

Environmental Tax Revenues and Economic Performance in Selected European Union Countries

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Abstract

This research explores the effectiveness and influence of environmental taxes across Slovakia, Germany, Finland, and France. The aim was to analyze how these countries incorporate environmental taxes into their economic policies and their effectiveness in achieving sustainability goals. Regression and correlation analyses examined the relationship between environmental tax revenue and Gross Domestic Product (GDP), using data from Eurostat and the Organization for Economic Cooperation and Development (OECD) for the five-year period before the crisis. The results show significant differences between countries: Finland and France align better with sustainability objectives, while Germany and Slovakia show lower efficiency and a weaker relationship between tax revenue and GDP growth. The results indicate that the successful application of environmental taxes relies on their alignment with comprehensive fiscal and environmental policies.

Keywords

energy taxes, environmental taxes, pollution taxes, resource taxes, transport taxes



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Introduction

Environmental taxes have increasingly become a critical subject of discussion in recent years, primarily because they seek to internalize the negative externalities produced by economic activities that harm the environment (Shahzad, 2020). These taxes aim to provide economic incentives to reduce environmentally harmful behaviors, and they have remained a constant feature of many nations' political agendas (Delgado et al., 2022). A common feature of their implementation is offering exemptions and tax relief to specific sectors, especially in manufacturing, to ease economic pressures and maintain competitiveness (Ekins, 1999). In the European Union (EU), environmental taxes currently account for around 2.5% of Gross Domestic Product (GDP) and 6% of total taxation, underscoring their growing fiscal role in recent years. Many prominent economists support these taxes as highly cost-effective measures to reduce environmental harm, mainly because they promote substantial behavioral shifts while keeping administrative and compliance costs relatively low. (Baranzini et al., 2017).

The development of environmental taxes in economic theory

The foundational literature on environmental economics is shaped by seminal works such as Baumol and Oates (1988), who laid the groundwork for understanding externalities and taxation as corrective measures, and Tietenberg (1990), who emphasized market-based environmental regulation. Xepapadeas (1997) examines the fundamental aspects of economic theory related to environmental issues, while Dijkstra (1999) provides an in-depth exploration of the political efficiency of various policy instruments. Other key contributions to tool selection include Bohm and Russell (1997), Russell and Powell (1996), Stavins (2002), and the Nordic Council of Ministers (1999), each offering unique perspectives on policy design and implementation. Sterner and Coria (2011) compile textbooks on theory and practical applications, highlighting the diversity of approaches across developing and industrialized nations. Additionally, Ekins and Specks (1999) conducted a comprehensive survey of European environmental taxes, providing key insights into their implementation and development across different jurisdictions. In economic theory, taxes are viewed as essential market-based tools in environmental policy, valued for their ability to achieve environmental objectives cost-efficiently (Kosonen and Nicodème, 2009). The generalization of theoretical principles established by leading global researchers has facilitated the systematization of key features of environmental taxes as an effective operational system, emphasizing their significance in tackling humanity's global challenges. Within the realm of environmental taxation across European countries, a diverse array of environmental tax types has been identified, alongside the widespread adoption of environmental tax reforms in the world's most developed nations (Kwilinski et al., 2019). Politically, awareness and adoption of environmental taxes are thriving in regions like Scandinavia and the Benelux countries. More recently, industrialized nations such as Germany, France, Italy, and the United Kingdom have embraced these measures. Additionally, developing economies, including Estonia, Poland, China, and Hungary, have started integrating environmental policies with economic initiatives (Domenech and Bahn-Walkowiak, 2019).

The importance of environmental taxes in politics, economics and taxation

Environmental taxes have become an important topic in recent years because they aim to tax economic activities that create negative externalities on the overall environment (Shahzad, 2020) and have become a permanent part of the political agenda. A shared feature of their implementation is the provision of exemptions and tax relief, especially for certain sectors within the manufacturing industry (Ekins and Specks, 1999). In recent years, environmental taxes have accounted for approximately 2.5% of GDP and 6% of total tax revenue within the EU (Delgado et al., 2022). Many global economists argue that these taxes are among the most cost-efficient tools, as they significantly influence decision-making globally while incurring minimal costs (Baranzini et al., 2017). Key foundational works in environmental economics, such as those by Baumol and Oates (1988) and Tietenberg (1990), have laid the groundwork for understanding the economic principles behind taxing negative externalities. These authors focus on how market-based environmental regulations can incentivize better environmental outcomes. Xepapadeas (1997) adds depth to this discussion by focusing on basic economic theory, while Dijkstra (1999) examines the political efficiency of environmental policies. Other important contributions, such as those by Bohm and Russell (1997) and Russell and Powell (1996), provide comparative analyses and practical advice on selecting effective policy tools. Stavins (2002) further expands on market-based instruments, emphasizing their role in developed and developing economies.

Additionally, regional studies, such as those by the Nordic Council of Ministers (1999), examine how different countries implement economic instruments to address environmental issues. Sterner and Coria (2011) provide a broad perspective on applying these theories in various contexts, while Ekins (1999) offers an in-depth survey of European environmental taxes, illustrating the diversity of approaches within the EU. These works collectively offer a comprehensive understanding of environmental policy tools, from theoretical foundations to practical applications across regions.

In economic theory, taxes are regarded as crucial market-based instruments in environmental policy because of their ability to support the achievement of environmental objectives in a cost-efficient way (Kosonen and Nicodème, 2009). The synthesis of theoretical foundations proposed by leading global researchers has enabled the systematization of core characteristics of environmental taxes, highlighting their efficiency and importance in addressing global challenges faced by humanity. In the context of environmental taxation across European countries, a diverse array of environmental tax types has been identified, along with the growing popularity of environmental tax reforms in the world's most developed nations (Kwilinski et al., 2019). Politically, awareness and adoption of environmental taxes have thrived in regions like Scandinavia and the Benelux countries. Recently, industrialized nations such as Germany, France, Italy, and the United Kingdom have also embraced these measures. Furthermore, developing economies, including Estonia, Poland, China, and Hungary, have begun integrating environmental initiatives with economic strategies (Domenech and Bahn-Walkowiak, 2019).

Gaps in sustainability and environmental tax revenues

Schratzenstaller et al. (2017) describe sustainability gaps, such as the high and growing weight of labor taxes, declining tax-system progressivity, the declining importance of Pigovian taxes aimed at internalizing external costs, intensifying tax competition, and problems with tax compliance and tax fraud. Golušin et al. (2013) collected results for the EU-27 and compared them with data from sample countries worldwide, including Brazil, Russia, India, China, and South Africa (BRICS). Revenues from environmental taxes in the EU-27 are not negligible and represent approximately 3 % of total revenues. Other studies (Thanasas et al., 2023) emphasize that environmental taxation plays a vital role in promoting green growth by boosting state revenues and addressing environmental challenges at both European and international levels. In the EU, maintaining the downward trend in labor taxation is essential to achieving the objective of enhancing employment rates (Bojnec and Kosi, 2006).

Kurtinaitytė-Venediktovienė et al. (2014) analyzed environmental taxes implemented in eight Baltic countries (Denmark, Germany, Estonia, Latvia, Lithuania, Poland, Finland, and Sweden) from 2002 to 2011. Their study highlighted differences in environmental taxation among these countries, primarily attributed to variations in tax reform.

Some researchers criticize environmental policy as excessively lenient for several reasons. Pindyck (2013) highlights the uncertainties stemming from difficulties in accurately estimating costs and benefits, which complicate the standard economic analysis employed in integrated assessment models (Nordhaus, 1993). These models provide estimates of optimal stringency levels that are often debated (Pindyck, 2013; Stern et al., 2022). The effectiveness of environmental taxes was validated in the study by Arbolino and Romano (2014), which demonstrated that these taxes actively prevent environmental degradation across 26 European economies. Conversely, Ganda and Garidzirai (2021) found that an analysis of 28 selected EU economies between 2010 and 2017 indicated that comprehensive environmental taxes did not effectively reduce greenhouse gas emissions, even though they contributed to environmental sustainability. This may be because they failed to allocate tax revenues to increase energy efficiency, as Bastian et al. (2013) note, limiting their capacity to reduce greenhouse gas emissions.

Parry and Bento (2000) argue that inefficient tax preferences, such as unjustified deductions, credits, and exemptions within the income tax system, reduce the tax base. As a result, environmental taxes generate revenue more efficiently than income taxes, suggesting that optimal environmental tax rates should exceed marginal damages. Famulska et al. (2022) underscore the pivotal role of environmental taxes in the EU's energy and climate policy, describing them as indispensable tools for fostering sustainable development, applicable across all EU Member States.

Williams III (2016) emphasizes the dual benefits of environmental taxes, noting their potential to provide new revenue streams and offer a cost-effective way to reduce pollution emissions. Bluffstone (2003) and Galieriková and Sosedová (2016) report that several countries, including those in Central and Eastern Europe, the former Soviet Union, and China, have implemented large-scale pollution tax systems. Others have experimented with taxes on environmentally harmful products, such as transport fuels, to both generate revenue and curb pollution. Bian and Zhao (2020) contrast tax and subsidy policies, showing that while subsidies encourage manufacturers to invest more in emissions reduction, they may not reduce net emissions as much as taxes. This is because the transient effects of tax policies limit total emissions, whereas subsidy policies do not impose such constraints.

Key environmental challenges and the need for taxation reforms

Environmental challenges, including greenhouse gas emissions, ecological footprints, biodiversity loss, and ecological deficits, arise from consuming both renewable and non-renewable resources (Danish et al., 2019; Waheed et al., 2019). Historically, few empirical studies have examined the impact of environmental taxes on

environmental outcomes and energy consumption (Morley, 2012; Cottrell et al., 2016; Hashmi and Alam, 2019; Sarvašová et al., 2019).

When introducing new environmental taxes, European Union states should proceed systematically and incorporate comprehensive strategies based on thorough evaluation and coordination. First, an analysis of potential ecological, economic, and social impacts is necessary to determine the optimal scope and structure of taxes (Barrage, 2020). The process should be transparent and include public debate to increase awareness and support for the measures in question. Coordination at the EU level is critical to prevent market distortions and ensure a level playing field for all member states (Weiß, 2024). Gradual and flexible introduction enables effective adaptation and minimizes negative impacts (Thalmann, 2012). An important aspect is also the focus on justice, where relief or compensation can help mitigate regressive effects on disadvantaged groups (Jagers et al., 2019). Education and information campaigns are key to increasing the acceptance and support of sustainable practices. In conclusion, continuous monitoring and evaluation of tax effectiveness are necessary to adapt policies to current needs and outcomes (Kohlscheen et al., 2024). This multidimensional approach ensures that new environmental taxes are effective and fair, increasing their acceptability and positive impact on society and the environment.

Objective and hypothesis

The purpose of this study is to compare and analyze environmental taxes in selected EU countries, highlighting similarities in their application as key tools of environmental policy, and to propose specific solutions within this context. Our research centers on analyzing data from selected European Union countries on energy taxes, transport taxes, environmental pollution taxes, and resource taxes. The statistical testing will use data from Eurostat (2021) and the Organization for Economic Cooperation and Development (2021), covering a five-year period identified as the pre-crisis era. The Organization for Economic Cooperation and Development databases, in particular, serve as a crucial resource for research on environmental taxes in the selected countries. These databases provide extensive, detailed, and categorized information, enabling the analysis and comparison of various aspects of environmental taxation across EU Member States. Including data from both Eurostat and the Organization for Economic Cooperation and Development provides a comprehensive, reliable foundation for assessing trends and the fiscal impacts of environmental taxes in the European Union. Access to these robust data sources is invaluable for policymakers, academics, and analysts seeking to optimize environmental taxes as tools to mitigate environmental burdens. Such data support the identification of effective strategies for aligning taxation with sustainable development goals. This study will focus on the development of various aspects of environmental taxes in the European Union. To do so, linear regression and correlation analysis will be used to explore statistical dependencies based on the formulated hypotheses, specifically assessing the strength and direction of the relationship between environmental tax revenues and GDP. Accordingly, the following hypotheses are formulated:

H₀: At least half of the share of environmental taxes in the country's GDP is influenced by environmental tax revenues.

and the alternative hypothesis H₁: Less than half of the share of environmental taxes in the country's GDP is influenced by environmental tax revenues.

Results

Slovakia applies the following environmental taxes: pollution taxes, including fees for discharging wastewater into surface waters, air pollution fees, and payments for mining land use. Another important category is transport taxes, which include the motor vehicle tax (road tax) and the motor vehicle registration fee. Additionally, there is a tax for entering and parking a motor vehicle in the historic part of a city. Energy taxes are also significant and cover taxes on mineral oils, electricity, coal, natural gas, the location of nuclear facilities, and payments for gas and liquid storage, as well as emission quotas. However, Slovakia has no taxes on resources or raw materials. Within the European Union, environmental management systems focus on embedding environmental policies into organizational practices. These systems address environmental aspects, set clear objectives, and implement management programs aligned with internationally recognized standards such as ISO 14001 or EMAS. Environmental taxes, as defined by the ESA (European System of Accounts) 2010 framework, are based on physical units of activities or products that demonstrably harm the environment (European Commission, 2014). These taxes help mitigate environmental damage by targeting specific areas of concern.

In the subsequent section, we will examine key areas of environmental taxation within the EU. Under regulations established by the European Parliament and Council, environmental taxes fall into four primary categories: transport taxes, pollution taxes, resource and raw material taxes, and energy taxes. This categorization provides a structured approach to addressing diverse environmental challenges across Member States. The share

of environmental taxes in Slovakia's GDP declined from 2005 to 2021. In the last year analyzed, environmental taxes increased by 0.03% compared with the previous year. Further details are presented in the following graph.

The bar chart provided shows the breakdown of environmental tax revenue in millions of euros from 2005 to 2023, categorized into three main groups: energy, pollution, and transport taxes. A quick visual analysis shows that energy taxes represent the largest share of total environmental tax revenue across all years, averaging around 85% annually. This category consistently dominates the tax structure, highlighting its central role in Slovakia's environmental tax system. Transport taxes account for approximately 10% of the total environmental tax revenue on average, with slight fluctuations across the years. Although less significant than energy taxes, transport taxes contribute consistently to overall revenue, with no strong upward or downward trend. Pollution taxes contribute the least, averaging only 5% of total environmental tax revenue each year. This category shows minimal growth, with small increases in some years but remaining relatively stable overall. Resource taxes are not represented in this chart, as they are not applied in Slovakia. The data suggests a stable reliance on energy taxes as the primary source of environmental tax revenue, with limited contributions from pollution and transport taxes (Slovak Environmental Agency, 2023).

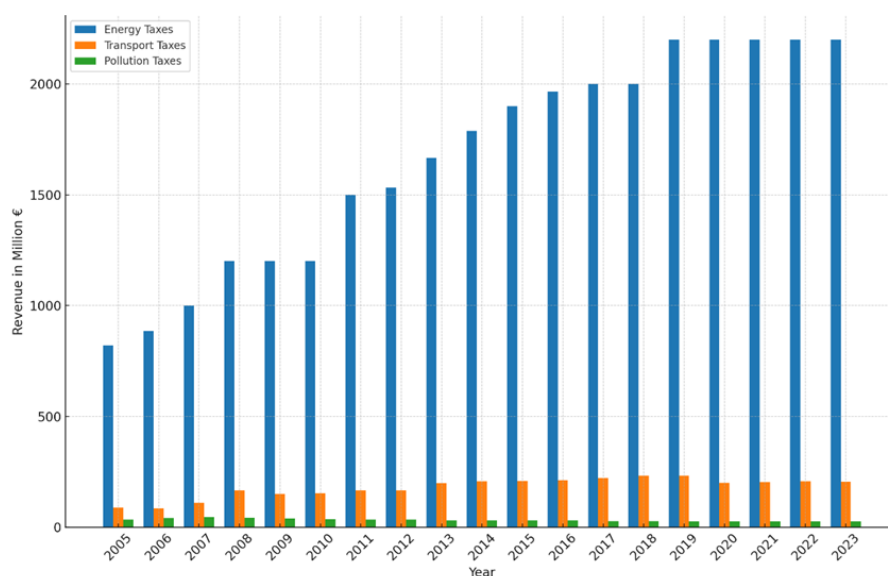


Fig. 1. Environmental Tax Revenue by Type (2005–2023)
Source: own processing according to Slovak Environmental Agency

However, we must clarify that within the specific regulatory and economic context of Slovakia, there was a significant change in the recent period—namely, the introduction of the "Next Generation EU" initiative, which the European Commission presented on May 27, 2020. The initiative aims to impose a tax or fee on non-recyclable plastics within EU countries. The method for implementing this obligation was left to the discretion of individual member states, including Slovakia, where the tax or fee is set at 800 € per ton. This decision is expected to have a considerable impact on businesses in sectors such as retail, consumer goods, chemicals, and packaging, as well as other industries that use plastics in their product packaging. The process of introducing this new legislative measure can be followed in the diagram below.



Fig. 2. The process of introducing "New Generation EU" taxation
Source: own processing according to the European Commission

Slovakia has not yet imposed this tax, but it is a one-time transfer from the state budget of approximately 30 million €. Additionally, Slovakia has recently implemented a deposit return system for beverage packaging.

Significance of Statistical Results and Interpretation of Regression Analysis

In the next section, the analysis focuses on the interdependence between two variables, where Y is the dependent variable, and X is the independent variable, utilizing regression and correlation analysis. In our research, we define the share of environmental tax revenues as a percentage of GDP as the dependent variable (Y), while total environmental tax revenue for the country serves as the independent variable (X).

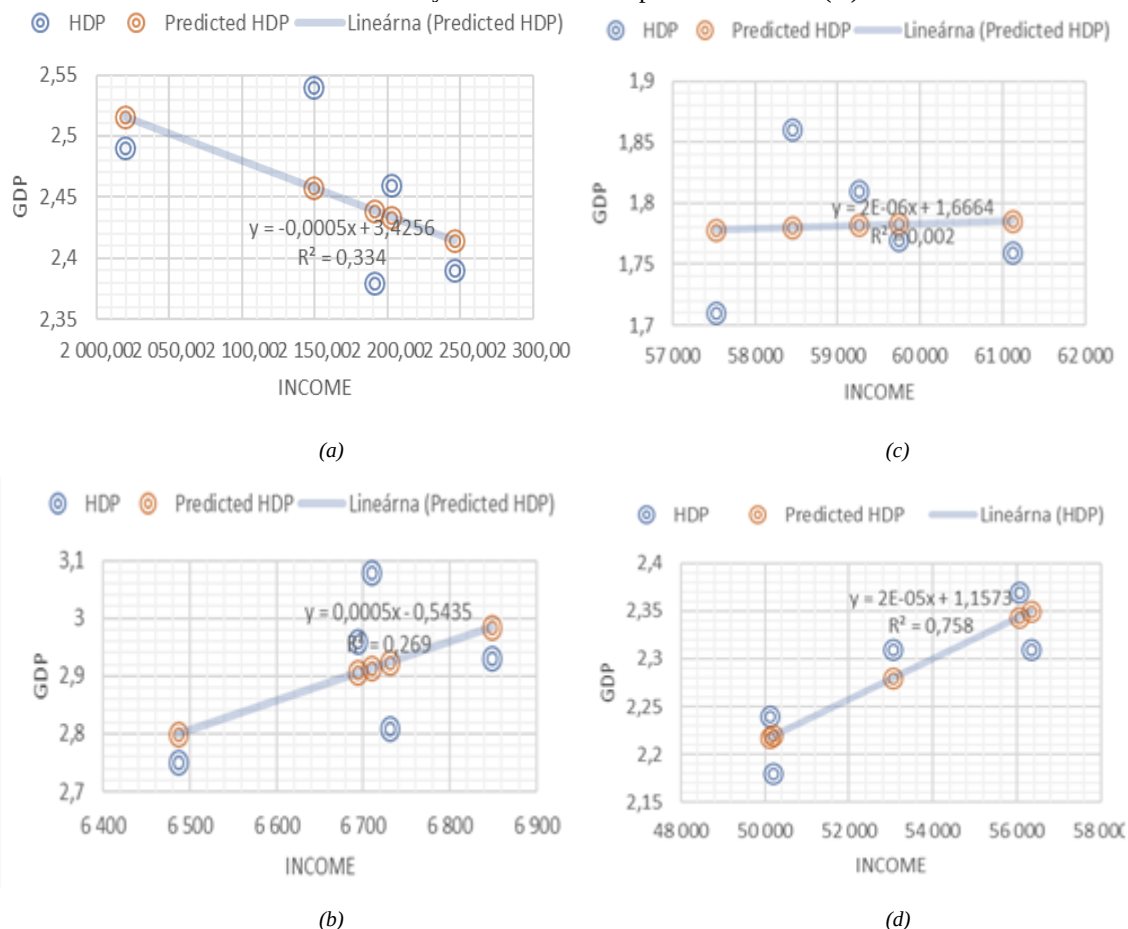


Fig. 3. Environmental Tax Revenues as % of GDP, (a) Slovakia, (b) Finland, (c) Germany, (d) France
Source: own processing according to European Commission

Here are the individual regression functions for each country:

$$\text{Slovakia} = -0.0005x + 3.4256 \quad (1)$$

$$\text{Germany} = 2 \cdot 10^{-6}x + 1.6664 \quad (2)$$

$$\text{Finland} = 0.0005x - 0.5435 \quad (3)$$

$$\text{France} = 2 \cdot 10^{-5}x + 1.157 \quad (4)$$

The regression equation and corresponding graph suggest a negative relationship between the variables, with a correlation coefficient of 0.578, indicating a moderate to strong correlation. The coefficient of determination (R^2) is 0.334, signifying that the regression model explains 33.4% of the variance in the proportion of environmental tax revenue relative to GDP. The remaining 66.6% of the variation is attributable to other external or unaccounted-for factors not captured within the current model. This highlights the presence of additional influences affecting the relationship between environmental taxation and GDP. Consequently, for Slovakia, we dismiss the null hypothesis H_0 , thereby affirming the alternative hypothesis H_1 . The failure to reject the alternative hypothesis indicates that environmental taxes in Slovakia do not exhibit a strong correlation with GDP growth. The decreasing share of environmental tax revenues suggests a more lenient approach to environmental taxation, potentially reflecting the structure of the Slovak economy or regulatory priorities. This may result in fewer incentives for environmental improvements and pose long-term sustainability risks. Conversely, the decline in Germany's environmental tax revenues likely reflects increased efficiency and a structural shift toward more sustainable industries. Although this reduces immediate tax income, it could drive innovation and enhance long-term economic competitiveness.

In contrast, examining the coefficient of determination for Germany reveals it to be 0.000002 in regression equation (2), which effectively denotes a negligible influence of environmental tax revenues on the country's GDP as a percentage. From this information, it is evident that the null hypothesis H_0 is refuted, leading to the endorsement of the alternative hypothesis H_1 . The contributions from environmental taxes in Germany have an inconsequential (or minimal at best) impact on the proportional representation of these taxes in the nation's GDP. This conclusion prompts further investigation into the matter. This prompts further investigation into structural factors within Germany's economy. The data suggests that Germany may have transitioned to a more energy-efficient industrial base, reducing the taxable base of environmentally harmful activities. Additionally, strong regulatory frameworks may be driving investments in green technologies, indirectly supporting environmental goals. Thus, while the fiscal impact of environmental taxes on GDP is minimal, these economic adjustments may still contribute to Germany's sustainability objectives. Further research should focus on these structural changes and their implications for long-term growth.

The regression analysis for Finland presents a positive relationship, as indicated by the regression equation (3). The positive nature of this regression is affirmed by both the graph and the function. With a correlation coefficient of 0.518, this relationship is strong. The statistical tests lead us to reject the null hypothesis H_0 in favor of the alternative hypothesis H_1 . This result suggests the need for further investigation into the structural factors within the Finnish economy. The data indicate a positive relationship between environmental taxes and the share of GDP, which may suggest that Finland has effectively integrated environmental taxes into its fiscal policy. This positive trend could result from strong policies focused on sustainable development and green technologies, supporting higher tax revenues from environmental sources.

In examining France's environmental tax data, the regression equation is equation (4), which the graph and function both support as a strongly positive relationship. A very high correlation coefficient of 0.8704 signifies an extremely strong relationship. The coefficient of determination is 0.758, suggesting the regression line accounts for 75.8% of the variance in the proportion of environmental tax revenue to France's GDP. Based on these findings, we uphold the null hypothesis (H_0). Across the countries analyzed, we upheld H_0 for every country except France, where we did not support H_0 . These findings suggest that France has a highly significant positive relationship between environmental tax revenues and GDP, indicating that environmental taxes play a crucial role in the country's fiscal structure. The high determination coefficient (0.758) implies that environmental taxes are tightly linked to the country's economic output, likely driven by France's strong regulatory frameworks and commitment to green initiatives. This suggests that environmental taxes in France are more effective at influencing GDP than in the other countries analyzed.

The regression results indicate different levels of dependence between environmental taxes and GDP across the analyzed countries. In Slovakia, the coefficient of determination (R^2) is 0.334, meaning the model explains 33.4% of the variability in the share of environmental taxes in GDP. This result suggests that other factors influence the share of environmental taxes in GDP, such as macroeconomic policies, investments in green technologies, or changes in the structure of the economy.

In contrast, in France, the coefficient of determination is 0.758, indicating a significantly stronger relationship between environmental taxes and GDP. This may imply that in this country, environmental taxes are an important part of the fiscal system and have a clearer impact on overall economic performance.

Another key indicator is the correlation coefficient, which measures the strength of the relationship between environmental taxes and GDP. In Slovakia, the correlation coefficient is 0.578, indicating a moderate positive

correlation. On the other hand, in France, this value rises to 0.8704, suggesting a strong link between environmental taxation and GDP growth.

These results suggest that in countries where environmental taxes correlate more strongly with GDP (e.g., France), these taxes may be more effective as a tool to stimulate sustainable economic growth. In countries where this relationship is weaker (e.g., Slovakia), policymakers may need to reassess tax policies, whether by increasing tax rates, expanding the tax base, or better targeting revenues for environmental measures.

The countries selected for this analysis (Slovakia, Germany, Finland, and France) represent a diverse range of environmental taxation approaches within the EU. Slovakia and Germany offer contrasting perspectives, with Slovakia emphasizing relative fiscal contributions and Germany focusing on industrial efficiency. Finland and France were chosen for their strong environmental initiatives and integration of environmental taxes into fiscal policy.

Implications of Regression Analysis Results for Environmental Tax Policy

The regression analysis results reveal that the impact of environmental taxes on GDP varies significantly across the analyzed countries. While Finland and France exhibit a strong relationship between environmental taxation and economic performance, Slovakia and Germany show a weaker connection. These findings suggest that different fiscal structures, regulatory frameworks, and tax policies influence the effectiveness of environmental taxation in each country.

In Slovakia, the weak correlation suggests that environmental taxes have a limited impact on GDP, likely due to their relatively low rates and exemptions for certain industries. This indicates that environmental taxation is not yet an effective tool for influencing economic behavior, and policy adjustments, such as expanding the tax base or increasing tax rates, may be necessary to enhance its impact.

In Germany, the weak link between environmental taxes and GDP can be attributed to the country's reliance on subsidies and carbon pricing mechanisms rather than direct taxation. Germany's strong regulatory framework and energy efficiency policies already mitigate environmental damage, reducing the need for high environmental taxes. Future improvements could involve strengthening carbon pricing and aligning tax policies with sustainability objectives.

In Finland, the strong correlation between environmental taxes and GDP suggests these taxes are well integrated into the fiscal system and effectively support sustainability goals. Finland's approach, which includes high pollution taxes and reinvesting revenues in green projects, shows how environmental taxation can drive sustainable economic growth. Maintaining this strategy and sharing best practices with other countries could further enhance its effectiveness.

In France, the strong correlation suggests that environmental taxation plays a significant role in the country's economic and environmental strategy. France successfully aligns tax policies with sustainability goals by reinvesting revenues into climate adaptation measures and green energy initiatives. Strengthening tax incentives for low-carbon technologies and harmonizing EU-level policies could further improve the effectiveness of France's environmental tax system.

Discussion

In Slovakia, the share of environmental taxes relative to GDP fell from 2.49% in 2016 to 2.38% in 2020, a reduction of 0.11% over five years. The only increase during this period was in 2017, when the share rose by 0.06% to 2.54%. Despite recording the lowest environmental tax revenue among the selected countries, Slovakia has the second-highest environmental tax-to-GDP ratio. This aligns with findings by Pászto et al. (2020), who analyzed the fiscal burden of environmental taxes in Central and Eastern Europe and noted that Slovakia places a stronger emphasis on relative tax contributions, despite lower absolute revenue levels.

Conversely, Germany, despite generating the highest revenue from environmental taxes in the EU, has the lowest percentage share of environmental taxes relative to GDP among the four countries examined. This share consistently declined over the period, starting at 1.86% in 2016 and falling to 1.71% by 2020, a total decrease of 0.15%. Chenghao et al. (2024) highlighted this phenomenon in their study of Germany's environmental taxation policy, attributing the decline to rising industrial efficiency and the transition to renewable energy, which reduced the taxable base of traditional energy-intensive activities.

Finland ranks second-lowest in environmental tax revenue among the selected countries, yet it has the highest share of these taxes relative to GDP. Like the other nations, Finland also experienced a negative trend in this ratio over the observed period. The country's highest environmental tax-to-GDP ratio was 3.08% in 2016, which fell to 2.75% by 2020, the largest reduction (0.33%) among the countries reviewed. Dobrovolska et al. (2024) discuss how Finland's shift towards green technology may have contributed to this trend, as environmental taxes decreased due to improvements in industrial sustainability and resource efficiency.

The fourth country examined is France. Based on the table or graph, the percentage of environmental taxes relative to GDP initially increased from 2.24% in 2016 to 2.37% in 2018, an increase of 0.13%. However, this upward trend reversed in the following years, with the ratio falling to 2.18% by 2020, a decline of 0.19%. Over the period 2016 to 2020, the share of environmental taxes in GDP fell from 2.24% to 2.18%, a modest reduction of 0.06%, the smallest decrease among the four countries reviewed. Giraud et al. (2014) found that France's environmental tax policies are heavily influenced by social and political considerations, which may explain the relatively stable tax share over the observed period.

Despite having the lowest total revenue from environmental taxes in the EU at 2191.2 € million, Slovakia's share of GDP allocated to environmental taxes is 2.38%, which is higher than the EU average of 2.24%. This suggests that, although Slovakia's total revenue from these taxes is below the EU average, the proportion of its GDP devoted to environmental taxes exceeds the EU mean, highlighting a greater relative fiscal emphasis on environmental concerns. Vartašova et al. (2024) confirm this trend in their comparative analysis of Slovakia's environmental tax framework, noting that the country's policy objectives prioritize GDP allocation over total revenue.

Slovakia's revenue from energy taxes amounts to 1965.13 € million, while the average revenue from energy taxes across all EU countries stands at 8607.83 € million. Although Slovakia's revenue from these taxes is below the EU average, it dedicates a comparatively higher share of its GDP to energy taxes (2.13%), exceeding the EU average of 1.74%. This indicates that Slovakia has a more substantial proportion of its GDP influenced by energy taxes compared to the average EU country.

Additionally, in transport taxes, Slovakia earns 200.16 € million, considerably lower than the EU average of 2105.10 € million. Transport taxes account for 0.22% of Slovakia's GDP, compared with 0.42% in the EU average. Huttmanová and Mikča (2024) note that Slovakia's underperformance in transport tax revenue reflects both its smaller vehicle fleet and less stringent road-use policies than those of larger EU countries.

Overall, although Slovakia's total environmental tax revenue is lower at 2191.2 € million than the EU average of 11,106.84 € million, it allocates a higher percentage of GDP to environmental taxes (2.38%) than the EU average (2.24%). This shows a stronger emphasis on environmental taxation relative to GDP than the EU average. Červená et al. (2021) argue that this reflects Slovakia's focus on aligning its tax policies with EU environmental goals, despite lower overall revenues.

Furthermore, Slovakia's revenue from road pollution taxes stands at 25.91 € million, substantially less than the EU average of 360.13 € million (OECD, 2021). Environmental taxes offer several significant benefits, including environmental and economic efficiency, the potential to increase public revenues, and transparency. Funds generated from environmental taxes can be allocated to purposes beyond environmental protection, such as reducing income taxes, corporate taxes, or social security contributions. They can also address issues such as waste management, water pollution, and air emissions. The success of environmental taxes depends heavily on the policy frameworks and political-economic considerations surrounding their implementation.

Csikósová et al. (2021) emphasize the impact of environmental taxes on the business environment, noting both opportunities for sustainability and challenges for competitiveness. Their findings align with our analysis, particularly in highlighting the economic pressures that smaller markets, like Slovakia, face under increased environmental taxation. This suggests the importance of balancing environmental policies with support mechanisms to maintain business viability.

The future development of environmental taxes in EU countries is shaped by various factors, as highlighted in recent studies. According to research by Famulska et al. (2022), there is a growing trend among EU Member States to expand the implementation of environmental taxes, particularly in the energy sector. Piciu and Trică (2012) also observed a general movement towards increasing the use and development of environmental taxes across EU countries, drawing from the experiences of more advanced economies.

Ekins and Specks (1999) discussed competitiveness and exemptions from environmental taxes in Europe, emphasizing the varied application across sectors and countries. Ghazouani et al. (2021) provided evidence on the interaction between environmental taxes, renewable energy, and environmental technologies, showing a nuanced impact on major emitting countries in Europe depending on national contexts.

Conclusion

Our research supports these findings, particularly highlighting how countries like Finland and France have effectively integrated environmental taxes into their economic frameworks. In Finland, for example, the positive relationship between environmental tax revenue and GDP suggests strong alignment with sustainability goals, as our regression analysis confirms. Conversely, in Slovakia and Germany, environmental taxes show weaker correlations with GDP, suggesting a potential gap in policy effectiveness or the influence of other economic factors that dilute the impact of such taxes. These results clearly demonstrate the varying effectiveness of environmental taxes across different EU nations, driven by national policies and economic structures.

Overall, the studies suggest that the adoption and refinement of environmental taxes within the EU will likely continue, driven by both economic and environmental considerations. Our findings suggest that the success of these taxes in reducing environmental impacts while supporting economic growth largely depends on how well they are integrated into broader fiscal and environmental policies. Specifically, countries with strong regulatory frameworks, such as Finland and France, seem better equipped to use environmental taxes as effective sustainability tools.

As environmental challenges evolve, taxation's role in addressing them becomes increasingly significant. Future research will likely focus on the efficacy of environmental taxes in promoting sustainable practices across various sectors, including industry, transportation, and agriculture. This research will examine how taxes can be designed to be both economically viable and environmentally effective, exploring pricing strategies, exemptions, and subsidies. Additionally, understanding how environmental taxes interact with other policy tools, such as emissions trading systems and regulatory measures, will be crucial to assessing the holistic impact of fiscal policies on environmental outcomes.

One limitation of our research was the inability to thoroughly explore the socio-economic impacts of environmental taxes across all demographic groups due to time and resource constraints. However, this area represents a critical avenue for future research. Further studies should investigate how these taxes affect economically vulnerable groups, ensuring that environmental policies do not exacerbate social inequalities. Mechanisms to mitigate regressive effects, such as revenue recycling through tax rebates or increased social services, need further exploration. This is particularly relevant in countries like Slovakia, where the tax base is relatively small.

Moreover, while our study focused primarily on national contexts, the global dimension of environmental taxation should also be considered in future research. International cooperation and policy harmonization are essential to address transboundary environmental issues, such as climate change and biodiversity loss. This research would help refine environmental tax policies, making them more adaptable and effective in the face of global environmental challenges.

In conclusion, our findings clearly show that the integration of environmental taxes into national economies varies significantly across the EU. While countries like Finland and France have demonstrated the effectiveness of these taxes in supporting GDP growth and environmental goals, others, such as Slovakia and Germany, reveal gaps in their implementation. Further research should examine these disparities to ensure environmental taxes are tailored to both national and global sustainability targets.

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