introduction

In literature, scholars indicate the necessity of boosting public spending on environmental protection (Postula & Radecka-Moroz, 2020). Simultaneously, the spending policy should preserve the principles of sound public finance, i.e., fiscal discipline, allocative efficiency, and cost-effectiveness (Peszko, 2002). The fiscal discipline is aimed at controlling total government expenditures, both at the central and local government levels, to decrease the risk of unsustainable deficits and unstable macroeconomic conditions. In turn, allocative efficiency often brings the best outcome of prioritising competing claims of various social objectives such as education, health services, or the environment, taking into consideration limited public funds. In contrast, cost effectiveness implies achieving objectives at minimum cost, which requires autonomy in the field of management and finance.

Simultaneously, the concept of fiscal federalism was developed to indicate the possibility to increase efficiency in the public sector through fiscal decentralization (Oates, 2008) and the division of public functions. The basics of greater local government autonomy rests on arguments that local government: (Hallett, 2017) (a) has more precise information on local needs/conditions; (b) can adjust the policy to local circumstances; (c) is more accountable. The decentralization of the fund's allocation may lead to more efficient levels of public output due to the fact that expenditure decisions are tied more closely to real resource cost (Jha, 2015), which also concerns environmental policy. Therefore, theorists are developing the idea of an environmental federalism that is linked to environmental policymaking (Steurer & Clar, 2015) and the concept of decentralization. Hu et al. (2021) underline that institutional structure is important for the governing of environmental policies and, therefore, can have a significant impact on environmental quality.

In literature, multiple studies concentrate on the effects and the efficiency of public expenditures on environmental protection (Wójtowicz et al., 2022; Barak & Tunç, 2022; Barrell et al., 2021; Gholipour & Farzanegan, 2018). The sectoral issues are analysed here, as well as the characteristics of the expenditures in the local budgets, e.g., values, aims, and functions (Beke-Trivunac et al., 2014; Broniewicz, 2007). In addition, according to the findings of Guo et al. (2020) fiscal decentralization may negatively affect the reduction of environmental pollution. However, the decentralization of expenditures exacerbates local environmental pollution less significantly than the decentralization of revenues. Therefore, deepening environmental federalism through controlling the decentralization of revenues and increasing the decentralization of expenditures can play a key role in stimulating economic growth and

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ameliorating environmental pollution. The credibility of the government's fiscal position is critical for the enhancement of sustainable growth, in cases where public expenditures should support more efficient resource use (Gupta et al., 2002). At the same time, considering the international perspective, there is a lack of surveys that analyse factors affecting the distribution of funds for environmental protection in the budgets of local governments. Therefore, the aim of this article is to examine the influence of financial, socio-economic, and environmental degradation determinants on the scope of expenditures of environmental federalism in local governments, on the basis of 26 European countries (Table 1). This paper attempts to extend the knowledge about the factors which influence the significance of expenditures on environmental protection in local public budgets and the predictors of the local governments' expenditures on environmental protection within the general expenditures of the government sector at large. The research hypothesis of the article posits that the sound fiscal position of the local government and the financial sustainability stemming from it deepens the expenditure side of environmental federalism when taking into account the population and its structure, the size of the economy, and the extent of the pollution generated by it.

Literature review

In economics and finance, the concept of environmental federalism advocates delegating authority over environmental regulations concerning public goods to local governments (Hu et al., 2021). This refers to the debate about the 'optimal' level of government at which environmental policymaking should be assigned (Fisch, 2018). Thus, environmental federalism concerns studies that analyse the relationships between fiscal decentralization (both the revenue and expenditure side) and environmental pollution (Cai et al., 2022). This stems from the view that environmental protection is closely related to the decentralization of the government (Guo et al., 2020). The researchers investigated legal and financial issues related to the decentralization of environmental tasks, functions and policies. Subsequently, Nath and Madhoo (2022) applied the term 'environmental fiscal federalism', thus emphasising the core issue of environmental federalism, i.e. its financial dimension. The financial aspect can, in turn, be analysed in terms of revenues (e.g. the possibility of implementing environmental fees and taxes, the level of state transfers for environmental policy) and expenditures (e.g. the significance of expenditures on environmental protection in the local budgets). As a result, the scientists highlighted the positive aspect of devolution (taxes, expenditures, environmental standards, etc.), as subnational units compete for mobile residents (research of Ch. M. Tiebout) and possible efficiency of

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the local environmental authority with interjurisdictional competition for capital is found (research of W. E. Oates & R. M. Schwab) (Millimet, 2014). On the other hand, the fiscal policy of local public units might be less efficient in comparison to the centralized approach, because local authorities may reduce environmental standards to decrease the costs of pollution control for new private entities that incorporate within their borders (Oates, 1999). Hence, environmental federalism should provide for the geographic patterns of benefits and costs (Oates, 1997). Therefore, common minimum environmental standards are necessary to prevent potential excessive negative externalities, i.e. in the field of production and consumption (Gruber, 2016), destructive interregional competition, and excessive discounting of future environmental damage (Cumberland, 1980). Kitchen et al. (2019) note that area-wide environmental protection practices are indispensable if local governments are to prevent their neighbouring units from neglecting their environmental responsibilities. Therefore, an optimal approach to environmental federalism could be to allow sub-national units to protect local environmental interests and to adjust policies and instruments to local concerns, while the central government would set common standards, provide funding and expertise, and address interlocal issues (Butler & Macey, 1996). Local authorities are also crucial in ensuring that conservation programs are flexible enough to address local needs and circumstances, and in tailoring them to socioeconomic and environmental conditions (Teets et al., 2021). Therefore, Assetto et al. (2003) claim that environmental protection is the sphere in which democratization might be expected to promote decentralization and capacity accrual by local governments.

Considering the scope and the division of environmental tasks between the various levels of public authorities, economic and political circumstances which create the institutional framework should be analysed. Abbott and Jones (2022) estimated that government environmental protection expenditures are procyclical. Their cyclicality can be explained by systematic changes in the intensity of political pressures to raise government expenses. In economic upturns, there is a pressure to increase government environmental expenditures, whereas in recessions there is a pressure for the reduction of such expenditures, due to intensified government social expenditures. Elections increase voter awareness of spending policies, so even in periods of economic upturn, if elections are being held, public authorities are reluctant to increase environmental expenditures. The existence of political factors was also presented by List and Sturm (2006). They found that, in the USA, governors who face a binding term limit increase environmental expenditure per capita. Another study (Köppl-Turyna et al., 2015) showed a slight growth in environmental protection expenditures during elections due to its visibility to the voters. It is worth adding that, in the group of political and institu-

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tional issues of environmental federalism, corruption and lobbying are also studied (Hu et al., 2021).

Previously analysed studies showed that the influence of local units' fiscal health on environmental expenditures is not in the main subject of the surveys. According to Köppl-Turyna et al. (2015), these expenses seem to be compensated with a drop in spending on education, similarly to the election cycle. However, apart from the expenditure composition, there are other financial factors determining environmental expenditures (Table 1). Firstly, the financial soundness of these units, especially if their indebtedness is low and they enjoy a balanced budget, can promote increased attention to the protection of the environment. It is worth adding that the indebtedness and the budget balance of a local government are the main indicators of its fiscal sustainability (Uryszek, 2018). In addition, more extensive fiscal decentralization or enlarged autonomy might affect the local policy concerning sustainable development, which is tied to the efficiency of the local environmental expenditures (Soukopova & Bakos, 2010). Financial outlays are then required to achieve positive environmental effects (Mesjasz-Lech, 2017). Brzozowska et al. (2022), analysing the municipalities in Poland, noticed that high expenditures for environmental protection and municipal services management are in units which are adjacent to protected wildlife areas and those suffering from pollution. Moreover, Malinowski (2022) disclosed ties between the cleanliness of the natural environment and the growth in the self-financing ratio of the local government (positive relation), and the debt burden (negative relation). As a result, increases in environmental expenditures by municipalities are closely related to an improvement in financial health (Dziekański, 2020). Furthermore, those expenditures might be determined by the demographic structure (Table 1) resulting from urbanization which, in turn, affects the structure of local revenues and expenditures. It is also claimed that the high cost of capital renders environmental protection activities prohibitively expensive (OECD, 2020).

The scope of fiscal federalism in the country should be considered in the context of the size of the economy and the degree of environmental degradation (Table 1). Some authors argue that, as the economy grows, environmental pollution also increases; necessitating higher government spending, appearing to manifest the scale effect (Zeraibi et al., 2021). Economic growth is accompanied by higher demand for energy and the associated environmental degradation but, when the economy reaches a certain level, the society clamours for a better-quality and proactive environmental protection (Le & Ozturk, 2020). Nevertheless, this activity often requires financial assistance from public institutions. Economic growth and consequent environmental degradation may require increased expenditure from the central government, rather than from local authorities whose limited funds and compe-

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tences are insufficient to handle the problems that arise from the situation. In those circumstances, fiscal federalism can be reduced. In line with the findings of Banzhaf and Chupp (2012) a centralised policy may outperform policies on the sub-national level and the quality of air, for example, can be improved more efficiently through supervision (Hu, 2022) and intensified inspections (Xu et al., 2020) on the part of central public bodies.

It is seen that scholars may examine multiple predictors that influence public (government) expenditures on environmental protection. However, most of the studies are based on data concerning the central government. Nevertheless, the determinants concerning the local public sector can be classified into broad categories, such as: economic, social, financial, political, institutional, or environmental degradation (emission) factors (Table 1). Financial and non-financial issues may also be addressed in the studies. Research on spending decentralization (e.g. Delgado, 2021; Bojanic, 2020) in this and other areas (e.g. education, health services) can also be used to select predictors on the expenditure side of environmental federalism. In these surveys both socio-economic, financial or institutional variables are examined. In this study, the author assumed that the significance of the local government expenditures on environmental protection, both in the local budgets, and in the general government sector, may be determined by the fiscal position of these units pertaining to i.e. fiscal decentralization and autonomy, fiscal balance, debt burden, investment activity or the possibility of those expenses competing with other budget categories, especially with education. De Mello and Jalles (2022) found that there is a direct relationship between the decentralization and government spending on environment-related programmes. Sound fiscal situation, in contrast, may result in higher engagement in policies on environmental protection, especially considering the spending structure. It is worth adding that financial autonomy, the debt burden, and the fiscal balance are key factors determining fiscal distress in local governments which, in many cases, results in the restructuring of expenditures (Galiński, 2022). Thus, fiscal discipline may require cuts in public spendings, and trigger trade-offs between budget functions and policies (Sanz & Velázquez, 2003). In contrast, the scope of decentralization may affect the composition of spendings (Halásková & Halásková, 2014), including the expenditures on environmental protection. Socio-economic factors, in turn, control the aspects pertaining to the size of the economy, as well as the population and its structure. These issues determine the needs in the field of environmental protection and create pressure on social policy (Martell et al., 2021), whereas the population can be a proxy for the market size (Fahmi et al., 2016). Moreover, highly developed states can allocate more funds to natural resources management (Broniewicz, 2018; Rokicki et al., 2019). In addition, the level of interest rates may determine the competitive-

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ness of green energy technologies (Monnin, 2015,). Furthermore, the engagement of the local government in the policy on environmental protection may also be affected by environmental degradation factors (Broniewicz, 2011). Dougherty and Montes Nebreda (2022) proved that both total and subnational environmental public expenditures are associated with lower exposure to air pollution. Thus, in the empirical research, these aspects were included (Table 1).

Table 1. Potential financial, socio-economic and environmental degradation factors, as well as the countries for which the panel data models were applied

Label (Definition)	Variable calculation	Source	Aim of the application (specificity)	Expected sign
Dependent Variable				
LGEEP_ in_LGTE	Expenditures on environmental protection as a % of the total in local governments	OECD	The variable presents the role ofexpenditures aimed at the prevention, reduction, and elimination of pollution and other forms of environmental degradation. This budget category is studied because of the structure and specificity of the official statistics.	not applicable
LGEEP_ in_GGEEP	Local government expenditures on environmental protection as a % of the general government expenditures on environmental protection	OECD	The variable shows the expenditure decentralization in the field of environmental protection. In the models, this ratio has two forms, i.e.: ‚Spent by' approach (LGEEP_in_ GGEEPs) and ‚Funded by' approach (LGEEP_in_GGEEPf)	not applicable
Independent Variables				
Financial				
Decentralization	Local government expenditures as a % of general government expenditures	OECD	The empirical evidence in research by Sigman (2014) does not suggest higher overall pollution levels with greater decentralization. In turn, Guo et al. (2020) revealed the nexus between fiscal decentralization and environmental pollution. As a consequence, a research question arises whether greater decentralization determines a higher share of expenditure on environmental protection. For 2020, due to the lack of the data for Switzerland in the OECD database, the calculation is based on the Eurostat data.	(+)

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Label (Definition)	Variable calculation	Source	Aim of the application (specificity)	Expected sign
Tax Revenues	Taxes other than social contributions as a % of total revenues (natural log)	OECD	Tax revenues create their own income potential and financial autonomy, which may drive structural transformation (Satoła et al., 2019), also aimed at environmental protection policy. Gu et al. (2022) found that strong financial resources have significant positive effects on the efficiency of environmental governance at the local level. However, Phillips and Strickland (2016) assumed an inverse relationship between the share of tax revenues in total revenues and environmental action, which was not confirmed in the regression.	(+)
Fiscal Balance	Local government fiscal balance as a % of GDP	OECD	Fiscal imbalances affect the right pattern between fiscal capacity and service provision (Ansori et al., 2021), which may result in reduced expenditures on environmental protection.	(+)
Debt burden	Debt as a % of total expenditures (natural log)	OECD	Public debt may significantly affect the natural environment, and local government debt spending can effectively promote a reduction in urban emissions (Qi et al, 2022). However, the excessive debt burden may restrain new borrowing to finance environmental protection. Debt entails fiscal strain (McKinney, 2004), which is tied with fiscal sustainability. Therefore, local government with the higher indebtedness can refrain from further borrowing to fund environmental protection expenses. Phillips and Strickland (2016) showed that the degree of debt, as a category of fiscal distress, is correlated with a lower likelihood of implementing environmental programs. In turn, Malinowski (2022) found inverse relationships between the debt burden and the cleanliness of the natural environment.	(-)
Investment activity	Investment spending in total expenditures (%)	OECD	The variable applied to verify whether increased investment spending leads to greater investment in environmental protection or worsens the possibilities for financing environmental policy expenditures. This is an indicator affecting sustainable development, considered in the institutional-political domain (positive relationship) (Ogrodnik, 2017).	(+)/(-)
Expenditures on Education	Expenditures (Exp) on Education in Total (%)	OECD	Sanz and Velázquez (2003) highlight that fiscal discipline will require cuts in government spending, leading to trade-offs between distinct functions. Finally, this affects the expenditure composition. According to the research of Köppl-Turyna et al. (2015), changes in the expenditures on environmental protection may be tied with the alterations in expenditures on education. This predictor represents the importance of the principal task in fixed budgets. In turn, budget rigidities include institutional and legal structures such as quasi-autonomous spending that are beyond direct government control (Mattina & Gunnarsson, 2007).	(-)

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Label (Definition)	Variable calculation	Source	Aim of the application (specificity)	Expected sign
Socio-economic				
GDP	Gross Domestic Products (natural log)	World Bank	This predictor reflects the size of the economy that, in theory, could generate excessive expenditures concerning certain public services (Bellot et al., 2017). Wekulom (2021) revealed that GDP correlates positively with spending on environmental protection. GDP in current US dollars.	(+)
Population	Number of inhabitants (natural log)	World Bank	Demand for certain public goods/functions may be affected by population size. Greater or lesser population creates greater or lesser demand for services and pressure on social policy (Martell et al., 2021) and is a proxy for market size (Fahmi et al., 2016). The level of the population controls the scale of the economy (Gallo & Ndiaye, 2021).	(+)
Working Age	Population ages 15-64 as a % of the total population	World Bank	The share of the active population controls the composition effects in the population (Gallo & Ndiaye, 2021). Urbanised regions tend to attract working-age inhabitants (Kashnitsky et al., 2021), which affects both the revenues and the scope of the tasks.	(+)
Urban population	People living in urban areas as a % of the total population	World Bank	The variable applied as a proxy of urbanization by Tang (2022). Urbanization is associated with the industrialization of the localities and could have an impact on the spending policy aimed at environmental protection. This predictor was applied in the estimations of Wekulom (2021). Gallo and Ndiaye (2021) indicate that the share of urban population is expected to be positive, as high urbanization usually goes together with environmental degradation and requires policies of intensified spending on environmental protection.	(+)
Interest Rates	Long Term Interest Rates (%)	OECD, IMF	Monnin (2015) presents that a low interest rate environment makes green energy technologies more competitive. For Estonia, for the period between 2011 and 2020, the following were applied: Harmonised Euro Area Rates, Loans, Non-Financial Corporations (IMF).	(-)
Environmental degradation				
CO_2 emissions	Carbon dioxide emissions per capita (natural log), (excluding LULUCF*, tonnes of CO_2 equivalent)	OECD	This is a variable applied as a proxy for environmental degradation (Hatmanu et al., 2022). Scholars examined the ties between government expenditures on environmental protection and environmental quality (emissions of pollutants) (Barrell et al., 2021; Halkos & Paizanos, 2014; Donkor et al., 2022; Wójtowicz et al., 2022). Barrell et al. (2021) confirmed the problem of deteriorating efficiency of environmental expenditures across the selected EU countries. Donkor et al. (2022) found both positive and negative influence of government finance expenditures on environmental quality in different countries.	(+)/(-)

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Label (Definition)	Variable calculation	Source	Aim of the application (specificity)	Expected sign
Codes of the 26 countries included in the research				
AUT, BEL, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRE, ITA, LTU, LVA, LUX, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, GBR, ROU				

* Land use, land use change and forestry

Source: author's work based on the literature review and databases of the OECD, the World Bank, and the IMF.

Research methods

The article studies financial, socio-economic and environmental degradation factors affecting the scope of the environmental federalism in 26 European countries (the members of the Organisation for Economic Co-operation and Development [OECD] plus Romania; Iceland and Turkey were excluded due to the lack of data) between 2007 and 2020. The data was extracted from the databases of the OECD, the World Bank, and the International Monetary Fund (IMF). Since the article examines European countries in the period between 2007 and 2020, panel data models were estimated for the set of variables specifying the determinants of the expenditures side of environmental federalism (Table 1).

Based on the results of the Wald test (the F statistic), the Breusch-Pagan test (the χ^2 statistic) and the Hausman test (the χ^2 statistic) (Gruszczyński, 2020), a panel model with fixed effects was selected for each set of variables (Table 1) to examine determinants of the share of the expenditures on the environmental protection in the total expenditures of the local governments (LGEEP_in_LGTE). The specification of this model has the following form (Cottrell & Lucchetti, 2023):

$$y_{it} = x_{it}\beta + \alpha_i + \varepsilon_{it}, \quad (1)$$

where:

y_{it} – is the dependent variable for the cross-sectional unit i (a country in this research study) in the period t,
x_{it} – is a $1 \times k$ vector of independent variables for unit i in the period t,
β – is a $k \times 1$ vector of the parameters,
α_i – is a unit-specific and time-invariant constant coefficient,
ε_{it} – is an observation specific error term.

In turn, to reveal the predictors of the share of local governments' expenditures on environmental protection in the general government expenditures on environmental protection (LGEEP_in_GGEEP), a panel model

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with random effects was selected due to the outcomes of the aforementioned tests, i.e. Wald test, the Breusch-Pagan test, the Hausman test. This model includes the individual specific random component (v_i) and takes the form (Cottrell & Lucchetti, 2023):

$$y_{it} = x_{it}\beta + v_i + \varepsilon_{it}. \quad (2)$$

In the regressions clustered standard errors were applied in the presence of the heteroscedasticity (Modified Wald test) and the autocorrelation (Wooldridge test for serial correlation) (Hill et al., 2011). During the process of estimations, the multicollinearity between independent variables was controlled using the absolute value of correlation of the coefficients with the threshold of 0.7 (Dormann et al., 2013; Reddy & Balasubramanyam, 2021). For the estimated models, goodness of fit measures: within R^2 and LSDV R^2 are presented. Therefore, five models were estimated to show the determinants of the share of expenditures on environmental protection in the total expenditures of local governments (LGEEP_in_LGTE), i.e.: (a) model 1 with the variables for the available data the whole period 2007–2020 (without the variable 'Population', which appeared insignificant and had the largest correlation of the coefficient); (b) model 2 with all considered predictors (without the variable 'Population' due to aforementioned aspects); (c) model 3 containing significant variables for the period 2007-2020; (d) model 4 containing the variables from model 3 except for the predictor 'Debt burden'; (e) model 5 consisting of significant factors only in the field of the fiscal position of the local government in the analysed countries. In turn, to show the determinants of the share of local government expenditures on environmental protection in the general government expenditures on environmental protection (LGEEP_in_GGEEP), the 'Spent by' approach (LGEEP_in_GGEEPs) and 'Funded by' approach (LGEEP_in_GGEEPf) of this dependent variable were applied. Thus, two models were estimated, i.e. (a) model 6 with significant variables for LGEEP_in_GGEEPs; (b) model 7 with significant variables for LGEEP_in_GGEEPf. It is worth noting that the 'Funded by' approach allows one to answer the question on which level of government expenditures in certain areas are actually funded (also called the 'initial source of public funds'), whereas the 'Spent by' approach, pertains to the specific government level that actually executes spending programmes for the sector (Dougherty & Montes, 2023). The two models for LGEEP_in_GGEEP include 21 countries due to the lack of data for some countries (i.e. for: Germany, Latvia, Poland, Romania), or very high negative values of those ratios in Estonia in 2010 and 2011 (indicated as outliers according to the Grubbs' test). The applied procedure was also aimed at avoiding misleading outcomes and conclusions and at

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confirming the stability of the results. Thus, the methodology takes into consideration the issues pertaining to robustness checks.

Finally, for the panel models with fixed effects, Pregibon's link test was performed to check whether the independent variables are correctly specified, conditional on the specification of the dependent variable (Deb et al., 2017). Hence, in the re-estimated regression with two variables as predictors, i.e.: $\hat{y}$ and $\hat{y}^2$, the square of the predicted value ($\hat{y}^2$) shouldn't be significant (Hoffmann, 2022; Majeed & Ozturk, 2020).

The potential differences in the average level (for the period 2007-2020) of the variables: LGEEP_in_LGTE, LGEEP_in_GGEEPf, LGEEP_in_GGEEPf between less and more industrialised economies, were also checked. As a result, the countries (used in the panel models) were divided into two groups, i.e. according to the membership to G12 states (industrially advanced countries, i.e. Belgium, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, United Kingdom). Then, the Mann-Whitney U test was performed to verify whether the two groups (G12 states, and non-G12 states included in the panel models with fixed effects – for the variable: LGEEP_in_LGTE, and in the panel model models with random effects – for the variables: LGEEP_in_GGEEPs and LGEEP_in_GGEEPf) have the same distribution of those variables. Additionally, a t-test was performed to check whether there are significant differences between the means of these two groups (Hawkins, 2014). It should be added that the three studied variables were normally distributed (verified by the Shapiro-Wilk's test) and were characterized by the equality of variances (verified by the Levene's test).

Results of the research and discussion

In the analysed European countries, expenditures on environmental protection finance all activities and actions that are aimed at the prevention, reduction, and elimination of pollution and of any other degradation of the environment. This also includes tasks and measures that contribute to the restoration of the environment after it has been degraded (Björk et al., 2016). In the studied countries, in the period between 2007 and 2020, differences were noted both in the share of the local government environmental protection expenditures in the expenditures of the general government sector (Table 2, Figure 3), and in the share of environmental protection expenditures in total (Table 2, Figure 1, Figure 2). A high and growing ratio was noted in Greece and Luxembourg, whereas in the countries of north-eastern Europe, the analysed share was relatively small. However, in Greece between 2007 and 2013, i.e. in the period of economic slowdown (e.g. GDP growth in 2007 was 3.3% in comparison to -10.1% in 2011, -7.1% in 2012, or -2.5% in 2013),

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the share of the local government expenditures on environmental protection in general government expenditures on environmental protection ('Spent by' approach, LGEEP_in_GGEEPs) decreased from 55.33% to 33.58% and then increased to 48.15% in 2020. The largest share of expenditures on environmental protection in the local government was also noted in Spain, Ireland, and Portugal (Figure 1, Figure 2), in which the average levels of LGEEP_in_GGEEPs were at 65.66%, 64.95% and 77.58% respectively. In the analysed period the highest value of the share of environmental protection expenditures in total was 20.11%, whereas the lowest was 0.28% (Table 2). There appeared differences in the value of the applied independent variables in the domains of finances, in the socio-economic situation, and in that of environmental degradation (Table 2).

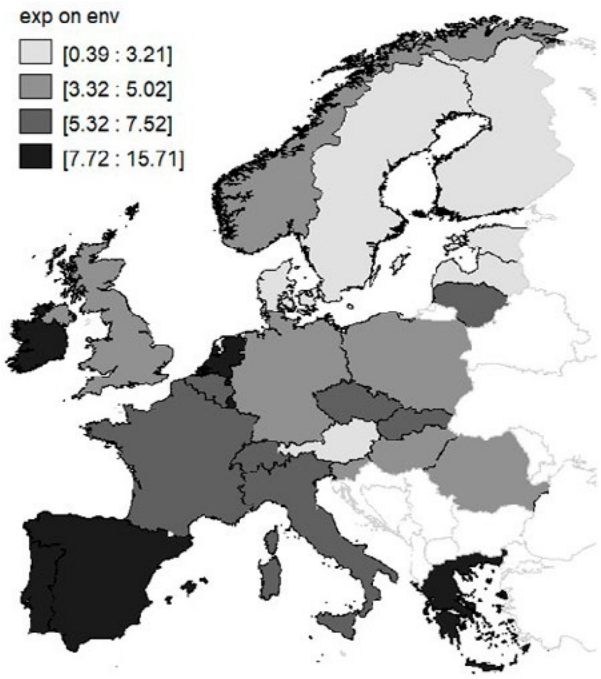

Figure 1. Average expenditures on environmental protection (exp on env) as a percentage of the total in 26 European countries in 2007-2020 according to the quantiles

Source: author's work based on databases of the OECD.

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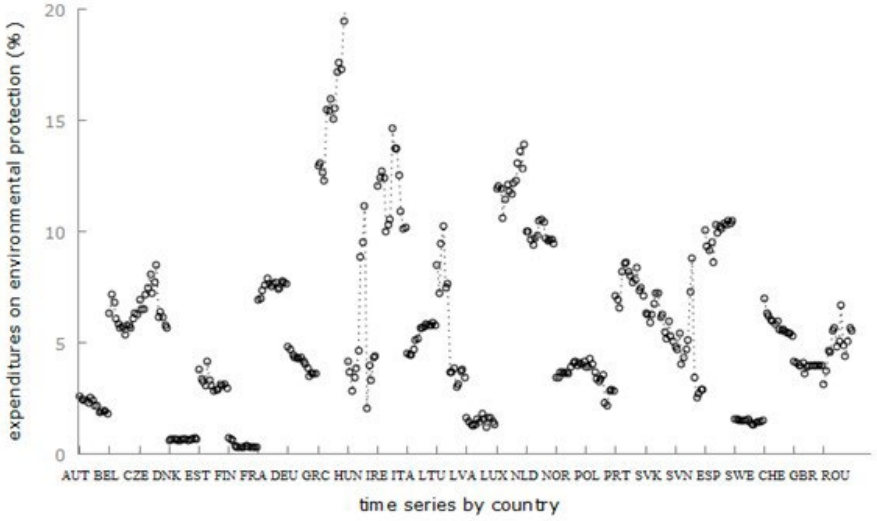

Figure 2. Expenditures on environmental protection as a percentage of total in 2007-2020, by country

Source: author's work based on databases of the OECD.

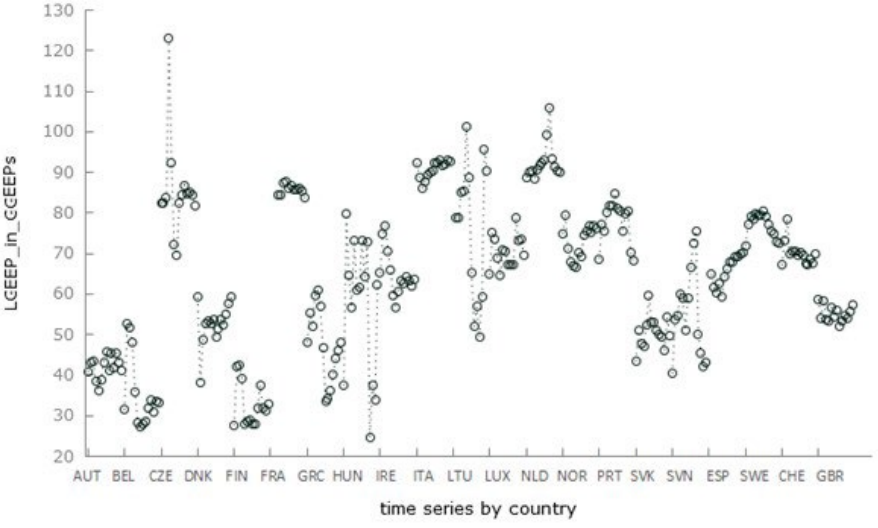

Figure 3. Local governments' expenditures on environmental protection in general government expenditures on environmental protection using 'Spent by' approach (LGEEP_in_GGEEPs, %), in 2007-2020, by country

Source: author's work based on databases of the OECD.

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Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
LGEEP_in_LGTE [%]	364	5.76	3.83	0.28	20.11
LGEEP_in_GGEEPs [%]	289	64.37	18.75	24.54	123.18
LGEEP_in_GGEEPf [%]	289	60.49	20.47	-3.22	114.43
Decentralization	364	23.83	12.37	5.66	64.61
Tax Revenues [%]	312	30.55	15.90	2.45	59.97
Tax Revenues [natural log]	312	3.20	0.76	0.90	4.09
Fiscal Balance	364	-0.09	0.42	-1.80	2.47
Debt burden [%]	364	62.66	29.06	8.37	143.39
Debt burden [natural log]	364	4.03	0.49	2.12	4.97
Investment Activity	364	15.77	7.23	3.52	50.30
Expenditures on Education [%]	364	21.29	10.98	0.39	41.15
Population [natural log]	364	16.08	1.25	13.08	18.24
Urban Population	364	73.28	12.03	51.98	98.08
Working Age	364	66.37	2.17	61.58	72.22
GDP [natural log]	364	26.48	1.36	23.69	29.01
Interest Rates [%]	364	2.99	2.69	-0.52	22.50
CO_2 emission [per capita]	364	7.72	3.28	3.48	23.58
CO_2 emission [per capita, natural log]	364	1.97	0.38	1.25	3.16

Source: author's work based on databases of the OECD, the World Bank, and the Eurostat.

Applying the characterised methodology and the variables (Table 1), five panel models with fixed effects were estimated for the dependent LGEEP_in_LGTE, and two panel models with random effects, i.e. for the dependent variables: LGEEP_in_GGEEPs and LGEEP_in_GGEEPf (Table 3). It is worth noting that that there were significant (at the p-value<0.05) and direct relationships between LGEEP_in_LGTE and LGEEP_in_GGEEPs (Pearson's correlation coefficient was 0.2483), and between LGEEP_in_LGTE and LGEEP_in_GGEEPf (the correlation coefficient was 0.2100). Therefore, an increase of the importance of the local governments' expenditures on environmental protection in these expenditures of the general government sector was associated with an increase in the share of expenditures on environmental protection in total expenditures by local governments.

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Table 3. Factors determining LGEEP_in_LGTE, LGEEP_in_GGEEPs and LGEEP_in_GGEEPf in European countries in 2007-2020 – panel data models

Variable	Model 1 (FE)	Model 2 (FE)	Model 3 (FE)	Model 4 (FE)	Model 5 (FE)	Model 6 (RE)	Model 7 (RE)
Dependent variable	LGEEP_in_LGTE					LGEEP_in_GGEEPs	LGEEP_in_GGEEPf
Decentralization	0.0636 (0.0523)	0.1094 (0.0807)	0.0771* (0.0445)	0.0894* (0.0435)	–	–	–
Tax Revenues	–	1.5705** (0.7345)	–	–	2.4078** (1.0270)	–	–
Fiscal Balance	0.7656*** (0.2306)	0.9095*** (0.2628)	0.5872** (0.2334)	0.6244** (0.2776)	0.7283** (0.3323)	3.5461** (1.6498)	3.0644* (1.8106)
Debt Burden	-1.1033** (0.5057)	-1.2297** (0.4748)	-1.2636** (0.5020)	–	-1.2599* (0.6721)	–	–
Investment Activity	0.0464 (0.0372)	0.0861** (0.0384)	–	–	0.1336*** (0.0462)	0.4687*** (0.1441)	0.2795* (0.1497)
Exp on Education	-0.1353*** (0.0473)	-0.1447** (0.0578)	-0.1338*** (0.0384)	-0.1469*** (0.0440)	–	–	–
GDP	-4.0449*** (1.1222)	-3.7033*** (1.0810)	-4.1195*** (1.1180)	-4.0205 (1.2227)	–	–	–
lnpop	–	–	–	–	–	6.3861** (3.1656)	7.6738* (4.2794)
Working Age	0.0992 (0.0720)	0.1498* (0.0817)	0.2020** (0.0831)	0.2388*** (0.0818)	–	1.4415*** (0.5428)	1.2974** (0.6404)
Urban Population	0.0128 (0.0605)	-0.0385 (0.0885)	–	–	–	–	–
Interest Rates	0.0915 (0.0699)	0.0722 (0.0788)	–	–	–	–	–
CO_2 emissions	-2.3931** (0.9173)	-2.7789** (1.0237)	-2.3045** (0.8591)	-2.2972*** (0.8354)	–	–	–
Intercept	114.9343*** (34.1436)	101.0928*** (30.9518)	112.1240*** (31.2117)	101.9510*** (33.2136)	1.1453 (4.6192)	-140.3660** (71.0900)	-152.3871 (96.7393)
No. obs.	364	312	364	364	312	289	289
Within R^2	0.4152	0.4536	0.3842	0.3394	0.2272	0.1113	0.0656
LSDV R^2	0.9552	0.9584	0.9528	0.9494	0.9412	–	–

Note: 1) ***, ** and * denotes statistical significance at 1%, 5% and 10% levels respectively; 2) FE – panel model with fixed effects, RE – panel model with random effects; 3) clustered standard errors in parentheses (…); 4) since the data for 'Tax Revenues' are for the period 2009–2020, the model 2 and the model 5 are for these years.

Source: author's work based on databases of the OECD, the World Bank, and the Eurostat.

As far as the panel data models are concerned, the choice of their types stemmed from the performed statistical tests, i.e.: the Wald test, the Breusch-Pagan test and the Hausman test (Table 4). In turn, the outcomes of

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Pregibon's link test for the fixed effects panel models showed that the independent variable is correctly specified, conditional on the specification of the examined share of expenditures on environmental protection in local government budgets. As a result of the tests for the heteroskedasticity and the autocorrelation, clustered standard errors were applied both for the panel models with fixed and random effects (Table 4).

Table 4. Diagnostic tests for the estimated models

Test	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Wald test	77.89 [< 0.001]	65.20 [< 0.001]	118.44 [<0.001]	109.86 [< 0.001]	95.72 [< 0.001]	69.33 [< 0.001]	78.63 [< 0.001]
Breusch-Pagan test	1,213.43 [< 0.001]	816.06 [< 0.001]	1,612.05 [< 0.001]	1,609.30 [< 0.001]	1,036.01 [< 0.001]	1,256.01 [< 0.001]	1,310.38 [< 0.001]
Hausman Test	63.59 [< 0.001]	63.16 [< 0.001]	55.55 [< 0.001]	49.99 [< 0.001]	24.55 [< 0.001]	1.31 [0.8599]	0.91 [0.9236]
Modified Wald test for Heteroscedacisity	2,345.75 [< 0.001]	4,040.08 [< 0.001]	3,572.60 [< 0.001]	4,061.35 [< 0.001]	20,854.53 [< 0.001]	3,849.03 [< 0.001]	16,302.18 [< 0.001]
Wooldridge test for Aurocorrelation	6.92 [0.014]	6.51 [0.017]	6.58 [0.0167]	22.31 [< 0.001]	9.02 [0.006]	7.806 [0.011]	20.981 [< 0.001]
Pregibon's link test ($\hat{y}^2$)	0.0299 [0.101]	0.0285 [0.133]	0.0298 [0.110]	0.0219 [0.319]	0.0491 [0.507]	–	–

Note: 1) the ***p***-value in brackets [...] can be found under the level of the statistic.
Source: author's work based on databases of the OECD, the World Bank, and the Eurostat.

The estimations showed that the share of expenditures on environmental protection in local government budgets (LGEEP_in_LGTE) is significantly determined by the fiscal position of public finance units. Growth of the *Fiscal Balance* (especially a rise of the budget surplus) and the drop of the *Debt Burden* resulted in an increase of the share of environmental protection expenditures in the total (Table 3). Therefore, the devolution of tasks in the field of environmental protection from central to local government is connected with fiscal sustainability. Moreover, according to Model 2, a one percentage point increase in investment activity affected the growth of the share of expenditures on environmental protection by 0.0861 percentage point, *ceteris paribus*, in the budgets of the countries in question (Table 3). This nexus was found to be stronger in Model 5, which contains only significant fiscal variables. The expenditure composition also determined the environmental protection spending policy. According to the regressions (Table 3), a decrease in expenditures on education positively stimulated growth of the engagement in environmental policy. In addition, Model 3 showed that an increase of 1 percentage point in the working age population contributed to

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an increase in the importance of environmental expenditure by 0.2020 *ceteris paribus*. The impact was more significant in Model 4, where it was confirmed. A working age population increase affects the improvement of tax revenues, which promote fiscal independence of the local government. In turn, according to Model 5, a one percentage point increase of tax revenues resulted in the growth of the studied expenditures by 2.4078, *ceteris paribus*. Furthermore, Model 3 showed that an increase of expenditure decentralization, measured by the local government expenditures as a percentage of general government expenditures, resulted in an increase in environmental protection expenditures (Table 3). Simultaneously, both the *Urban Population* and the *Interest Rate* did not show statistical significance. Thus, environmental federalism was mainly driven by systemic factors, rather than the costs of capital. On the other hand, in countries in question, the importance of expenditures on environmental protection in local government budgets between 2007 and 2020 was lower both in larger economies and in countries with more severe environmental degradation. For example, according to Model 2: a 1% increase in GDP caused the share of the analysed spendings to drop by 0.0370, *ceteris paribus*, whereas a 1% *per capita* increase of CO_2 emissions produced a reduction of this share by 0.0278, *ceteris paribus*. This indicates that the authorities in larger and more polluted economies delegate public environmental protection spendings on the central level.

The regressions for the variables: LGEEP_in_GGEEPs and LGEEP_in_GGEEPf confirmed the outcomes of the models for the LGEEP_in_LGTE, for some factors. Growth of the *Fiscal Balance* resulted in an increase of the local governments' expenditures on environmental protection in these expenditures of the general government sector (Table 4). In addition, an increase in investment activity of the local governments affected the growth of LGEEP_in_GGEEPs and LGEEP_in_GGEEPf. Furthermore, a rise of the population and the share of the working age resulted in the greater decentralization of the expenditures on environmental protection. Therefore, these factors affected the expenditure side of environmental federalism.

The results of the Within R^2 for each panel model with fixed effects indicate that from 22.72% (Model 5) to 45.36% (Model 2) of the variation in the applied dependent variables within the units are captured by these models. The difference in the Within R^2 of Model 2 and that of Model 5 also confirm that non-financial factors play a key role in fiscal federalism. The exclusion of the 'Debt burden' predictor from Model 3 decreased the Within R^2 from 0.3842 to 0.3394, which means that this variable, as a proxy for fiscal strain, has an important role in explaining the variation of environmental protection expenditures. As a result, fiscal sustainability and a sound fiscal position of the local government significantly determines the scope of fiscal federalism and sustainable development policies at the local level. In addition, the levels

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LSDV R^2s show that these models explain from 94.12% (Model 5) to 95.52% (Model 2) of the variation in the role of environmental expenditures in the local governments of the analysed countries, also including the fixed effects. In turn, comparing the panel models with random effects, i.e. Model 6 and Model 7, the higher level for Within R^2 was in the regression for the LGEEP_in_GGEEPs, i.e. 0.1113 (Table 3).

Table 5. Results of the Mann-Whitney U test and the t-test

Variable	Mann-Whitney U test		t-test	
	z	*p*-value	t	*p*-value
LGEEP_in_LGTE	-0.6737	0.5251	-0.2406	0.8119
LGEEP_in_GGEEPs	-1.4484	0.1614	-1.4508	0.1632
LGEEP_in_GGEEPf	-1.6657	0.1042	-1.7489	0.0965

Additionally, the performed Mann-Whitney U test (Table 5) showed that two groups of countries, i.e. G12 (more industrialised) states and non-G12 (less industrialised) states had the same distribution of the average level (for the period 2007-2020 in the analysed panel models) of the variables: LGEEP_in_LGTE, LGEEP_in_GGEEPs, and LGEEP_in_GGEEPf. Furthermore, there were no significant differences in the means between these two groups (t-test, Table 5).

Conclusions

The concept of environmental federalism concerns the division of tasks, actions, and activities between different levels of public authority in the field of environmental policy. It may be implemented to a different extent in each country and pertains to public goods. The article examined how the above is determined by different financial and socio-economic factors and how it is also connected to the size of the economy and the level of environmental degradation. Therefore, it is crucial to examine the real influence of the predictors of the analysed federalism in the context of other policies promoting economic growth, sustainable development, and the stability of public finances. Therefore, the local governments' expenditures on environmental protection should be studied with regard to fiscal decentralization and the autonomy of these units, their financial position and indebtedness, composition of expenditures, demographic structures determining both revenues and policy, the size of the economy and the level of pollution emissions.

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Simultaneously, for the period between 2007 and 2020, the distribution of the average levels of the share of these expenditures in the budgets of local governments and in these expenditures of the general government sector were the same in both less and more industrialised countries in Europe.

The article showed that that fiscal sustainability promotes the expenditures side of environmental federalism and leads to sustainable development at the local government level. Therefore, it confirms the survey of Phillips and Strickland (2016) that the growing debt burden inhibits local governments from undertaking environmental tasks. In European countries included in the study, the growth in the share of expenditures on environmental protection in the local governments' budgets and in these expenditures of the general government sector was positively and significantly affected by the improvement in fiscal health, e.g. better fiscal balance. Moreover, the higher the engagement in the investment activity, the larger the share of expenditures for environmental protection and the decentralization of these spendings. This means that the intensification of restructuring of local economies, combined with spending autonomy, positively influences a more significant scope of environmental protection activities. It is also related to other results presented in the paper (e.g. to the research of De Mello and Jalles (2022)), according to which the decentralization of expenditures contributes to the importance of environmental expenditures in local budgets. In turn, this type of decentralization, according to the mentioned survey of Guo et al. (2020), may exacerbate local environmental pollution less than would be the case with revenue decentralization. The estimation of the regressions also expands the outcomes of research by Köppl-Turyna et al. (2015) concerning the election cycle, namely that changes in expenditures on environmental protection are related to changes in education expenditures. Hence, a less rigid expenditure structure positively stimulates expenditures on environmental protection as well as the reallocation of expenditures towards sustainable development. Thus, a sound fiscal position of the local government and the avoidance of financial stressors contribute to a deepening of the expenditures side of environmental federalism. Therefore, the delegation of environmental tasks should be accompanied by the transfer of an adequate amount of financial resources, so as not to create upward pressures on debt and deficit.

Simultaneously, the findings revealed that, in the studied countries, the share of expenditures on environmental protection in the local budgets was driven mainly by systemic factors, especially expenditure decentralization, as well as the fiscal condition of the local government, rather than by the situation on the financial markets, i.e., the cost of access to capital. The study showed that, in the European countries in question, the share of expenditures on environmental protection in the local budgets can be controlled by

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the size of the economy and was intensified in places that enjoy less pollution. In cases to the contrary, the authorities prefer to develop environmental protection spending policy at the central level. While encountering more significant pollution problems, the central approach enables the coordination of environmental protection actions and activities in order to overcome the negative externalities. In line with the mentioned study of Banzhaf and Chupp (2012), centralized policies could outperform sub-national policies. Furthermore, in contrast to the study of Phillips and Strickland (2016), the regression models indicated that, in the process of econometric modelling, a direct relationship between fiscal autonomy and environmental actions should be assumed. The paper proved that the growth of tax revenues' budgetary importance positively stimulated environmental protection expenditures at the local level. In addition, the greater the population or the share of the working age, the higher the level of the decentralization of expenditures for environmental protection. Thus, an increase in these factors contributes to the deepening of the expenditure side of environmental federalism.

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