Environmental tax reform efficiency: Prerequisites and consequences

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Abstract. Ensuring green transformations of the national economy requires the careful development of effective mechanisms for influencing the behaviour of key stakeholders who impact the environment. Implementing environmental tax reforms (ETR) to balance environmental and economic effects was successful for many European countries. Adapting this experience for developing countries requires considering the impact of national specifics on the expected result. In the first stage, the key consequences of the ETR implementation were assessed using the Differences-in-Differences method. In the second stage, the impact of economic, social, technological and institutional factors on the result of the ETR implementation was tested using panel regression modelling. The calculations showed that the positive effect of increasing the security of the national economy

due to the ETR implementation occurs with a relatively long time lag. This indicates that ETR should be considered a strategic instrument for regulating the national economy and developed for the long term, supported by tactical operational tools. At the same time, the most significant manifestations of ETR are observed in the context of their impact on business activity and foreign trade. The key prerequisites for ensuring the ETR's effectiveness are the role of the fiscal and budgetary system, the welfare and gender equality of society, the spread of digital technologies among the population and the rule of law.

1. INTRODUCTION

The problems of ensuring sustainable development, reducing the ecological footprint and forming a carbon-neutral economy have been the focus of scientific attention for a long time. It is traditionally believed that economic growth and environmental security are controversial concepts. Empirical data confirm that energy transformations have a negative impact on fiscal stability (Wang & Li, 2024). At the same time, based on empirical data from EU countries, Mehedintu & Soava (2024) and Svazas et al. (2023) prove the existence of a long-term equilibrium relationship between economic growth and renewable energy, indicating a broader argument for the necessity of green transformations. The implementation of environmental policy at the global and national levels has led to various regulatory mechanisms to ensure environmental transformations, implemented through administrative methods and economic instruments. An analysis of the landscape of modern scientific literature on carbon-neutral economy has shown that the least studied area is the organisational mechanisms of energy system transformation (Vakulenko et al., 2023; Vîrjan et al., 2023). At the same time, a key component of the sustainable development management system is its financial support (Ziabina & Acheampong, 2023). Today, financial support for environmental policy is implemented in various forms: state support programs, special funds, soft loans, etc. On the other hand, the effectiveness of different approaches to financing environmental issues is important. Researchers determine that climate funds often have limited effectiveness due to the low level of transparency of the reporting system and an imperfect coordination system (Bozhenko et al., 2023). On the other hand, the most significant factors influencing the carbon intensity of GDP in European countries are public investments and taxes (Humenna et al., 2020; Zábojník et al., 223). The key objective of applying environmental taxes is to achieve a balance between environmental, economic and social outcomes to maintain equilibrium in the national economy (Yoshimori, 2024). Since the 1990s, many European countries have implemented environmental tax reforms to ensure the comprehensive achievement of environmental and economic goals. At the same time, introducing environmental taxes often leads to the displacement of environmentally harmful production and disruption of the country's trade balance (Kubatko et al., 2024), negatively affecting the country's economic development. This indicates that the design of regulatory mechanisms should include any safeguards to neutralise the effects of negative economic shocks. For developing countries, the issue of developing and implementing environmental taxes does not lose its relevance. In their implementation, the experience of benchmark countries is often used. In this case, adapting the experience to national specifics is important. That is why it is necessary to consider the primary features of the country's development, which ensure the effectiveness of implementing environmental tax

reforms and contribute to achieving positive synergy, which became the study's goal. The key tasks of the research are to analyse the consequences of the implementation of environmental tax reforms and to study the key prerequisites that determine the differences in the results of their implementation.

2. LITERATURE REVIEW

The design of tax reforms should be carefully considered. Thus, there is a close relationship between the tax burden and the shadow economy, which can lead to the levelling of the effectiveness of tax instruments (Lyeonov et al., 2023). Previous studies have empirically confirmed that the design of environmental taxes is important in ensuring their effective impact on the security of the national economy (Samusevych et al., 2023). At the same time, the effectiveness of individual environmental taxes varies significantly depending on countries' socio-economic development level (Vasylieva et al., 2020). Fernandez et al. (2011) tested different combinations of taxes to find the optimal environmental tax reform and ensure the achievement of economic and environmental goals. Rodríguez et al. (2019) conclude that environmental tax reform can ensure the achievement of regulatory goals in transforming the energy system.

Bucur & Rus (2024) argue that a high level of economic development is favourable for improving environmental and social components. However, this impact significantly depends on national policy and environmental management. On the other hand, the results obtained by Vasylieva et al. (2022) indicate that even developing countries can demonstrate balanced socio-economic development. However, it will be significantly slower than in initially well-developed countries. Based on the analysis of a large sample of countries, Dinu et al. (2024) conclude that the impact of institutional and economic factors on the state of the environment in a country significantly depends on its level of development. In particular, the growth of industry share in the economy has a more harmful impact on the environment in less developed countries than in more developed ones. This concept is continued in the results obtained by Dvorsky et al. (2024), which indicate that a key prerequisite for the environmental responsibility of companies is their good financial condition. At the same time, large enterprises demonstrate better sustainable development indicators than small and medium-sized businesses (Yadav & Yadava, 2023). This is, in particular, due to differences in the scale of the financial base, which indicates the need to support small businesses first and foremost to ensure transformations on the path to sustainable development. The level of financial literacy of company management must be an incentive for increasing their environmental orientation and achieving sustainable development goals (Ratnawati et al., 2024), along with gender equality issues (Keelson & Padi, 2024). At the same time, corporate responsibility is important for ensuring the financial performance of companies, and this relationship is also mediated by the influence of information technology (Wang et al., 2024). Many companies consider forming a green brand while implementing a sustainable development policy (Hraiga, Fadel & Abbas, A. 2023; Starchenko et al., 2021). On the other hand, the growing demands for inclusive and sustainable development of companies have led not only to their real progress in this direction but also to the emergence of unscrupulous approaches and the creation of illusions of corporate responsibility (Morin & Burrell, 2024).

An extremely important aspect of ensuring ecological transformations is considering the impact of economic and institutional factors on changing the environmental situation. Analysing empirical data from Canada, researchers prove that the quality of institutions, productivity factors and renewable energy consumption reduce environmental burden. At the same time, income growth leads to increased environmental pollution (Mukhtarov et al., 2024; Grebski & Kuzior, 2022). It should be noted that the quality of institutions has a very close inverse relationship with the level of the shadow economy in the country, while the growth of the shadow economy is a significant factor in influencing the deterioration of the environmental situation along with inflation and economic growth (Tran, 2022). Another significant

factor influencing the quality of institutions is the country's level and perception of corruption (Maile & Vyas-Doorgapersad, 2023). Rajiani (2023) argues that the influence of public institutions on ensuring green transformations is determined not only by general state policy but also by the motivation and behaviour of civil servants. Khodaparasti & Garabollagh (2023) argue for the transmission effect of green governance on the environmentally responsible behaviour of the population, while Azeez et al. (2024) demonstrate that centralised regulatory policy is not enough to ensure the progress of sustainable development. A well-formed regulatory mechanism should cover all sectors of the national economy which affect the environment. At earlier stages of scientific research, the focus of limiting the negative impact was the industrial economy. At the same time, considerable attention is now paid to agriculture, which impacts the environment and depends significantly on the quality of natural resources (Huzenko & Kononenko, 2024). Analysing sustainable development in the agricultural sector, Aziz et al. (2024) determine that institutions play a key role in creating a stimulating context for implementing environmentally friendly technologies. Personal beliefs form the basis of the environmentally responsible behaviour of the population (Fenitra et al., 2024), which is why education and information campaigns are important factors in the development of the environmental responsibility of the population and business (Al Chami, 2023). In addition, researchers confirm the contribution of the country's cultural development to ensuring progress in sustainable development (Titko et al., 2023).

Alkaf et al. (2023) state that human capital plays a very important role in ensuring the transition to the principles of sustainable development. Sharma et al. (2023), based on the results of the population survey of different countries, determine that people's attitude towards the implementation of the principles of sustainable development has quite significant differences across countries. This indicates that the implementation of environmental regulation should be carried out considering the population's readiness to develop a green economy. To ensure environmental regulation, governments of different countries use a wide range of tools for implementing climate strategies: financial and fiscal measures, public procurement, investment and innovation instruments; however, the effectiveness of their application depends on the model of interaction between the state and business (Avlogiaris et al., 2023). Corruption and the shadow economy are always factors that reduce the effectiveness of regulation and level the effectiveness of tax functioning (Dobrovolska et al., 2024). In finding the most successful approaches to ensuring the effectiveness of regulatory actions, it should be noted that a necessary condition for achieving the expected results is supplementing incentive measures with control measures, such as inspections (Ishwardat et al., 2024). A fairly common practice is to set limits on carbon emissions. However, researchers have proven this tool is effective only in the first two years and has certain negative regional externalities (Bai et al., 2023). The results obtained by Lyu & Liu (2023) confirm this thesis and show that the impact of environmental regulation on the development of the green economy is cyclical and characterised by spatio-temporal heterogeneity, providing the greatest effect on non-state enterprises. Kowalska & Bieniek (2022), studying the sustainable development of the food industry, note that in the context of the digitalisation of the economy, the traditional list of tools for its provision should be supplemented by the use of blockchain technologies, the organisation of green supply chains, media campaigns, etc. On the other hand, the results of a study conducted by Hornungová & Petrová (2023) demonstrate the existence of a weak connection between the technological development of the country and the volume of greenhouse gas emissions, the growth of which creates significant threats to the development of agriculture (Hamam et al., 2023). Piwowarski (2024) determines that properly designed advertising materials create significant incentives for environmentally responsible behaviour, which is empirically confirmed by Mehta et al. (2024). In this context, Folgado-Fernandez et al. (2023) prove the importance of information technologies for ensuring the sustainable development of tourism.

Researchers also prove the importance of structural transformations in the economy to ensure environmental efficiency using the example of waste management. Thus, the aggregate level of GDP per capita is a factor that reduces the efficiency of waste management, and the growth of the circular economy ensures its increase (Potkány et al., 2024). On the other hand, an effective transition to the implementation of the principles of the circular economy requires the readiness of all its stakeholders, including business, society, state and public institutions (Zhidebekkyzy et al., 2023; Kuzior et al., 2022a), as well as a certain achieved level of technological efficiency (Gedvilaite & Ginevicius, 2024).

It should be noted that the transition to a green economy requires considering all factors without exception. Thus, Van Den Engel et al. (2024) prove that monetary policy has a transmission effect on the sustainable development of the economy. Thus, the real interest rate has an inverse effect on carbon dioxide emissions by reducing energy consumption, and on the other hand, it has a direct effect by discouraging green investments, which are key to ensuring environmentally responsible behaviour and forming a low-carbon economy (Talha, 2023). At the same time, the country's financial system indicators are always closely related to political stability (Dahal et al., 2024). Using the example of analysing the transformation of the energy system, Kuzior et al. (2021) prove the need to supplement the state strategy with organisational and economic mechanisms for its implementation at different levels and to involve all stakeholders in the country.

Streimikiene (2023) identifies import dependence, supplier concentration, and energy infrastructure development as determinants of energy security. Wołowiec et al. (2022) determined that energy losses during distribution increase total energy consumption by 17%. Reducing the share of fossil fuels in the structure of the energy system is not only a guarantee of energy security but also affects the improvement of socio-economic indicators. Reducing the level of environmental pollution allows for a significant improvement in the level of population health, which in turn reduces the costs of maintaining the healthcare system (Badreddine & Larbi Cherif, 2024; Balcerek-Kosiarz, Jarubas, Kozicki & Mitkow, 2024) since their level is directly related to the intensity of the workload on doctors (Sheliemina, 2023). All this, in combination, leads to an improvement in the level of national security (Firstová & Vysochyna, 2024). Recent studies show that the development of digital technologies positively impacts energy efficiency, increasing the safety and efficiency of energy production methods.

The study indicates the potential connection of social, economic, managerial and technological factors with the effectiveness of implementing environmental tax reforms, which allows us to substantiate the key hypotheses of the study. The first hypothesis is to verify the key environmental and economic consequences of environmental tax reforms. The study's second hypothesis is to identify effective economic, social, technological and institutional factors determining the effectiveness of implementing environmental tax reforms.

3. METHODOLOGY

To test the hypotheses regarding the preconditions for the consequences of implementing environmental tax reforms, the specifics of their experience in European countries were investigated. For this purpose, a sample of two groups of countries was formed. The main research group was formed by 14 countries that successfully implemented environmental tax reforms: Denmark (1994-1998, 1996-2000, 1999-2002), Finland (1997), Germany (1999-2003, 2006), Ireland (2009, 2010, 2013), Netherlands (1996), Norway (1991, 1999), Sweden (1991, 1997, 2001), United Kingdom (1996), Italy (1999), Austria (1999), Belgium (1993), Czechia (2007), Switzerland (2008), Estonia (2005). The control group was formed by 18 European countries that had no experience in implementing environmental tax reforms (France, Bulgaria,

Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Ukraine, Cyprus, Luxembourg, Malta, Iceland).

A list of parameters was formed to assess the consequences of environmental tax reforms that can serve as potential indicators of their effectiveness. The first comprehensive indicator is the level of security of the national economy (NSE), which summarises indicators of environmental, energy and economic security and reflects the synergy of the impact of environmental tax reform on the state of the national economy. The works present the methodology for constructing this indicator in detail (Štreimikienė et al., 2021; Samusevych et al., 2021). In addition, to assess the potential consequences of environmental tax reforms, a set of economic indicators was formed: the indicator of net outflow of foreign direct investment, % GDP (FDI), which characterises the change in the country's investment attractiveness as a result of the tax reform; the indicator of economic openness, measured by the sum of the country's exports and imports about GDP, % (Trade), which is a parameter of the global competitiveness of the economy; the inflation rate, measured by the annual percentage increase in the consumer price index (Inflation); as well as the density of new business registrations per 1,000 economically active population (NewBusDens), which characterises the reaction of businesses to new taxation conditions.

A set of parameters for the country's economic, social, and technological development and public administration quality has been formed to measure the prerequisites for ensuring the effectiveness of environmental tax reforms. Economic prerequisites demonstrate the following parameters: the level of the total tax burden, measured by tax revenues in the country's GDP, % (TR), which characterises the role of the tax system in the national economy; central government debt, % GDP (Debt), which reflects the level of economic stability of the country; total budget revenues, excluding grants, % GDP (Rev), which characterises the features of the country's budget system; the net change in a country's holdings of international reserves resulting from transactions on the current, capital, and financial accounts, U.S. dollars (Res), which is a characteristic of the country's economic stability. To characterise social development, the following indicators were selected: gross national income per capita, constant 2015 U.S. dollars (GNI), which reflects the general level of well-being of the country's population; current health expenditure, % of GDP (Health), which is a characteristic of the performance of social functions of the state; Gini index (Gini), which demonstrates the equality of income distribution of the population; the share of the urban population in the overall structure, % of total population (Urban), which characterises the impact of urbanisation on the environment; Women Business and the Law Index Score (Women), which reflects the economic opportunities of women and is a characteristic of gender equality in society. The quality of institutions is described by a set of indicators of the quality of public administration: government effectiveness (GovEf); perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism (PolSt); regulatory quality perception (RegQ); the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence (RuleLaw). To measure the indicators of technological development, the parameters of the development of science and technology, as well as their dissemination in society, were selected: worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office by residents and nonresidents (Patent); research and development expenditure, % of GDP (R&D); fixed broadband subscriptions, per 100 people (Subcr); high-technology exports, % of manufactured exports (TechExp).

Given that most countries implemented environmental tax reforms in the early 1990s, the study period covers 1994-2023, as 1994 represents the earliest available international statistics.

The study was conducted in two stages. The first stage assessed the differences in performance indicators reflecting the effectiveness of environmental tax reforms before and after their implementation using the Differences-in-Differences method, described by Clarke & Schythe (2020). Modifying the

Differences-in-Differences method for the study of events staggered across groups involves constructing a graph that reflects the difference in the performance indicator level for the study and control group before and after the occurrence of an event. In the current study, such an event is the first year of implementation of the environmental tax reform. For this purpose, a dummy variable (PostEvent) was generated, which takes the value 1 in the first and all subsequent years after the start of the tax reform and 0 in the years before the start of the environmental tax reform.

At the second stage of the study, a set of economic and mathematical models was built that characterise the impact of the prerequisites for implementing environmental tax reform using the panel regression modelling method with random effects. The model includes the main factors that are characteristics of the prerequisites for the implementation of environmental tax reforms, as well as variables generated by the multiplication of the main factors and the dummy variable PostEvent, which allows for assessing the effectiveness of the implementation of environmental tax reforms in ensuring changes in the studied performance indicators. The main factor variables were tested for correlation to prevent multicollinearity. Therefore, the model for assessing the impact of economic prerequisites on the implementation of environmental tax reforms has the following general form:

$$\{ETRR_{it}^n\} = \beta_o + \beta_1 TR_{it} + \beta_2 TR_{it} \cdot PostEvent_{it} + \beta_3 Debt_{it} + \beta_4 Debt_{it} \cdot PostEvent_{it} + \beta_5 Rev_{it} + \beta_6 Rev_{it} \cdot PostEvent_{it} + \beta_7 Res_{it} + \beta_8 Res_{it} \cdot PostEvent_{it} + \varepsilon \qquad (1)$$

where $\{ETRR_{it}^n\}$ demonstrates a set of *n* indicators of the effectiveness of the implementation of environmental tax reforms (NSE, FDI, Trade, Inflation, NewBusDens) in country *i* in period *t*; β_o – constant; $\beta_1 - \beta_8$ – coefficients for factor variables, ε – standard error of measurement and specification.

The general appearance of the model for assessing the impact of social prerequisites on the outcome of the implementation of environmental tax reform is demonstrated as follows:

$$\{ETRR_{it}^n\} = \beta_o + \beta_1 GNI_{it} + \beta_2 GNI_{it} \cdot PostEvent_{it} + \beta_3 Health_{it} + \beta_4 Health_{it} \cdot PostEvent_{it} + \beta_5 Gini_{it} + \beta_6 Gini_{it} \cdot PostEvent_{it} + \beta_7 Urban_{it} + \beta_8 Urban_{it} \cdot PostEvent_{it} + \beta_9 Women_{it} + \beta_{10} Woman_{it} \cdot PostEvent_{it} + \varepsilon \qquad (2)$$

The impact of institutional quality on the effectiveness of environmental tax reforms was investigated using the following model:

$$\{ETRR_{it}^n\} = \beta_o + \beta_1 GovEf_{it} + \beta_2 GovEf_{it} \cdot PostEvent_{it} + \beta_3 PolSt_{it} + \beta_4 PolSt_{it} \cdot PostEvent_{it} + \beta_5 RegQ_{it} + \beta_6 RegQ_{it} \cdot PostEvent_{it} + \beta_7 RuleLaw_{it} + \beta_8 RuleLaw_{it} \cdot PostEvent_{it} + \varepsilon \qquad (3)$$

To describe the impact of technological prerequisites on the outcome of the implementation of environmental tax reforms, a model of the following form was constructed:

$$\{ETRR_{it}^n\} = \beta_o + \beta_1 Patent_{it} + \beta_2 Patent_{it} \cdot PostEvent_{it} + \beta_3 R\&D_{it} + \beta_4 R\&D_{it} \cdot PostEvent_{it} + \beta_5 Subscr_{it} + \beta_6 Subscr_{it} \cdot PostEvent_{it} + \beta_7 TechExp_{it} + \beta_8 TechExp_{it} \cdot PostEvent_{it} + \varepsilon \qquad (4)$$

Estimation is carried out separately for each outcome variable. Thus, 20 econometric models were constructed in the overall study. Stata 14/SE software was used for calculations. Each model is estimated in two stages. In the first stage, a general model is built, and in the second stage, all insignificant variables are removed, and the model is recalculated.

4. EMPIRICAL RESULTS AND DISCUSSION

In most European countries, environmental taxation was introduced and developed through "green" tax reforms – comprehensive measures that integrated environmental taxes into the tax system and state regulatory policy. The European Environmental Agency (2005) defines environmental tax reform as "changes in a national tax system where the tax burden is shifted from economic functions, sometimes called "goods", such as labour (personal income tax), capital (corporate income tax) and consumption (VAT and other indirect taxes), to activities that lead to pressure on the environment and the use of natural resources". Finland was the first European country to start environmental tax reform by introducing a carbon tax on all energy resources, except for fuel for transport purposes, in 1990. In the following years, many European countries introduced environmental tax reforms. At the same time, each had its characteristics regarding the purpose of implementation and the instruments used. The analysis made it possible to identify a list of key elements that determine the design features of environmental tax reforms and summarise possible options for their implementation, as shown in Table 1.

Table 1

A description of the environmental tax reforms design carried out in the world

Non-ecological goals of environmental tax reform	Economic development support (EE, AU)	National economy competitiveness increase (EE, FI, DE, BE)		Improving energy efficiency (DK, DE, NL)	Reducing unemployment (EE, AU, FI, DE)	Rising a revenue base (DK, FI, IE, BE)	
Tax instruments	Carbon tax (DK, FI, SE, CH, IE, AU, NO, GB, IT)	Air pollution taxes (SE, DK, NO)	Energy tax (DK, CZ, FI, DE, NL, NO, SE, IT, AT, BE)	Transport tax (DE, IE, SE)	Wastewater tax (DK	Package tax (DK)	Tax on waste (GB)
Environmental taxpayers	Mostly households (SE, FI)	Households and industry (DK)			Industry (NO)	Households (BE)	
Tax exemptions	Emissions trading scheme participating companies (IE, NO)	Fuel for transportation purposes (FI, CH, AU)	Fisheries (IT, NO)		Electricity (IE)	Coal for heating (DE)	
Tax burden restructuring	Personal income tax (SE, NL, EE, CZ, DK, FI, NO)	Employers' social contributions (DK, NL, DE, GB, CZ, NO, IT, BE)		Employee social contributions (DE, CZ		Corporate income tax (NL, CZ, NO)	
Environmental taxes revenues redistribution	Tax discounts and benefits for households (EE, AU)	Tax credit and accelerated depreciation mechanisms (NL)	Investments in energy savings technology (CH, AU, DK, DE, AT)	One-time discounts for households and companies (CH, NL)	Public transport (AT)	Special Fund (GB, DK, NO)	
Additional regulatory instruments	Emissions trading scheme (GB, AU, SE)		Mechanism for automatic tax rate increases (CH)	Investments in renewable energy and energy efficiency (AU)	Water pricing (IE)		

Note: AU – Australia, AT – Austria, BE – Belgium, CH – Switzerland, CZ – Czech Republic, DE – Germany, DK – Denmark, EE – Estonia, FI – Finland, GB – United Kingdom, IE – Ireland, IT – Italy, NL – Netherlands, NO – Norway, SE – Sweden.
*Source*: Authors' results, based on Andersen (1994); Dresner et al. (2006); Ekins & Speck (2011); Hoerner & Bosquet (2001); Kühnhenrich (2024); Vehmas et al. (1999).

Summarising the conducted research, it should be noted that the political goals of environmental tax reforms, in most cases, were related to ensuring socio-economic development, increasing the national economy's competitiveness and overcoming the unemployment problem. That is why, when developing the

design of environmental tax reform, the governments of many countries focused on creating preferential conditions for strategically important sectors of the national economy. At the same time, the reform was quite widespread in ensuring increased energy efficiency, which determined energy taxes as the most frequently used. In most cases, environmental taxes were to become an element of restructuring the tax burden, while other taxes were reduced to ensure achieving economic goals. Despite this, some countries considered introducing environmental taxes to fill the budget, which led to the absence of compensatory mechanisms for redistributing the tax burden. It is important that the policy of using tax revenues from environmental taxes was also different: in some countries, funds were accumulated in the general budget without a specific purpose; in others, the expected revenues were planned to be used as a source of financing for supporting economic measures, including accumulating revenues from environmental taxes in special extra-budgetary funds. Some countries implemented environmental tax reform with other economic instruments, which was supposed to increase its regulatory effectiveness.

At the same time, the issue of the comprehensive effectiveness of environmental tax reforms remains relevant. Figure 1 demonstrates the difference in the levels of security of countries' national economies before and after implementing environmental tax reforms.
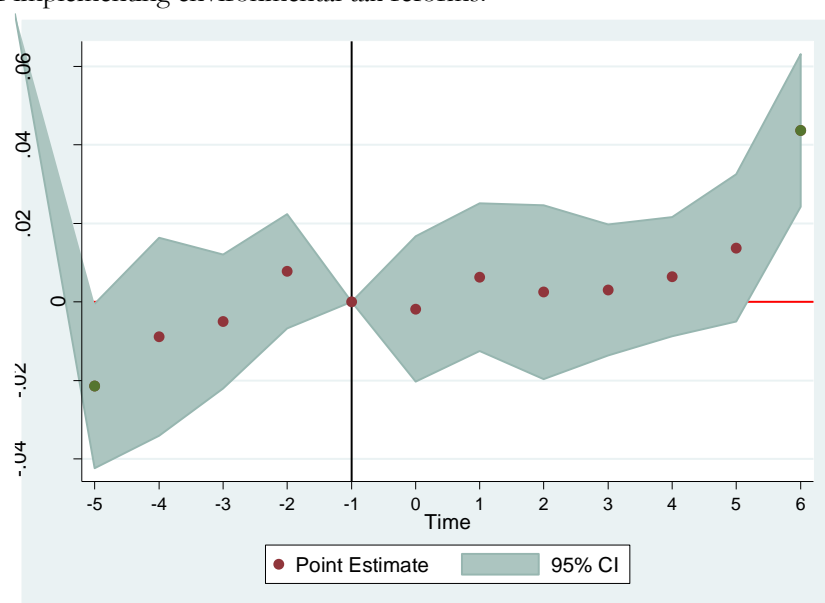

Figure 1. Level of countries' national economy security before and after the implementation of environmental tax reforms

Source: Authors' results.

The assessment results show that the difference in the levels of security of the national economy of countries that have implemented environmental tax reforms and the control group of countries increases significantly after their implementation. However, it should be noted that a sufficient level of statistical significance of the indicators is observed only in periods with a time lag of 5 or more years after implementing environmental tax reforms. This indicates that a comprehensive restructuring of the tax system requires a long time to adapt to the national economy and achieve significant results. At the same time, analysing other economic consequences of implementing environmental tax reforms is quite interesting. Figure 2 demonstrates the change in the openness of national economies in the context of their active participation in external economic relations. It should be noted that the level of economic activity of countries that have implemented environmental tax reforms increases significantly compared to the control group, while the results are statistically significant in most of the analysed periods. At the same time, the

structure of exports and imports should be analysed in more detail to assess the impact of environmental taxes on the scale of foreign trade and the specifics of economic transactions.

It is worth noting that implementing environmental tax reforms significantly decreases business activity in countries. Thus, only 6 years after the implementation of environmental tax reforms, there is a surge in population activity in the context of opening a new business (Fig. 3).
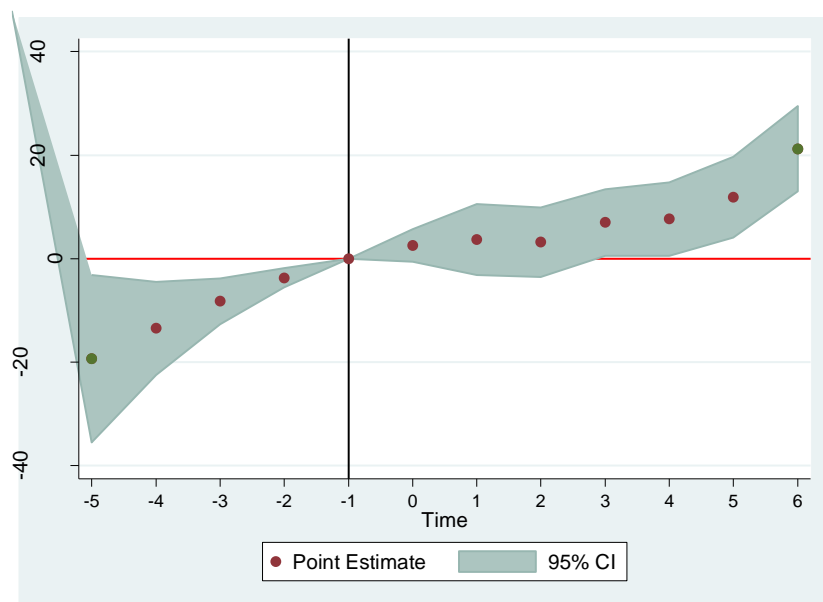
Figure 2. The level of foreign trade of countries before and after the implementation of environmental tax reforms
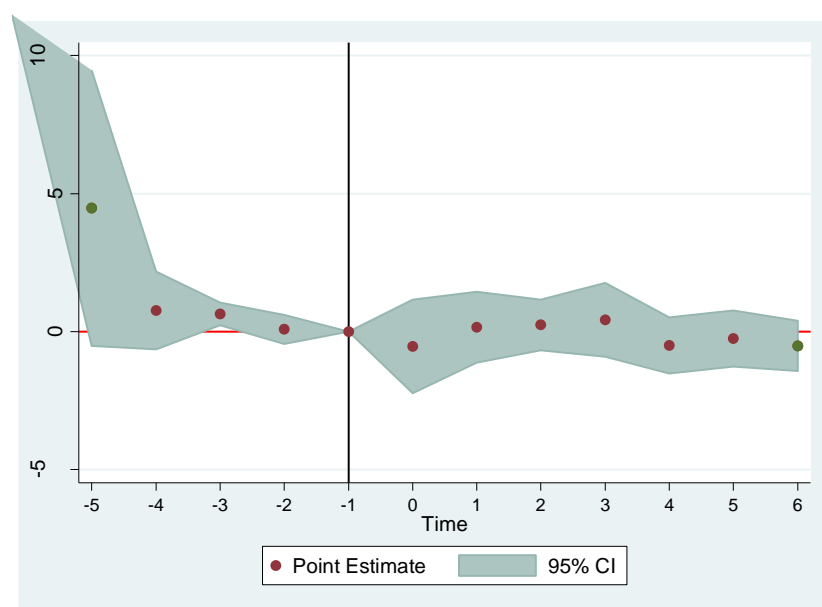
Source: Authors' results.
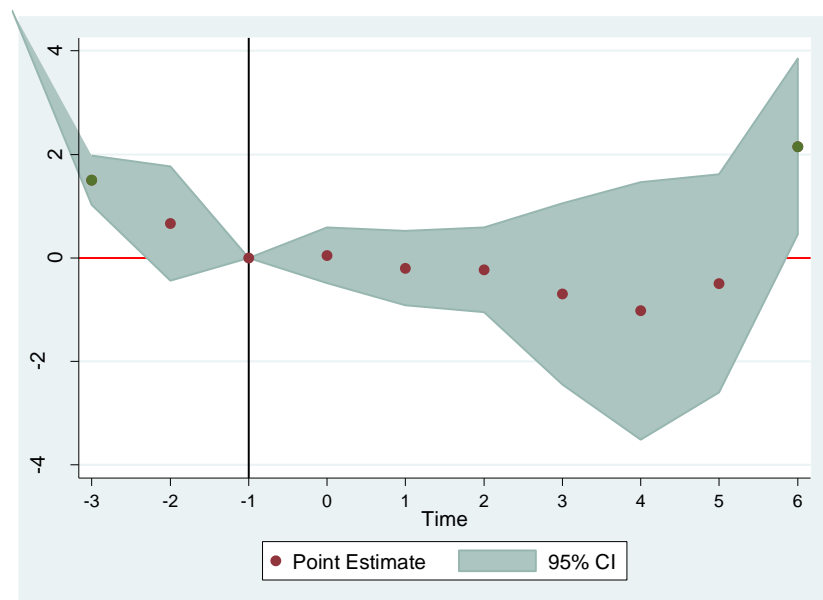
Figure 3. Level of new business density of countries before and after the implementation of environmental tax reforms

Source: Authors' results.

This indicates the need for careful planning of state support measures for businesses to avoid losses in the country's economic development.

Contrary to expectations of higher inflation due to the passing of environmental taxes to the final consumer, Figure 4 shows a reduction in inflation gaps across countries after implementing environmental tax reforms. On the other hand, the lack of price growth may be evidence of production relocation to other territories to avoid paying environmental taxes.
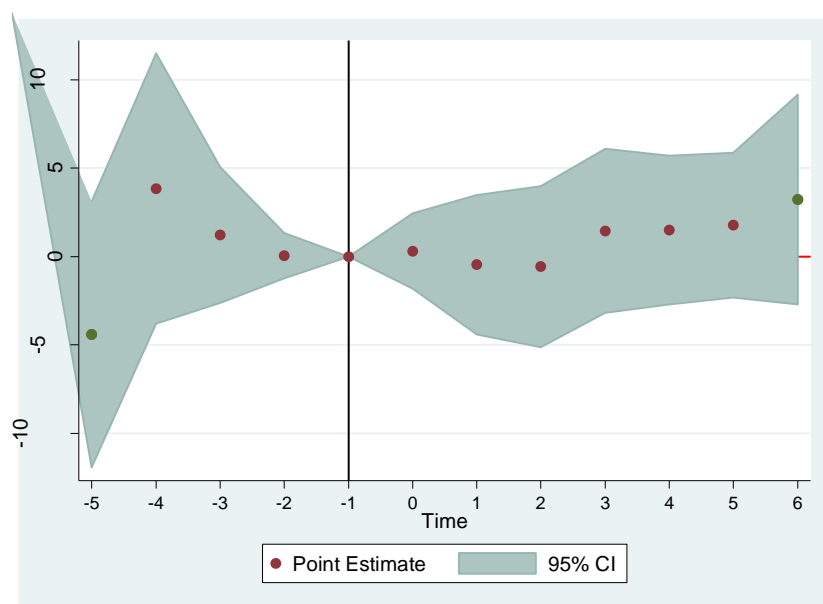

Figure 4. Inflation levels of countries before and after the implementation of environmental tax reforms

Source: Authors' results.

The expected consequence of the environmental tax reform is an investment outflow outside the country due to increased business costs. At the same time, the results obtained did not allow us to unequivocally confirm or refute this hypothesis due to the low level of statistical significance of the results obtained (Fig. 5).

In the second stage of the study, we will analyse the impact of the prerequisites for the implementation of environmental prerequisites on the result of their implementation. So, as shown in Table. 2, the relevant factors of the national economic security are the tax burden, government debt and budget revenues. The total level of the tax burden has a positive relationship with the level of security of the national economy; however, in the process of implementing environmental tax reforms, it restrains their effectiveness, which is quite natural, given the fact that even with the transformation of the tax burden in the process of reform, the taxation conditions for taxpayers become more complicated. On the other hand, the growth of budget revenues is a factor that allows for the increase in the effectiveness of environmental tax reforms to ensure the security of the national economy. At the same time, it should be noted that the impact of most factors on the outflow of foreign direct investment and the level of inflation in the process of implementing environmental tax reforms turned out to be statistically insignificant, which confirms the previously obtained results regarding the absence of a direct relationship between the implementation of environmental tax reforms and the dynamics of foreign direct investment and price growth. Thus, the level of inflation is not determined by all the examined economic factors. In contrast, the level of foreign direct investments depends on the tax and budget revenues in general but is not changed in the process of environmental tax

reforms. It is noticeable that the level of countries' trade openness during environmental tax reform may increase because of the government debt growth. Analysing the factors determining the impact of environmental tax reforms on the business environment, it should be noted that the increase in the tax burden can somewhat offset the overall impact on the development of new businesses, as can the high level of public debt. On the other hand, such relationships may indicate that the growth of new business units can occur in parallel with the growth of the shadow economy since the growth of budget revenues demonstrates an inverse relationship with the resulting variable. The values of Prob>chi2 confirm the goodness of models presented in Table 2, which is lower than 0.05. At the same time, the obtained R-square values are quite low, which is often for economic research and is a result of limited variation across panel datasets.

Figure 5. Level of foreign direct investment outflows of countries before and after the implementation of environmental tax reforms

Source: Authors' results.

Table 2

Results of assessing the impact of economic prerequisites for the environmental tax reforms on the outcome of their implementation

Variable		NSE	FDI	Trade	NewBusDens
TR		0.0074***	1.1861**		
TR*PostEvent		-0.0060**			0.6940***
Debt		0.0006***		0.2766***	
Debt*PostEvent				0.0511**	0.0365***
Rev		-0.0082***	-0.6511***	-1.3607***	
Rev*PostEvent		0.0045***			-0.5644***
Const		0.6305***	6.3096**	131.0883***	5.7934***
Wald chi2		66.99	5.32	55.25	18.29
Prob>chi2		0.0000	0.0700	0.0000	0.0004
R-sq:	within	0.1797	0.0013	0.1633	0.1077
	between	0.0019	0.1099	0.1672	0.0001
	overall	0.0084	0.0194	0.0154	0.0009

Source: Authors' results. ** indicates significance level at 0.05 level, *** indicates significance level at 0.01 level.

Analysing the impact of social prerequisites for the implementation of environmental tax reforms, we note that the factors that stimulate their effectiveness in ensuring the security of the national economy include the parameters of gross national income per capita and gender equality, while the increase in healthcare spending and the share of the urban population lead to the opposite effect (Table 3). It should be noted that a high level of social security in the population also allows for maintaining business activity while implementing environmental tax reforms. In contrast, the increase in the share of the urban population worsens this indicator and reduces the level of foreign trade activity. None of the variables studied are significant in terms of impact on the level of foreign direct investment, so that model was excluded from the further calculations.

Table 3

Results of assessing the impact of social prerequisites for the environmental tax reforms on the outcome of their implementation

Variable	NSE	Trade	Inflation	NewBusDens
GNI	0.0029***	0.5353***	-4.1907***	
GNI*PostEvent	0.0023***			0.1508***
Health		-4.6089***		-1.0821***
Health*PostEvent	-0.0107***			1.0975***
Gini	-0.0030***			
Gini*PostEvent		2.0679***		
Urban	0.0027***	3.0648***		0.2619***
Urban*PostEvent	-0.0018***	-0.5867***		-0.1429***
Women	0.0021***	1.2937***	-1.1167***	0.0993***
Women*PostEvent	0.0026***			
Const	0.2377***	-196.1677***	112.9037	-13.1343***
Wald chi2	281.80	444.24	94.83	48.54
Prob>chi2	0.0000	0.0000	0.0000	0.0000
R-sq: within	0.3916	0.5028	0.1192	0.1145
between	0.0050	0.0237	0.1266	0.1471
overall	0.0339	0.0312	0.1198	0.1463

Source: Authors' results. *** indicates a significance level of 0.01 level.

It is quite important that among the indicators of the quality of public administration, the main factor ensuring the growth of the effectiveness of environmental tax reforms in the context of their impact on the level of security of the national economy is the level of the rule of law (Table 4). Other factors turned out to be either insignificant or demonstrate an inverse relationship. In addition, a high level of the rule of law also has a positive impact on the level of business activity, which is evidence of the need for a stable legal environment to increase the confidence of the business community in the possibilities of doing business even in the context of regulatory changes. The level of institutional quality does not determine the level of foreign direct investment during the environmental tax reform process.

Table 4

Results of assessing the impact of the quality of institutions and governance in the design of environmental tax reforms on the outcome of their implementation

Variable	NSE	Trade	Inflation	NewBusDens
GovEf	0.0346**			3.4304***
GovEf*PostEvent	-0.0999***			-5.9259***
PolSt		-15.3208***		
PolSt*PostEvent	-0.0311**			
RegQ	-0.0243**		-5.7630***	4.0823***
RuleLaw	-0.0386**	16.2868***		-3.8573***
RuleLaw*PostEvent	0.1432***			5.3319**
Const	0.5473***	101.1743***	10.0918***	2.0765***
Wald chi2	66.90	37.15	61.34	35.13
Prob>chi2	0.0000	0.0000	0.0000	0.0000
R-sq: within	0.0970	0.0628	0.0440	0.0774
between	0.1036	0.0314	0.5589	0.1416
overall	0.0914	0.0116	0.1430	0.1396

Source: Authors' results. ** indicates significance level at 0.05 level, *** indicates significance level at 0.01 level.

The last block of analysis is devoted to studying the impact of technological development on the effectiveness of implementing environmental tax reforms (Table 5).

Table 5

Results of assessing the impact of technological development during the environmental tax reforms on the outcome of their implementation

Variable	NSE	FDI	Trade	Inflation	NewBusDens
R&D	0.0108**	-9.8449**			
R&D*PostEvent					-2.4560***
Subscr	0.0009***		1.4436***	-0.1721***	0.0625**
Subscr*PostEvent	0.0004**		-0.4165**		0.1755***
TechExp		0.7613**	-0.4412***	0.0363**	0.1593***
TechExp*PostEvent			1.1242***	-0.0295**	
Const	0.4906***	14.6311*	80.4606***	6.7475***	1,8079**
Wald chi2	100.07	8.40	204.60	43.52	55.56
Prob>chi2	0.0000	0.0150	0.0000	0.0000	0.0000
R-sq: within	0.1548	0.0023	0.3742	0.0942	0.1340
between	0.1389	0.2126	0.0003	0.2360	0.1710
overall	0.1099	0.0679	0.0063	0.1178	0.2186

Source: Authors' results. ** indicates significance level at 0.05 level, *** indicates significance level at 0.01 level.

The calculations showed that the increase in the number of patent applications has no connection with any of the studied parameters of the effectiveness of environmental tax reforms. At the same time, increasing funding for the research and development sector can reduce the level of business activity in the process of implementing environmental tax reforms. A broad positive impact was demonstrated by assessing the impact of the spread of Internet technologies among the population, which contributes to increasing the national economy's security level and the density of new business openings. At the same time,

the growth of high-tech exports is a supporting factor for the openness of the economy in the context of environmental tax reform; however, it can lead to an increase in inflation during the implementation process.

5. CONCLUSION

The research aims to identify the key consequences of implementing environmental tax reforms and the prerequisites for ensuring their effectiveness. The research base was 14 European countries that successfully implemented environmental tax reforms and 18 European countries that formed a control group. Using the Differences-in-Differences method, the key differences between the experimental and control groups of countries before and after environmental tax reforms were assessed. This made it possible to determine that the complex effect of increasing the national economy's security level is achieved no earlier than 5 years after implementing environmental tax reforms. At the same time, their implementation is associated with an increase in the level of activity of countries in foreign trade processes, which should be considered when developing strategic priorities for reforming national tax systems. Contrary to expectations, environmental tax reforms do not lead to a significant outflow of foreign direct investment and an increase in inflation but somewhat restrain business activity when starting a new business. It should be noted that the results obtained turned out to be quite debatable and ambiguous based on their comprehensive interpretation. On the one hand, the positive manifestations of environmental tax reforms in ensuring the security of the national economy have been confirmed. On the other hand, other economic manifestations of implementing environmental tax reforms require further research.

Analysing the key prerequisites for ensuring the effective implementation of environmental tax reforms, it should be noted that the high level of centralisation of the country's GDP through the budget and tax system contributes to better achieving the effect of increasing the security of the national economy. Among the social prerequisites, it is worth noting the high level of welfare achieved by the population and gender equality. The most important institutional prerequisite was the rule of law, while among the parameters of technological development, it is worth noting the spread of digital technologies among the population. All this allows us to improve the basis for predicting the expected effects of implementing environmental tax reforms, develop mechanisms for combining tax instruments with technologies to ensure their effectiveness and take into account deviations in potential results due to differences in the initial development conditions in the country.

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