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Implications of Environmental Taxation for Economic Growth and Government Expenditures in Visegrad Group countries

Vera Mirović, Branimir Kalaš, Jelena Andrašić, Nada Milenković

University of Novi Sad, Faculty of Economics in Subotica, Serbia

E-mail: vera mirovic@ef.uns.ac.rs, branimir.kalas@ef.uns.ac.rs (corresponding author),
jelena andrasic@ef.uns.ac.rs, nada milenkovic@ef.uns.ac.rs

Abstract

The paper shows an econometric approach to environmental taxes, economic growth and government expenditures in Visegrad Group (VG) countries from 1995 to 2018. The aim of this research is to explore how environmental taxes affect economic growth in Czechia, Hungary, Poland and Slovakia in the observed period. The subject of the research is to identify the relationship between total environmental tax revenues, energy tax revenues, transport tax revenues and economic growth. Also, empirical research includes the relation between environmental taxation and government expenditures to identify the character of their effects and influence on economic growth through government expenditures. The findings of VAR model I manifest that shocks in total environmental tax revenues and energy tax revenues positively and significantly affect the economic growth, whereas transport tax revenues have a negative and significant effect on economic growth. The results of VAR model II show that total environmental tax revenues are significantly positively related to government expenditures, which is not the case with energy tax revenues and transport tax revenues. Furthermore, empirical research finds a bidirectional causality between environmental taxes and economic growth, as well as unidirectional causality between environmental taxes and government expenditures in VG economies.

Keywords: Environment, taxes, economic growth, government expenditure, VG economies

JEL Classification: O11, O44, H23

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1. Introduction

The perfect tax system is one that enables valuable net gains for society in terms of economic efficiency, and states are increasingly focusing on environmental taxes to raise their revenue level (Zhou and Sagerson, 2012). Taxes should provide permanent revenue collection and no negative implications for economic development. Andrašić *et al*. (2018) determined taxes with the fundamental purpose to collect funds in order to finance public spending. It is essential for tax policymakers to identify possible impacts that changes in individual tax forms will have on comprehensive economic performance (Grdinić *et al*., 2017). Environmental taxes must be a function of environmental protection and encourage a higher implementation green technology in every country. Accordingly, Angelopoulos *et al*. (2013) argue that governments should try to find optimal taxation, while Annicchiarico and Di Dio (2015) highlight the importance for the world to understand the implications of environmental policy for economic activity. Optimal environmental taxation is an important issue; Chan (2019) points out that a higher environmental tax rate would regularly stymy production in a closed economy, as well as stimulate output through attracting labour inflow in an open economy. Golušin *et al*. (2013) argued that environmental taxes are capable of repairing market limitations and imperfections caused by externalities, whereas Castiglione *et al*. (2014) presented taxation as one of the most decisive market tools for environmental safety. Harring and Jagers (2013) determined environmental taxes as an illustration of a market-based push strategy designed for raising the price of unsustainable behaviour.

Developing economies use their natural resources for economic purposes in order to achieve rapid economic expansion (Zhang *et al*., 2022). A good government wants to increase society welfare (Bhattacharyya and Gupta, 2021). As environmental issues are becoming more and more relevant, governments have realized the importance of coordinated economic and environmental development (Gao *et al*., 2019). Piciu and Trica (2012) determined that environmental taxes are key for future tax policy for economies whose primary goals are environmental protection and healthy economy. He, Sun, Shen *et al*. (2019) pointed out that governments pay more attention to environmental taxes to control environmental pollution, whereas He, Ning, Yu *et al*. (2019) confirmed that environmental taxes reduce pollutant emissions in China and OECD countries. Klein and van den Bergh (2021) pointed out that carbon taxes are leading instruments of climate policy. Mardones and Cabello (2019) analysed the effectiveness of reducing local air pollution and environmental taxes in Chile to provide an economic optimization model. The authors noticed that changing the tax rate for one pollutant does not significantly affect the amount of emissions of other pollutant, so their research suggests that changing the tax rates jointly is more effective. Gebregiorgs (2018) highlighted that internalizing the social expenses of public authorities for waste collection and transport is one of these taxes' distributive functions. Environmental taxes were characterized by Labeaga and Labandeira (2020) as a cost-effective remedial strategy that supports development and utilizes clean technologies. These taxes are levied for environmental purposes and operate as a stimulus to lessen some environmental problems (Liobikiene *et al*., 2019). Based on the above, environmental taxes are one of the most important determinants of more effective environmental protection (Davidović *et al*., 2019). Likewise, Hu *et al*. (2020) determined that environmental taxes effectively mitigate environmental problems and reduce corporate pollutant emissions. Zheng *et al*. (2016) highlighted that environmental taxes encourage enterprises to mitigate pollution in China. Their results indicate that reform environmental fees to taxes can promote emission intensity reduction. At the beginning of the 2000, environmental taxes became more important in Europe compared to other continents (Radulescu *et al*., 2017).

The structure of this article is as follows. After the introduction, there is a theoretical background where similar research about environmental taxes, economic growth and government expenditures is presented. The third section is a methodological framework that identifies variables and all econometric procedures as well as preconditions for an appropriate vector autoregressive model. The fourth section is an empirical analysis of environmental taxes, economic growth and government expenditures in the VG countries (Czechia, Hungary, Slovakia and Poland) for the period 1995–2018. This section includes a descriptive analysis, correlation analysis, results of unit root tests, as well as VAR model results to determine which environmental taxes are relevant for economic growth and government expenditures in selected economies. The last section summarizes the findings and conclusions with recommendations for future research.

2. Literature Review

In order to address the dangers of climate change that could harm the financial stability, the necessity of a transition to sustainable economies has been reflected ever since the start of the global economic crisis in 2020 (De Pascale *et al*., 2021). Numerous empirical research has established a strong relationship between environmental policies and economic growth (Fischer and Springborn, 2011; Fischer and Heutel, 2013; Nuţă *et al*., 2015). One of the most crucial relationships for policymakers is that between the environment and economic growth (Mitić *et al*., 2017). According to Ivanová and Masárová (2018), gross domestic product is regarded as a main economic indicator as it most accurately captures the state of an economy. Dökmen (2012) investigated the relation between environmental taxes and economic growth in EU nations from 1996 to 2010. The empirical findings indicated a favourable and significant impact of environmental taxes on economic growth in these countries. Abdullah and Morley (2014) estimated the causal relationship between environmental taxes and economic growth in EU countries and OECD countries from 1995 to 2006. According to empirical research, there is both a long-term causal relationship between economic growth and environmental tax revenues, as well as a short-term causality going the other way. The empirical study of Xiao *et al*. (2015) showed that environmental taxes enhance environmental improvement, but have negative effect on economic variables such as GDP in China. The authors point out that policymakers should focus on long-term impacts, where negative effects are relatively smaller compared to the short run. Andrei *et al*. (2016) have investigated the relationship between environmental taxes and economic growth in Romania for the period. The results of their OLS models have manifested a negative relationship as well as a stable long-run cointegration when the taxes are the dependent variable.

Miceikiene *et al*. (2018) evaluated the impact of environmental taxes in in EU countries as well as the United States, Japan, China, Norway and Turkey from 1994 to 2015. Their findings suggest that countries with slower economic and tax growth will have a greater impact of environmental taxes. Furthermore, the quality of the human ecological life is directly correlated with environmental taxes, and ecological taxation stimulates development of technology that reduces pollution. He, Ya, Chengfeng *et al*. (2019) studied the nexus between environmental taxes, economic growth, energy consumption and carbon dioxide emissions in China, Finland and Malaysia for the period 1985–2014. Their findings showed that environmental taxes aid Finland and Malaysia's economies in energy conservation and carbon dioxide emission reduction. He *et al*. (2019) found that implementation of the energy tax reduced distorted taxes in the short run, as well as stimulating economic growth. According to Bădîrcea *et al*. (2020), the environmental tax level does not significantly affect economic growth in the short run. However, empirical findings confirmed their bidirectional causality in the long run in Romania and Sweden from 1995 to 2017.

According to the Granger test results, environmental taxes and economic growth have a significant causal impact on greenhouse gas emissions in Sweden. In addition to economic growth, environmental taxes are often related to government expenditures (Halkos and Paizanos, 2012) and energy consumption (Kosonen and Nicodème, 2009; Mikušova Meričkova *et al*., 2017; Radulescu *et al*., 2019). Lee *et al*. (2019) highlighted the role of government expenditures from the aspect of their effect on private productivity and economic growth. If government expenditures enhance private productivity, it can expect continued economic growth. Furthermore, the economic growth rate will slow down due to the crowding-out effect if the share of government expenditures rises over the steady state. Lu *et al*. (2019) showed that there is a positive spatial link between economic efficiency and environmental efficiency in thirty-one Chinese provinces. Accordingly, Hysa *et al*. (2020) analysed the relationship between circular economy indicators, environmental components and economic growth. Their research showed that environmental tax revenues positively and significantly affect the economic growth in EU countries from 2000 to 2017. Contrary to that, Hassan *et al*. (2020) analysed thirty-one OECD countries from 1994 to 2013 and their results indicated that there is no significant relationship between the environmental tax revenues and economic growth rate in the short and long term. Finally, the improved taxing plan could result in decreased carbon emissions and higher economic growth according to Sun *et al*. (2021).

3. Methodology and Data

Empirical research has analysed annual data series from the Organization for Economic Cooperation and Development (OECD Revenue Statistics) for the period 1995–2018 for the VG countries. The definition of variables is manifested in Table 1.

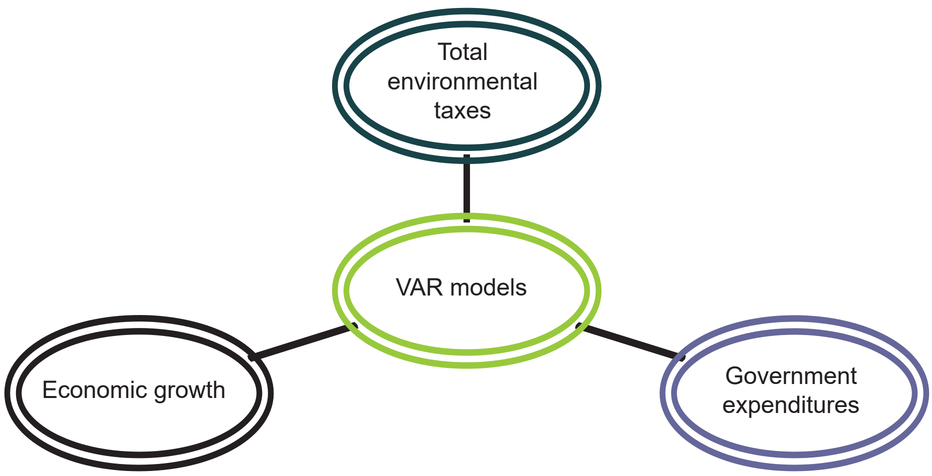
Table 1: Variable selection

Variable	Notation	Calculation	Expected impact
Gross domestic product	*GDP*	GDP annual growth rate	/
Government expenditures	*GE*	% of GDP	/
Total environmental tax revenues	*TET*	million EUR	+
Energy tax revenues	*ENT*	million EUR	+
Transport tax revenues	*TRS*	million EUR	+

Source: Authors' own elaboration

We used logarithmic values of the following indicators: *GDP* (annual growth rate), *GE* (government expenditures, % of GDP), *TET* (total environmental tax revenues, million EUR), *ENT* (energy tax revenues, million EUR), *TRS* (transport tax revenues, million EUR). The model construction in this paper has been set as follows (Figure 1) in accordance to the previously explained variables.

Figure 1: Model construction



Source: Authors' own elaboration

The empirical research includes two VAR models where dependent variables are economic growth, measured by GDP growth rate, and government expenditures, calculated by percentage share in GDP. The explanatory variables are total environmental tax revenues, energy tax revenues and transport tax revenues. The use of VAR models should identify which environmental taxes are significantly related to economic growth and government expenditures in VG countries. The VAR models were created using annual data between from 1995 to 2018 (88 observations) taken from OECD Revenue Statistics.

The research implies six hypotheses based on determined research goals that are developed as follows:

H_1: Total environmental tax revenues significantly affect the economic growth in VG countries.

H_2: Energy tax revenues significantly affect the economic growth in VG countries.

H_3: Transport tax revenues significantly affect the economic growth in VG countries.

H_4: Total environmental tax revenues significantly affect the government expenditures in VG countries.

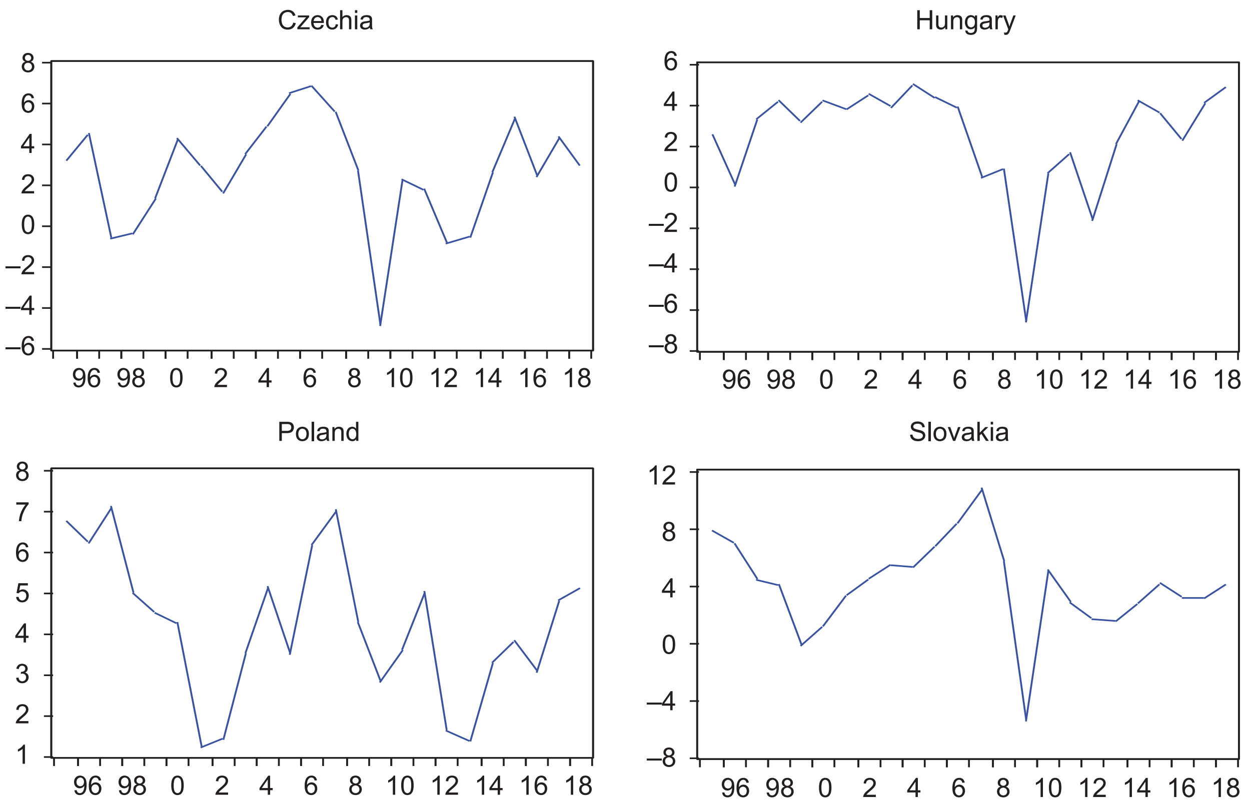
H_5: Energy tax revenues significantly affect the government expenditures in VG countries.

H_6: Transport tax revenues significantly affect the government expenditures in VG countries.

4. Empirical Investigation

This section includes trend analysis of selected macroeconomic variables (gross domestic product and government expenditures) and tax variables (environmental tax revenues, energy tax revenues and transport tax revenues) in VG countries (Czechia, Hungary, Poland and Slovakia) from 1995 to 2018. After that, the research consists of a descriptive and empirical analysis, which imply vector autoregressive models, as well as a causality analysis between explanatory variables for the analysed period.

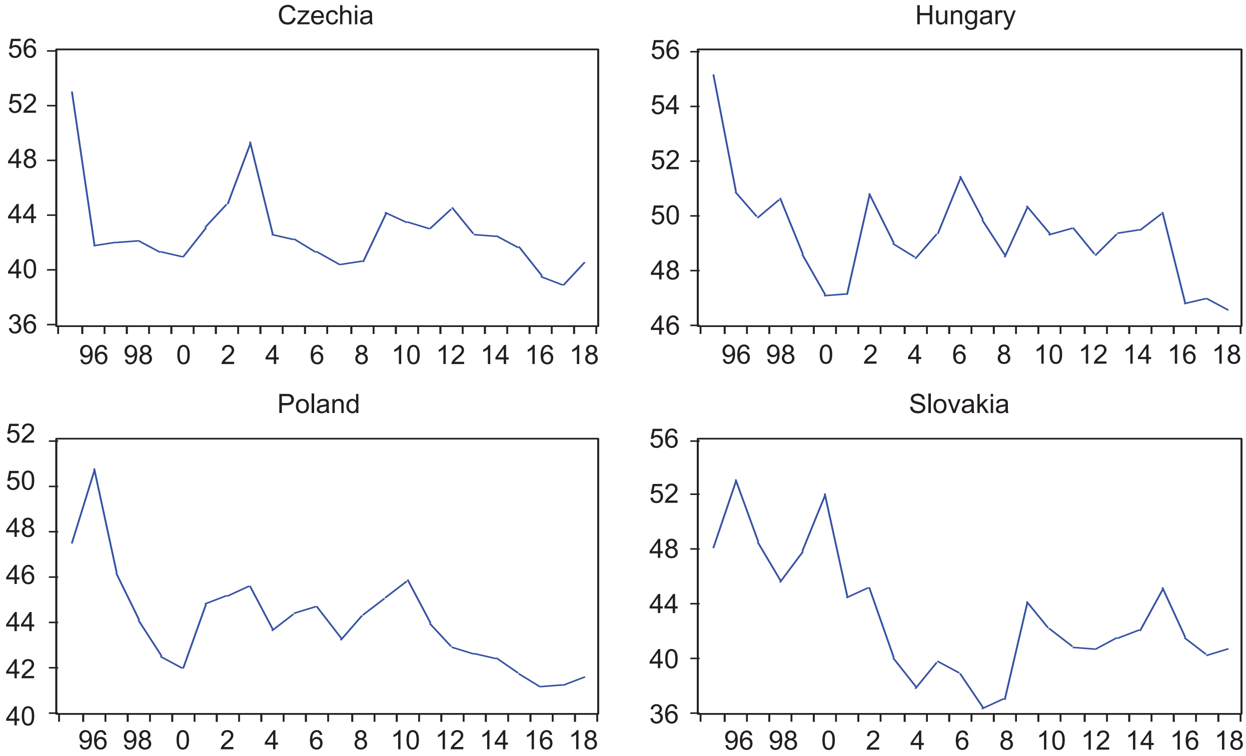
Figure 2: GDP growth rate in VG countries



Source: Authors' own calculations

Based on Figure 2, it can be concluded that VG countries had an average GDP growth rate of 3.35% during the observed period. Analysing by country, Poland and Slovakia had average GDP growth rates above 4%, which is almost double compared to Czechia and Hungary. More precisely, the economies of Poland and Slovakia had average growth rates of 4.19% and 4.07%, while Czechia and Hungary had 2.72% and 2.41% in the analysed period. The greatest GDP growth rate was identified in Slovakia (10.79% in 2007), while Hungary's GDP declined the most by 6.6% in 2009. However, Hungary and Poland registered the highest GDP growth rate in the last year, when these economies increased by 4.94% and 5.1%.

Figure 3: Government expenditures in VG countries (% of GDP)



Source: Authors' own calculations

Figure 3 shows the relative share of government expenditures in the gross domestic product in VG countries for the period 1995–2018. Specifically, Hungary recorded the highest mean percentage share of GE (49.28% of GDP), which is far more than the other analysed countries. Namely, Czechia, Poland and Slovakia had average percentage shares of GE in the interval 42–44% of GDP. When it comes to maximum values, Slovakia recorded the highest share of GE (53.09% in 1996). On the contrary, Czechia had the lowest share of GE (38.94% in 2017) compared to the other VG countries. Looking at the last year, Hungary recorded the highest share of GE, namely 46.47%. This is far more than the other VG countries, which registered relative shares of GE in the interval 41–42% of GDP. Analysing the potential effect of GE on GDP, it can be concluded that the optimal share of government expenditures should not be above 45% of GDP.

Table 2: Relative changes of total environmental taxes in VG countries

Year	Czechia			Hungary			Poland			Slovakia		
	TET	*ENT*	*TRS*	*TET*	*ENT*	*TRS*	*TET*	*ENT*	*TRS*	*TET*	*ENT*	*TRS*
1996	7.62	8.77	10.59	6.98	−1.96	17.01	21.51	30.66	39.83	0.83	0.09	5.03
1997	−3.48	0.64	−29.68	13.66	13.95	6.13	5.76	5.14	24.83	9.26	9.61	8.59
1998	3.75	5.31	13.46	28.79	31.73	35.41	17.05	25.29	−49.47	−1.23	−1.62	1.56
1999	9.82	9.77	19.55	7.43	7.82	17.65	15.07	24.92	12.83	−1.09	1.02	−11.31
2000	5.93	6.84	4.36	1.09	−2.13	7.95	19.12	16.23	66.95	26.59	27.73	22.89
2001	16.58	18.88	2.48	7.76	7.44	21.72	15.06	14.26	39.95	−5.97	−7.04	0.56
2002	12.36	12.05	15.46	16.24	14.78	25.09	12.47	12.53	9.64	22.59	21.16	6.58
2003	4.49	5.28	−1.18	4.11	−0.73	8.02	−6.78	−3.65	−18.63	25.45	29.24	3.31
2004	12.89	15.12	−4.26	20.32	6.09	−25.43	16.46	12.08	67.31	17.99	20.11	5.63
2005	15.97	17.07	4.66	5.75	20.36	11.48	17.19	22.38	−0.72	8.59	7.59	17.23
2006	8.93	8.72	14.64	4.32	2.18	21.65	10.64	10.07	−8.06	10.32	8.02	17.08
2007	8.42	8.34	7.85	8.49	4.87	−5.46	17.85	18.06	16.39	15.06	13.33	29.77
2008	13.91	14.44	9.73	2.58	3.92	−29.39	12.69	10.12	23.94	13.26	15.19	17.27
2009	−5.93	−5.39	−19.97	−14.17	−10.41	6.85	−17.71	−17.59	−22.45	−7.04	−7.25	−5.93
2010	4.37	4.18	8.05	6.28	9.54	2.28	23.67	26.11	6.04	12.27	14.41	1.96
2011	7.51	7.83	5.32	−1.87	−2.62	−13.09	1.74	2.37	−4.66	18.08	19.95	8.72
2012	−6.23	−6.31	−2.99	−2.32	−6.26	−3.25	0.55	1.91	1.49	−0.29	−0.21	−0.52
2013	−6.84	−6.98	−1.49	−1.54	−0.65	−1.11	−5.47	−2.75	4.63	8.27	7.35	19.69
2014	−2.34	−2.49	−0.71	2.62	3.22	3.77	11.13	8.42	8.61	3.08	3.02	4.61
2015	6.38	6.35	6.64	7.69	6.36	1.62	7.95	7.21	9.98	3.24	3.92	−1.81
2016	6.73	7.16	3.71	5.77	6.87	5.31	1.37	2.37	5.89	5.67	5.85	4.71
2017	6.69	6.85	6.66	5.21	3.86	1.36	8.26	8.93	10.18	5.69	6.12	4.58
2018	13.41	14.08	3.83	0.02	−0.03	−5.48	7.69	8.26	7.81	3.91	3.93	4.16

Source: Authors' own calculation

Table 2 represents the relative changes of total environmental taxes in VG countries and it can be concluded that all four economies recorded average growth of total environmental tax revenues for the analysed period. Namely, Poland and Slovakia had the highest average growth of total environmental tax revenues (9.27%) and (8.46%), while the mean growth of the total environmental tax revenues was smaller in Czechia (6.13%) and Hungary (5.88%). Hungary recorded the maximum growth of environmental tax revenues in 1998 (28.79%), while Poland had the minimum value in 2009 (−17.71%). Analysing energy tax revenues, Poland had the highest average growth 10.58%, while Hungary had the lowest average growth 5.14%. Hungary had the maximum value in 1998 (31.73%), while Poland recorded the minimum value in 2009 (−17.59%). Similarly, transport tax revenues had the highest average growth in Poland (10.97%), while their growth was the lowest in Czechia (3.33%). Poland recorded the highest growth of transport tax revenues in 2004 (67.31%), while the same economy had the lowest growth in 1998 (−49.47%).

Table 3: Descriptive statistics – environmental taxes

Variable	*TET*	*ENT*	*TRS*
Czechia			
Mean	2.28	2.06	0.18
Std. deviation	0.14	0.11	0.05
Variance	0.02	0.01	0.01
Minimum	2.07	1.89	0.13
Maximum	2.64	2.28	0.31
Hungary			
Mean	2.72	2.13	0.42
Std. deviation	0.23	0.25	0.13
Variance	0.05	0.06	0.02
Minimum	2.35	1.77	0.15
Maximum	3.31	2.79	0.76
Poland			
Mean	2.43	2.01	0.22
Std. deviation	0.33	0.36	0.05
Variance	0.11	0.13	0.01
Minimum	1.77	1.21	0.11
Maximum	2.74	2.38	0.34
Slovakia			
Mean	2.28	1.96	0.26
Std. deviation	0.18	0.19	0.03
Variance	0.03	0.04	0.01
Minimum	1.97	1.66	0.22
Maximum	2.54	2.24	0.33
Visegrad Group			
Mean	2.43	2.04	0.27
Std. deviation	0.29	0.25	0.12
Variance	0.08	0.06	0.02
Minimum	1.77	1.21	0.11
Maximum	3.31	2.79	0.76

Source: Authors' own calculations

Based on data from Table 3, it can be noticed that the average share of the total environmental tax revenues is 2.43% of GDP in the VG countries in the observed period. The maximum share of *TET* is recorded in Hungary, where it was 3.31% of GDP. The minimum share of this tax form is identified in Poland, where it was below 2%, precisely 1.77% of GDP. Similarly, the mean share of energy tax revenues was 2.04% of GDP in the VG countries. Hungary had a maximum value of 2.79% of GDP. Poland had the minimum share of this tax form in 1995, when the energy tax revenues were 1.21% of GDP. When it comes to transport tax revenues, their mean share was 0.27% of GDP in the VG countries for the analysed period. Hungary recorded the maximum value 0.76% of GDP in 2004, whereas the minimum share of transport tax revenues was identified in Poland (0.11%).

Table 4: Different unit root analyses

Variables	LLC test		IPS test		ADF-Fisher test		PP-Fisher test	
	Individual intercept	Individual intercept and trend	Individual intercept	Individual intercept and trend	Individual intercept	Individual intercept and trend	Individual intercept	Individual intercept and trend
GDP	−3.55 (0.000)	−2.86 (0.000)	−2.62 (0.000)	−1.09 (0.000)	20.57 (0.000)	11.39 (0.001)	23.26 (0.000)	12.71 (0.023)
GE	−2.87 (0.000)	−1.45 (0.001)	−3.19 (0.000)	−2.18 (0.001)	24.91 (0.000)	18.31 (0.013)	32.45 (0.001)	25.23 (0.011)
TET	−2.85 (0.002)	−1.52 (0.034)	−7.35 (0.001)	−1.46 (0.055)	11.59 (0.001)	6.52 (0.068)	30.56 (0.013)	11.98 (0.074)
ENT	−1.81 (0.014)	−1.68 (0.067)	−2.68 (0.022)	−1.58 (0.083)	27.10 (0.017)	9.51 (0.76)	19.07 (0.045)	12.68 (0.063)
TRS	−1.84 (0.021)	−1.52 (0.071)	−1.99 (0.036)	−1.35 (0.081)	8.46 (0.028)	2.54 (0.041)	27.78 (0.084)	14.37 (0.142)

Source: Authors' own calculations

The findings of Table 4 indicate that all the variables are stationary at the level of 1%, 5% and 10% for all the countries. According to these results, a VAR model can be applied because all the explanatory variables are stationary. After we have identified that a VAR model is appropriate, the next table shows the lag period selection tests. The results manifest that a three-lag period is an optimal period that implies that 3 lag periods are adequate for this VAR model.

Table 5: VAR lag selection

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	–35.79	NA	0.00	2.21	2.38	2.27
1	96.19	227.30	1.72	−4.23	−3.35*	−3.92
2	101.83	8.46	3.17	−3.66	−2.07	−3.10
3	138.36	46.67*	1.11*	−4.79*	−2.51*	−3.99*
4	156.55	19.20	1.19	−4.92	−1.93	−3.87
5	175.28	15.61	1.45	−5.07	−1.38	−3.78
6	195.49	12.35	2.13	−5.31*	−0.91	−3.77
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	–35.79	NA	0.00	2.21	2.38	2.27
1	96.19	227.30	1.72	−4.23	−3.35*	−3.92
2	101.83	8.46	3.17	−3.66	−2.07	−3.10
3	138.36	46.67*	1.11*	−4.79*	−2.51*	−3.99*
4	156.55	19.20	1.19	−4.92	−1.93	−3.87
5	175.28	15.61	1.45	−5.07	−1.38	−3.78
6	195.49	12.35	2.13	−5.31*	−0.91	−3.77

Source: Authors' own calculations

Table 6: VAR model I – economic growth

Variables	Coefficient	Std. error	*t*-statistic	Prob.
***GDP*(–1)**	0.75	0.11	6.65	0.000
***GDP*(–2)**	0.15	0.09	1.64	0.078
***GDP*(–3)**	0.01	0.08	0.06	0.027
***TET*(–1)**	7.07	7.96	0.89	0.043
***TET*(–2)**	29.05	8.84	3.28	0.017
***TET*(–3)**	–26.29	6.65	–3.95	0.028
***ENT*(–1)**	6.98	7.23	0.97	0.012
***ENT*(–2)**	26.62	7.82	3.40	0.070
***ENT*(–3)**	–27.17	5.73	–4.75	0.044
***TRS*(–1)**	–1.33	1.24	–1.08	0.009
***TRS*(–2)**	–2.46	1.51	–1.63	0.006
***TRS*(–3)**	–0.10	1.07	–0.09	0.000
C	–5.09	2.49	–2.04	0.078
***R*-squared**			0.72	
Adj. *R*-squared			0.65	
Sum sq. resids			43.96	
S.E. equation			0.99	
***F*-statistic**			9.67	
Log likelihood			–73.47	
AIC			3.03	
SC			3.50	
Mean dependent			7.95	
St. dev. dependent			1.69	

Source: Authors' own calculations

The results from Table 6 show that total environmental tax revenues are significant for economic growth. Namely, previous *GDP* has a positive and significant effect on current *GDP* at the level of 5%. Total environmental tax revenues and energy tax revenues have a positive and significant impact on the GDP growth rate at the level of 5% and 10%. Specifically, there is a significant and positive relationship between *GDP* and the first and second lags of *TET* and *ENT*. Also, there is a significant but negative relationship between *GDP* and the third lag of *TET* and *ENT*. Finally, the impact of transport tax revenue shock on *GDP* is negative and significant at the level of 5% and 10%. Precisely, there is a significant and negative relationship between *GDP* and the first, second and third lags of *TRS*. The value of *R*-squared is 0.72, which means that the VAR model explains 72% variations of explanatory variables. The results of the LM test (Table 7) manifest that the null hypothesis is accepted and that there is no serial correlation within 3 lag periods.

Table 7: VAR residual serial correlation LM test – model I

Null hypothesis: No serial correlation at lag *h*						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao *F*-stat**	**df**	**Prob.**
1	9.28	16	0.901	0.574	(16,220,6)	0.901
2	17.44	16	0.357	1.098	(16,220,6)	0.358
3	17.25	16	0.369	1.085	(16,220,6)	0.369
Null hypothesis: No serial correlation at lags 1 to *h*						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao *F*-stat**	**df**	**Prob.**
1	9.28	16	0.901	0.574	(16,220,6)	0.901
2	29.43	32	0.597	0.917	(32,252,4)	0.599
3	45.41	48	0.579	0.579	(48,248,6)	0.584

Source: Authors' own calculations

Table 8: VAR model II – government expenditures

Variables	Coefficient	Std. error	*t*-statistic	Prob.
***GE*(–1)**	0.66	0.11	5.91	0.000
***GE*(–2)**	0.09	0.12	0.77	0.039
***GE*(–3)**	0.17	0.09	1.81	0.071
***TET*(–1)**	0.57	0.31	1.82	0.069
***TET*(–2)**	0.61	0.36	1.71	0.088
***TET*(–3)**	–0.13	0.26	–0.48	0.613
***ENT*(–1)**	0.39	0.28	1.41	0.159
***ENT*(–2)**	–0.47	0.31	–1.51	0.131
***ENT*(–3)**	–0.11	0.23	–0.51	0.617
***TRS*(–1)**	0.13	0.05	2.66	0.168
***TRS*(–2)**	0.04	0.06	0.71	0.480
***TRS*(–3)**	0.03	0.04	0.75	0.454
C	2.82	0.98	2.88	0.004
***R*-squared**			0.75	
Adj. *R*-squared			0.71	
Sum sq. resids			0.14	
S.E. equation			0.04	
***F*-statistic**			17.68	
Log likelihood			149.15	
AIC			–3.24	
SC			–2.86	
Mean dependent			10.69	
St. dev. dependent			0.08	

Source: Authors' own calculations

The results from Table 8 show that total environmental tax revenues are statistically significant for government expenditures at the level of 5% and 10%. Namely, previous *GE* has a positive and significant effect on current *GE* at the level of 5%. Total environmental tax revenues have a positive and significant impact on *GE* at the level of 10%, while energy tax revenues and transport tax revenues are not significant for government expenditures in the VG countries. Namely, there is a significant and positive relationship between *GE* and the first and second lags of *TET*. When it comes to energy tax revenues, it can be noticed that there is a positive relationship between *GE* and the first lag of *ENT*, while the negative coefficient is identified at the second and third lags of *ENT*, but it is insignificant. Similarly, there is a positive relationship between *GE* and the first, second and third lags of *TRS*, but the coefficients are not significant. The value of *R*-squared is 0.75, which implies that the VAR model explains 75% variations of the explanatory variables. The results from Table 9 confirm that there is no serial correlation within 3 lag periods, which implies that the null hypothesis is accepted.

Table 9: VAR residual serial correlation LM test – Model II

H_0: No serial correlation at lag *h*						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao *F*-stat**	**df**	**Prob.**
1	9.32	16	0.899	0.577	(16,220,6)	0.899
2	16.70	16	0.405	1.049	(16,220,6)	0.406
3	18.62	16	0.289	1.17	(16,220,6)	0.289
H_0: No serial correlation at lags 1 to *h*						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao *F*-stat**	**df**	**Prob.**
1	9.32	16	0.899	0.576	(16,220,6)	0.899
2	25.62	32	0.779	0.793	(32,252,4)	0.781
3	44.04	48	0.635	0.911	(48,248,6)	0.640

Source: Authors' own calculations

Table 10: Variance decomposition of *GDP*

Variance period	Std. error	*GDP*	*TET*	*ENT*	*TRS*
1	1.38	100.00	0.00	0.00	0.00
2	1.47	98.66	0.98	0.24	0.11
3	1.55	90.18	6.57	3.16	0.09
4	1.63	81.97	12.49	5.44	0.08
5	1.69	76.46	16.35	7.09	0.08
6	1.73	72.87	18.78	8.26	0.08
7	1.76	70.62	20.25	9.04	0.07
8	1.78	69.22	21.11	9.68	0.07
9	1.79	68.34	21.62	9.95	0.07
10	1.81	67.78	21.92	10.22	0.07

Source: Authors' own calculations

The variance decomposition of *GDP* reflects that 67.78% of *GDP* variations are determined by the variations in *GDP*, while 21.92% of the *GDP* variations are determined by the change in total environmental tax revenues. Additionally, 10.22% of the *GDP* variations are explained by the change in energy tax revenues, whereas the effect of transport tax revenues is very small and below 1%. It implies that total environmental tax revenues have the greatest impact on the variability of *GDP* in the observed period.

Table 11: Variance decomposition of *GE*

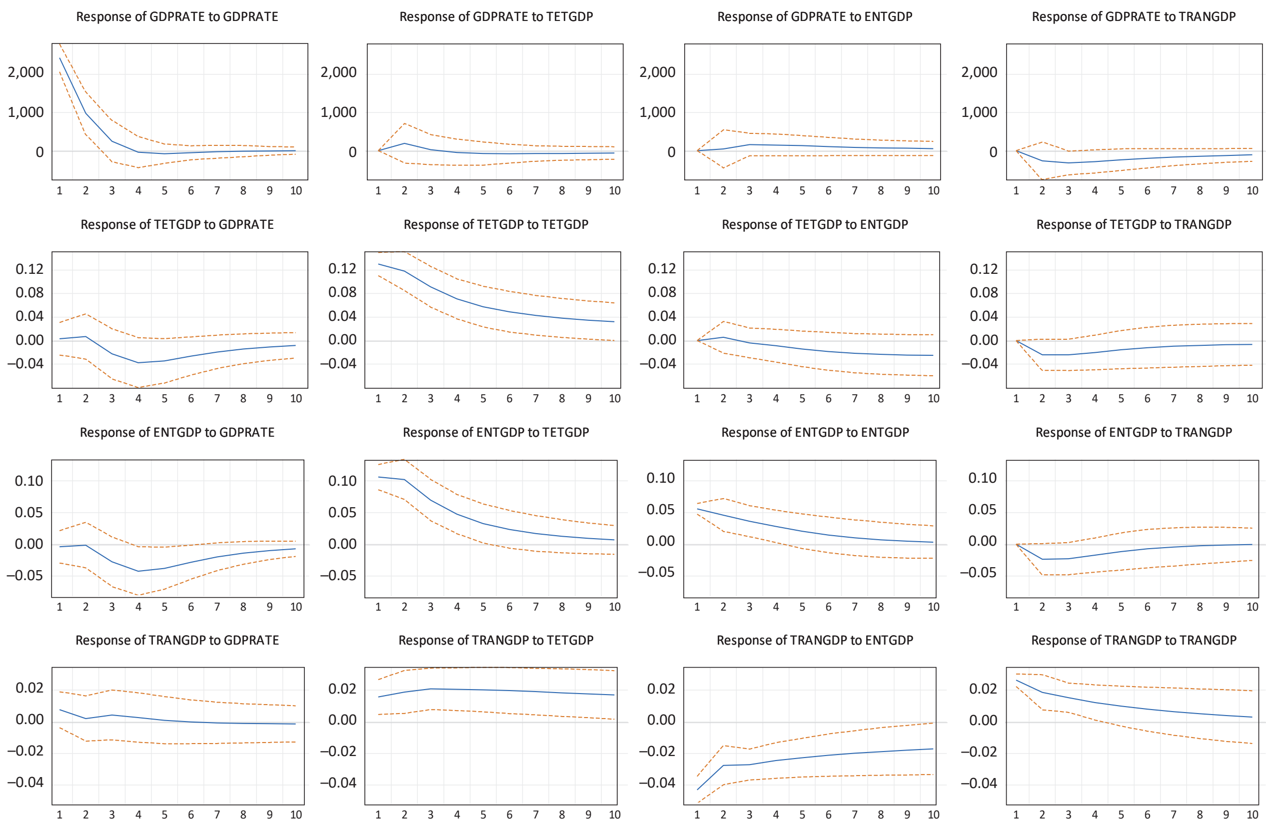
Variance period	Std. error	*GE*	*TET*	*ENT*	*TRS*
1	0.04	100.00	0.00	0.00	0.00
2	0.05	95.43	3.03	072	0.82
3	0.06	90.68	6.51	2.16	0.76
4	0.06	85.21	10.03	5.08	0.68
5	0.07	80.06	13.25	6.09	0.61
6	0.07	75.57	15.88	7.98	0.57
7	0.08	71.84	17.92	9.69	0.55
8	0.08	68.81	19.47	11.18	0.54
9	0.08	66.39	20.62	12.44	0.54
10	0.08	64.46	21.48	13.51	0.55

Source: Authors' own calculations

The variance decomposition of *GE* manifests that 64.46% of the *GE* variations are determined by the variations in the *GE*, while 21.48% of the *GE* variations are determined by the change in total environmental tax revenues. Finally, 13.51% of the *GE* variations are explained by the change in energy tax revenues, whereas the effect of transport tax revenues is very small and below 1%. Similarly, the variability of *GE* is mostly influenced by total environmental tax revenues.

Figure 4: Impulse response functions (*GDP*)

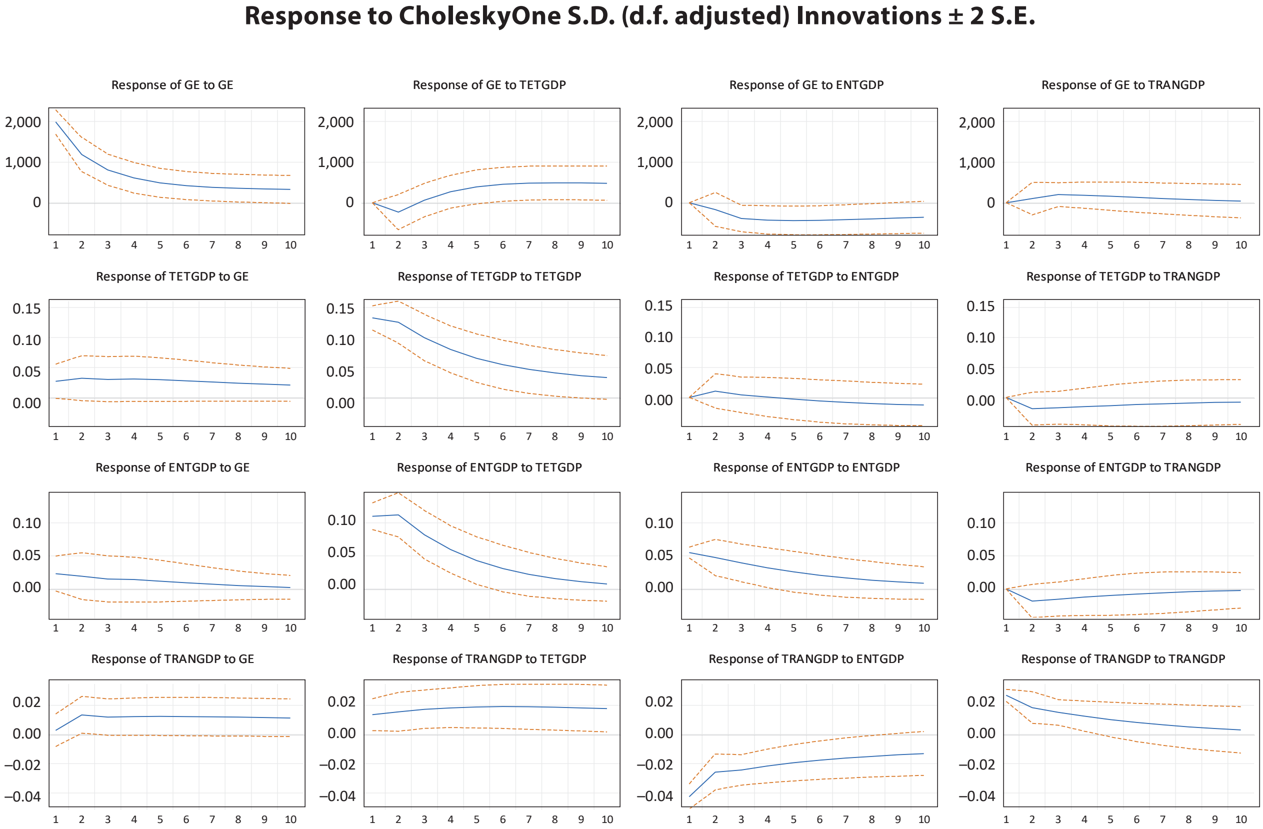
Response to CholeskyOne S.D. (d.f. adjusted) Innovations ± 2 S.E.



Source: Authors' own calculations

The analysis of IRF (Figure 4) shows that change in gross domestic product (*GDP*) causes positive gross domestic product (*GDP*) response until the third period, while the negative effects are neutralized in periods nine and ten. Change in total environmental tax revenues (*TET*) has a positive effect in periods one and two, whereas negative effects are present during the whole time period. Change in energy tax revenues (*ENT*) has a mild positive effect on gross domestic product (*GDP*) during the observed period. Change in transport tax revenues (*TRS*) has a negative response to gross domestic product (*GDP*) for the observed period.

Figure 5: Impulse response functions (*GE*)



Source: Authors' own calculations

The findings on IRF (Figure 5) show that shock in government expenditures (*GE*) causes positive government expenditures (*GE*) response during the whole time period. Change in total environmental tax revenues (*TET*) has a negative effect in the second period after it transforms into a positive trend during the analysed period. Additionally, change in energy tax revenues (*ENT*) has a negative effect on government expenditures (*GE*) during the whole time period. Finally, change in transport tax revenues (*TRS*) has a positive response to government expenditures (*GE*) for the observed period.

Table 12: Panel causality analysis

Direction	Obs	*F*-stat	Prob.
GDP* → *GE	88	2.31	0.427
GE* → *GDP	88	0.74	0.005
GDP* → *TET	88	3.63	0.003
TET* → *GDP	88	2.11	0.002
GDP* → *ENT	88	3.26	0.004
ENT* → *GDP	88	1.73	0.001
GDP* → *TRS	88	1.05	0.351
TRS* → *GDP	88	0.27	0.761
GE* → *TET	88	3.12	0.032
TET* → *GE	88	0.03	0.978
GE* → *ENT	88	0.37	0.685
ENT* → *GE	88	0.01	0.984
GE* → *TRS	88	0.35	0.701
TRS v GE	88	0.66	0.515

Source: Authors' own calculations

The empirical results from Table 12 show a bidirectional causality between *TET* and *GDP*. Also, there is a bidirectional causality between *ENT* and *GDP*, while on the other hand there is no causality between *TRS* and *GDP* (*p*-value > 0.05). The results confirm a unidirectional causality between *GE* and *TET*. Furthermore, there is no significant causality between *ENT* and *GE*, which is the case with the *TRS*. The obtained results indicate positive implications of interaction between environmental taxation, economic growth and government expenditures. Greater government expenditures boost the GDP growth rate in the VG countries, which enables higher revenue collection from environmental taxation.

5. Conclusion

The study examined the relations between environmental taxes, economic growth and government expenditures in the VG countries (Czechia, Hungary, Poland and Slovakia) from 1995 to 2018. The empirical analysis included VAR models, where gross domestic product (GDP) and government expenditures (GE) are determined as dependent variables while the independent variables are total environmental tax revenues (TET), energy tax revenues (ENT) and transport tax revenues (TRS). According to the expected impacts of total environmental tax determinants (Table 2), the obtained findings confirmed that TET and ENT have a positive effect on GDP. Precisely, the empirical findings confirmed that TET significantly affect the GDP and GE in the VG countries for the observed period. It implies that hypotheses H_1 and H_4 can be accepted. Precisely, the results of VAR model I show that shocks in total TET and ENT have a positive and significant effect on GDP, whereas TRS have a negative and significant impact on GDP (Table 6). Accordingly, these tax forms are significant for economic growth, which means that hypotheses H_2 and H_3 can be confirmed. The findings on the impulse response function confirm that an increase in TET causes a positive implication for GDP in the first two periods. Change in ENT implies a mild positive impact on GDP during the observed period, while change in TRS causes the opposite effect on GDP. The results of VAR model II show that TET are significantly positively related to GE, while it is not the case with ENT and TRS (Table 8). It means that these tax forms are not significant for government expenditures, so hypotheses H_5 and H_6 cannot be accepted. The findings on the impulse response function determine that an increase in TET has negative implications for GE in the second period after it transforms into a positive trend during the observed period. Change in ENT has negative implications for GE during the observed period, while change in TRS causes the opposite effects on GE.

The empirical results of the Granger causality analysis show that there is a bidirectional causality between TET and GDP, as well as a unidirectional causality between TET and GE. Analysing by tax forms, there is a bidirectional causality between ENT and GDP, while that is not the case with TRS. Finally, there is no causality between ENT and TRS and GE in the selected countries for the observed period (Table 12). Also, our empirical results confirm that there is a unidirectional causality running from GE to GDP, which implies that policymakers should focus on increasing government expenditures to improve the gross domestic product level.

The contribution of this research consists in information support and direction to policymakers about the importance of environmental taxes and their effects on economic growth and government expenditures in the VG countries. The governments of these countries should boost environmental tax revenue growth to provide positive effects for gross domestic product and government expenditures. It means that a higher level of government expenditures should enhance economic growth of these countries and rapid economic development. Future research will include a comparative analysis of environmental taxes in these countries with EU countries.

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