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## Article

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## Article

# Modeling Tax Revenue Determinants: The Case of Visegrad Group Countries

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**Abstract:** This article provides panel data estimations of the tax revenue determinants in VG (Visegrad Group) countries (the Czech Republic, Hungary, Poland, and Slovakia) for the period 1994–2023. The aim of this research was to determine how the macroeconomic determinants affect the tax revenues in the selected countries. Within the static models, the Hausman test showed that the FE (fixed effects) model is appropriate and reflects the significant effects of the gross domestic product, population, inflation, unemployment, import, government revenue, government expenditure, and EU enlargement on the tax revenue. The PMG (Pooled Mean Group) model is an adequate model among the dynamic models and manifests the significant effect of the lagged value of the tax revenue. In the short term, growth of the gross domestic product and population by 1% causes higher changes in the tax revenue of 0.14% and 2.93%. Likewise, growth of the inflation rate by 1% decreases the tax revenue by 0.037%, which is higher than in the long term. Further, the results show that EU enlargement is significant for tax revenue in the short term, as well as in the long term. In the long term, unemployment has a greater significant effect on tax revenue, where 1% growth decreases the tax revenue by 0.15%. In contrast, government revenue is significant for tax revenue only in the long term, where 1% growth increases the tax revenue by 0.77%.

**Keywords:** tax revenue; performance; determinants; VG countries; panel regression models



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## 1. Introduction

Political and economic changes in the late 1980s brought essential changes to the territorial structure of post-socialist countries (Koišová et al. 2019). After the end of socialism and the planning system at the beginning of 1990, the countries of Central and Eastern Europe developed different strategies to attract foreign capital to realize sustained economic growth (Qi and Li 2017). The Visegrad Group, or V4, is a political and cultural alliance of four Central European countries (the Czech Republic, Hungary, Slovakia, and Poland) that are also members of the European Union and NATO. The goal of the Visegrad Group is to contribute to building European security based on cooperation and coordination within existing European and transatlantic institutions (Visegrad Group 2023). To assess the issues of the tax performance and its associated selected economic indicators, this analysis includes the Visegrad Group countries, which have similar economic and social characteristics and close cooperation (Ivanová and Masárová 2018). These economies are recognized as an example of the successful transition from a centrally planned to a market economy (Bieszk-Stolorz and Dmytrów 2020).

The rising deficits and public debts of economies resulting from the global economic crisis identified the vulnerability of public finance sustainability (Tashevska et al. 2020). Šimović (2018) highlights that the growth of budget deficits was a result of the inadequate adjustment of public expenditures and raising interests on the public debt, causing losses

in tax revenues. Therefore, governments have an expanding need for financial resources (Surugiu et al. 2021). Parfenova et al. (2016) have indicated that the impact of the tax policy of the state is vital for a country's economy. Further, the core importance of taxes to wider development objectives shows that strengthening tax systems should be a central issue in strategies for state building, especially in post-conflict circumstances (van den Boogaard et al. 2018). When it comes to economic implications, tax reduction policies can enhance economic development, employment, and social equity (Liu and Zhang 2023). Therefore, it is necessary to create an adequate tax system that has enhanced economic activity, in which taxes enable permanent revenue collection and have no negative effects on economic development (Mirović et al. 2023a). For the optimum design of a tax, it is necessary to create the revenue capacity, which automatically responds to changes in the economic cycle (Sanz-Sanz et al. 2016). Utilitarianism is the basis for tax designs with intensive egalitarian effects (Blundell and Preston 2019). In the last decade, the tax revenue performances expressed as a percentage of the gross domestic product (GDP) have made modest improvements in many developing economies (Mawejje and Sebudde 2019). Mardan and Stimmelmayer (2020) indicate that advanced economies can increase higher levels of tax revenues relative to their GDPs than developing countries, where the tax revenue compositions differ between developed and developing economies. Urban et al. (2019) emphasize that countries introduce larger or smaller changes to their tax systems, searching for the optimal combination of tax parameters and adapting to internal and external circumstances. Nerudová et al. (2020) highlight that enormous differences between countries with high taxes and countries with low taxes are still present. However, Ganchev and Tanchev (2019) indicate that low proportional taxation does not guarantee an important level of international competitiveness.

The revenue level should be at an appropriate level to finance expenditures and cover public needs, and governments must be able to increase enough revenue to meet the expenditure needs (Mawejje and Odhiambo 2020). Likewise, Jaén-García (2019) cites that the optimum level of revenue sources to finance expenditures depends on its relative costs. Accordingly, Gnanngnon and Brun (2017) argue that the mobilization of government revenues, including tax revenues, is still a crucial issue in the world. Tax revenue mobilization is an essential tool for strong state building (Apeti and Edoh 2023). Similarly, tax revenue mobilization is important to supply public services and manage the economic, financial, and health shocks that economies may face (Gnanngnon 2022). As tax collection increases, it allows the government to create maximum development projects for the public interest and to improve the infrastructure of health and education, as well as the quality of people's lives (Streimikiene et al. 2018). A well-designed fiscal rule such as the revenue–expenditure relationship plays a significant role in avoiding undesired outcomes arising from uncoordinated fiscal policies (Karakas and Turan 2019). Feldstein (2015) indicates that countries can increase revenues without raising marginal tax rates. Also, Bertolotti and Marcellino (2019) cite that, in the case of a tax increase, the rise in tax revenues is intensive but often temporary in the high-uncertainty regime and is mild in the low-uncertainty regime. Countries can achieve changes in their tax revenue amounts through government steps and legislative changes (Helcmanovská and Andrejovská 2021). When it comes to changes, Cloyne and Surico (2016) argue that tax changes may affect consumption and other macroeconomic components. Meanwhile, Darvas (2020) highlights that the level and composition of expenditures and revenues have effects on economic development. Therefore, policymakers should strive for an optimal balance between revenues and expenditures. According to Moździerz (2015), governments have the option to increase revenues or reduce expenditures, as well as to increase revenues and reduce expenditures at the same time. The empirical results of Wang (2018) show that if the government uses a tax policy with an adequate level of expenditure decentralization, then countries could effectively achieve the allocation of fiscal resources and higher productive efficiencies.

The structure of this article is as follows. After the introduction, there is a literature review in which similar research about tax and the macroeconomic determinants is presented.

The third segment presents the methodology and data, identifying the variables and all the econometric procedures and preconditions for an appropriate panel regression model. The fourth segment presents an empirical analysis of the tax revenues and macroeconomic determinants in the Visegrad Group countries (the Czech Republic, Hungary, Slovakia, and Poland) from 1994 to 2023. This segment includes a descriptive analysis, correlation analysis, and static and dynamic panel modeling to determine which determinants are significant for the tax revenue level. The last segment summarizes the findings and conclusions with recommendations for future research.

## 2. Literature Review

There has been increasing research interest related to taxes and other revenue as a means of funding and reaching the development objectives of countries ([Ajeigbe et al. 2023](#)). Quantitative research on taxation is essential to be able to test which variables affect it and to determine strategies to boost tax revenues and cover public expenditures ([Castañeda Rodríguez 2018](#)). The effects of tax policies on economic activity are a long-standing debate ([van der Wielen 2020](#)), and taxes are, in general, considered an important policy tool that significantly affect the macroeconomic outcomes of tax policies ([Andrejovská and Puliková 2018](#)). [Lin and Jia \(2019\)](#) indicate that the conditions, growth rate, and structure of an economy have implications on the revenue level and tax structure. [Ferraro et al. \(2020\)](#) highlight that a central issue in macroeconomics is how taxes affect the growth rate of the economy. [Fatehin and Sjoquist \(2020\)](#) determine the importance of tax policy implications on state economic growth. [Durusu-Ciftci et al. \(2018\)](#) argue that taxation has significant implications for the gross domestic product per capita, especially taxes on consumption. [Barrios \(2020\)](#) points out the effect of tax reforms is one of the most essential issues in economic policy, and [Cubizol \(2019\)](#) emphasizes the model of tax reforms to increase consumption, reduce overinvestment, and attain an important level of welfare. When it comes to tax revenue, there are several determinants affecting it, and this research considers the effects of the main macroeconomic determinants in every country. There are many studies that have examined tax revenues and gross domestic products ([Belullo and Dužman 2011](#); [Castro and Ramírez Camarillo 2014](#); [Loganathan et al. 2017](#); [Andrašić et al. 2018](#); [Castañeda Rodríguez 2018](#); [McNabb 2018](#)). [Andrejovská and Puliková \(2018\)](#) identified the significant effects of the macroeconomic indicators on corporate taxation in the European Union for the period 2008–2016. [Andrašić et al. \(2018\)](#) confirmed that a 1% increase in tax revenue enhanced the gross domestic product by 0.29% in OECD (Organisation for Economic Co-operation and Development) countries from 1996 to 2016. [Loganathan et al. \(2017\)](#) identified a bidirectional causality between growth and taxation, and a unidirectional causality from stock traded to taxation as well as from growth to stock traded in emerging Asian countries (China, India, Indonesia, the Republic of Korea, Malaysia, and Thailand) for the period 1990–2014. [McNabb \(2018\)](#) indicated that personal income tax and social contributions could have harmful effects on the GDP growth rate in the long run, while corporate income tax positively influences the GDP but without significance. Also, [Castañeda Rodríguez \(2018\)](#) determined the agriculture share in the GDP, education, the population share above 65 years, and the quality of government and democracy as the relevant tax determinants on a sample of 138 countries for the analyzed 1976–2015 period. [Hodžić et al. \(2018\)](#) argue that tax systems should be business-friendly so they can have a significant positive impact on the economy, and [Scherf and Weinzierl \(2019\)](#) determined benefit-based taxation. Likewise, low taxes are not always enough to bring foreign firms and their capital ([Pieretti and Pulina 2020](#)), and an effective tax rate is a significant determinant of the tax revenue ([Andrejovská and Glova 2023](#)). Furthermore, [Belullo and Dužman \(2011\)](#) analyzed the relationship between the government revenues and gross domestic product in Croatia for the period 2000–2010. The results of their analysis confirmed that the GDP in the Granger sense has a significant effect on changes in government revenues. According to a study by [Castro and Ramírez Camarillo \(2014\)](#), a country with a high GDP per capita and a low share of FDI (foreign direct investment) is a

country with the greater possibility of having a high tax revenue. [Boschi and d'Addona \(2019\)](#) indicate that estimating changes in tax revenues caused by changes in income is a fundamental issue for the forecasting of government revenues. In empirical research on 32 Latin American countries over the period 1990–2009, [Dioda \(2012\)](#) showed that variables such as the population, political stability, education levels, as well as the size of the shadow economy have considerable influences on tax revenues. [Fujii \(2017\)](#) points out that a large population size and high income levels create greater fiscal revenues. [Ball and Creedy \(2014\)](#) analyzed population aging and argued that indirect tax revenue growth depends on the changing expenditure pattern over the life cycle. For example, [Neog and Gaur \(2020\)](#) confirmed that growth, aid, and trade had positive effects on tax revenue while inflation, development expenditure, and agriculture contributions negatively affected the tax revenue level in an analysis of India for the period 1986–2016. [Morrissey et al. \(2016\)](#) examined the tax revenue performances and vulnerability in developing countries from 1980 to 2010, and their research found a negative relationship between manufacturing exports and revenue in lower-income countries. Likewise, the tax revenue level can be improved by foreign direct investment. [Camara \(2023\)](#) confirmed that foreign direct investment inflows positively affected the tax revenues in a sample of 90 developing countries for the period 1996–2017. [Obadić et al. \(2014\)](#) argue that lower imports and consumption will result in lower revenues from customs and especially value-added tax. The effects of exports and imports on tax revenue are included because increasing the flows of international trade, as well as the strong impact of globalization, cause changes in economic growth ([Pilinkienė 2016](#)). Namely, these components of trade liberalization can positively or negatively affect the gross domestic product and cause further implications to the tax revenue level in the economy. [Gnangnon and Brun \(2019a\)](#) investigated 95 developing countries over the period 1981–2015, and their empirical analysis suggests that countries with higher degrees of trade openness can achieve positive effects on their tax revenues with proper tax reforms. Also, an empirical analysis by [Gnangnon and Brun \(2019b\)](#) shows that higher development aid flows and their smaller volatility enable tax reform to achieve a higher tax revenue-to-GDP ratio and lower tax revenue instability. [Liu and Liu \(2020\)](#) highlight that the tax-to-GDP ratio has been low in developing economies, usually between 10% and 20% in these countries compared to developed economies, where it is more than 40% of the GDP. [Ayenew \(2016\)](#) analyzed the macroeconomic determinants and tax revenue in Ethiopia for the period 1975–2013 and found a positive GDP impact as well as the negative effect of the inflation rate on the tax revenue. Analyzing the tax revenue determinants in the European Union, [Kalaš et al. \(2020\)](#) found that GDP, government expenditure, total investment, and population significantly and positively affected the tax revenue while inflation, unemployment, and gross national savings negatively influenced the tax revenue for the observed 2006–2018 period. [Nguyen et al. \(2022\)](#) verified the significant influences of the share of value added in industry to the GDP and the trade openness of the economy on the tax revenue in Southeast Asia from 2000 to 2016. Likewise, the results showed that the inflation rate is not a significant predictor of the tax revenue. When it comes to the study of [Mirović et al. \(2023b\)](#), the GDPpc, industry value added, trade, and government expenditures positively affected the tax revenues in Baltic countries for the period 1995–2020. Simultaneously, the inflation rate, government debt, and the exchange rate had negative influences on the tax revenues in the observed countries.

[Sanz-Sanz et al. \(2016\)](#) argue that lower imports and consumption will result in lower revenues from customs, and especially value-added tax. [Moravec et al. \(2019\)](#) analyzed corporate income tax in the Czech Republic and their results showed that the corporate tax revenue loss is not such a substantial issue compared to the value-added tax gap problem. Accordingly, [Chan and Ramly \(2018\)](#) highlight that value-added tax is a powerful tool to increase tax revenues in developing economies. [Feher et al. \(2019\)](#) emphasize the importance of consumption taxes, and these tax forms are identified as the valuable fiscal policy instruments for European Union member states. [Auray et al. \(2016\)](#) indicate that consumption tax offers the greatest long-term potential revenue improvement. On the



contrary, Janoušková and Sobotovičová (2017) point out that tax property revenues are essential and one of the stable revenues at the local level. Shu et al. (2018) points out that land transfer revenues have become the primary source of extra budgetary revenues in China. Guziejewska and Walerysiak-Grzechowska (2020) identify the importance of local revenues and argue that, during economic crises, local revenues sensitive to GDP fluctuations can imply hard budget restrictions. Finally, Acosta-Ormaechea et al. (2018) found that relying more on income taxes and less on consumption and property taxes causes less growth in the long run.

### 3. Materials and Methods

This research analyzed the four Visegrad Group countries (the Czech Republic, Hungary, Slovakia, and Poland) for the period 1994–2023. This analysis included the EU enlargement of the Visegrad Group in terms of generating tax revenue, because tax harmonization has been a matter of interest in the European Union as an instrument to reach the goal of a single market (Garcia et al. 2013). The research included annual data obtained from the International Monetary Fund (IMF), the Organisation for Economic Cooperation and Development Revenue Statistics (OECD), and the World Bank database (WB).

The model includes tax revenue as a dependent variable, while population, inflation, M2, unemployment, investment, imports, exports, government revenue, and government expenditure, as well as the dummy variable EU enlargement, are the explanatory variables (Table 1). The proposed model and hypotheses were created based on the studies of Kalaš et al. (2020), Nguyen et al. (2022), and Mirović et al. (2023b) that analyzed the tax revenue performances in the European Union, Southeast Asia, and Baltic countries. This study defines the general hypothesis with eight auxiliary hypotheses based on the research objectives of the Visegrad Group (VG) countries, which are determined as follows:

**Table 1.** Variable selection.

Variable	Calculation	Data Source
<b>Dependent variable</b>		
Tax revenue	TXR—USD billions	OECD
<b>Independent variables</b>		
Gross domestic product	GDP—annual growth rate	IMF
Population	POP—total population	WB
Inflation	INF—annual growth rate	IMF
Monetary aggregate 2	M2—annual growth rate	WB
Unemployment	UNM—annual growth rate	IMF
Investment	INV—percentage share in GDP	IMF
Import	IMP—percentage share in GDP	IMF
Export	EXP—percentage share in GDP	IMF
Government revenue	GR—percentage share in GDP	IMF
Government expenditure	GE—percentage share in GDP	IMF
EU enlargement	EU enlargement—0: period before enlargement; EU enlargement; 1: period after enlargement	

**H1.** Macroeconomic determinants significantly affect the tax revenues in VG countries;

**H1.1.** The GDP has a significant positive impact on the tax revenues in VG countries;

**H1.2.** The population has a significant positive impact on the tax revenues in VG countries;

**H1.3.** Inflation and M2 have significant negative impacts on the tax revenues in VG countries;

**H1.4.** Unemployment has a significant negative influence on the tax revenues in VG countries;

**H1.5.** Investment has a significant positive impact on the tax revenues in VG countries;

**H1.6.** Imports and exports have a significant impact on the tax revenue in VG countries;

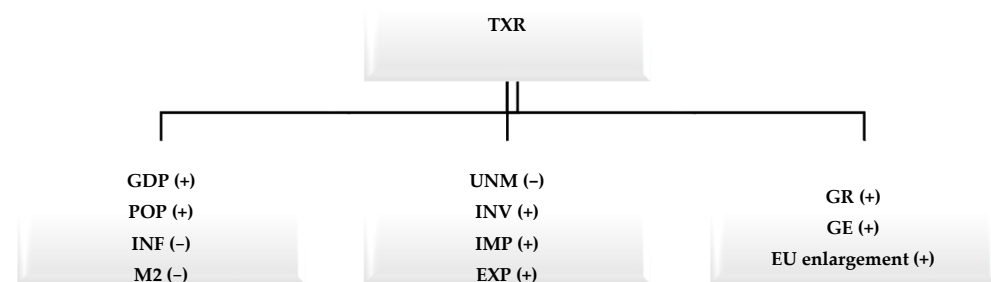
**H1.7.** Government revenue and government expenditure have significant impacts on the tax revenues in VG countries;

**H1.8.** EU enlargement has a significant positive influence on the tax revenues in VG countries.

The model construction in this article was set as follows (Figure 1) in accordance with the previously explained variables and hypotheses. The study included panel static and dynamic models that covered the time and space dimensions. The panel model estimation was used to identify the effect of the selected determinants on the tax revenues in the VG (Visegrad Group) countries:

$$\log TXR_{it} = \log TXR_{t-1} + \log GDP_{t1} + \log POP_{t2} + \log INF_{t3} + \log M2_{t4} + \log UNM_{t5} + \log INV_{t6} + \log IMP_{t7} + \log EXP_{t8} + \log GR_{t9} + \log GE_{t10} + EU\ enlargement_{t10} + \varepsilon_{it} \quad (1)$$

where *TXR* is the tax revenue expressed in USD billions; *GDP* is the gross domestic product growth rate; *POP* is the population; *INF* is the inflation rate; *M2* is the monetary aggregate annual growth; *UNM* is the unemployment rate; *INV* is the investment percentage share in the GDP; *IMP* is the import percentage share in the GDP; *EXP* is the export percentage share in the GDP; *GR* is the government revenue percentage share in the GDP; *GE* is the government expenditure percentage share in the GDP; the dummy variable is *EU enlargement* and the periods before and after the enlargement of these countries to the EU. Testing was performed on the logarithmically formed variables in order to avoid skewed data. Based on Figure 1, positive effects of the *GDP*, *POP*, *INV*, *IMP*, *EXP*, *GR*, *GE*, and *EU enlargement* were expected, while negative effects were expected for the *INF*, *M2*, and *UNM* on the *TXR*.



an average GDP growth rate of 3.12%, which is less than the average level of the inflation rate (5.83%). Also, the mean percentage shares of imports in the GDPs are greater than the exports in the selected countries, and the average government expenditures are above the government revenues in terms of the percentage shares in the GDPs. Although the average investment share in the GDP is higher than 20%, the average unemployment is 8.82% in these countries. Analyzing by country, Poland and Slovakia have double unemployment rates of 10.31% and 12.09%, while the Czech Republic has the smallest unemployment rate at 5.55% (Table 2).

**Table 2.** Descriptive analysis.

Czech Republic											
Variable	TXR	GDP	POP	INF	M2	UNM	INV	IMP	EXP	GR	GE
Mean	56.49	2.29	10,401	3.86	7.40	5.55	29.06	7.74	8.99	39.78	43.09
S.D.	27.75	2.84	0.15	3.59	6.59	2.19	2.75	7.11	8.64	1.28	2.91
Max.	100	6.85	10,694	16.34	29	8.76	35.69	29.89	40.7	42.46	52.93
Min.	17	−5.50	10,193	0.12	−11	2.01	24.67	−11.71	−10.5	37.39	38.94
Hungary											
Mean	41.77	2.47	10.02	7.83	11.37	7.32	24.66	7.58	8.96	44.26	49.25
S.D.	16.45	2.91	0.21	7.02	6.17	2.49	3.29	8.87	8.54	1.85	2.30
Max.	62	7.2	10.35	28.31	22	11.17	31.41	26.44	29.83	48.18	55.97
Min.	18	−6.61	9.72	−0.22	−5	3	19.49	−20.71	−17.8	41.14	45.79
Poland											
Mean	134.63	4.04	38,160	6.71	13.33	10.31	20.90	8.23	7.78	40.33	44.15
S.D.	66.31	2.13	0.28	8.19	9.84	5.25	2.14	8.07	5.70	1.76	2.21
Max.	250	7.09	38,667	32.2	38	19.93	24.94	28.01	23.21	45.88	50.72
Min.	40	−2.02	37,609	−0.93	−2	3	17.28	−12.38	−6.28	37.79	41.11
Slovakia											
Mean	23.7	3.69	5405	4.92	6.95	12.09	25.77	7.30	8.38	38.91	43.32
S.D.	10.74	3.26	0.03	4.02	3.93	4.53	4.83	9.14	9.04	2.80	4.11
Max.	42	10.8	5437	13.46	16	19.46	35.99	26.20	26.19	44.81	53.09
Min.	10	−5.42	5367	−0.47	−2	3.85	18.89	−19.40	−16.2	34.39	36.34
VG total											
Mean	64.15	3.12	15,997	5.83	9.76	8.82	25.09	7.71	8.53	40.83	44.95
S.D.	56.21	2.88	13.01	6.15	7.38	4.58	4.45	8.24	8.01	2.85	3.88
Max.	250	10.8	38,667	32.2	38	19.93	35.99	29.89	40.70	48.18	55.97
Min.	10	−6.61	5367	−0.93	−11	2.01	17.28	−20.71	−17.8	34.39	36.34

As we can see, most of these variables are stationary at levels of 0.05, except for the tax revenue, population, and inflation (Table 3). Furthermore, the same panel unit root tests are presented in Table 4 where all the variables are transformed into first differences. The results of these tests show that the selected variables are stationary at their first differences (Table 4). After the presented panel unit root tests, static and dynamic models were manifested in order to identify the tax revenue determinants in the VG for the period 1994–2023.

We used the VIF (Variance inflation factor) test to ensure an appropriate explanatory-variable selection. Based on the mean value of the test (1.62), it can be concluded that there is no issue of multicollinearity between the independent variables (Table 5). After that, we presented various panel regression models in order to estimate the potential effects of the selected macroeconomic determinants on the tax revenue.



**Table 3.** Results of panel unit root test—levels.

<b>H<sub>0</sub>: Panels Containing Unit Roots</b>				
<b>H<sub>a</sub>: Panels Are Stationary</b>				
<b>Variable</b>	<b>Number of Panels</b>	<b>LLC Test</b>	<b>Brt Test</b>	<b>Ht Test</b>
TXR	4	0.1825 (0.5724)	2.6917 (0.9964)	0.9707 (0.9242)
GDP	4	−3.3914 *** (0.0003)	−4.6413 *** (0.0000)	0.3859 *** (0.0000)
POP	4	1.0118 (0.8442)	4.2929 (0.9983)	0.9615 (0.8998)
INF	4	−6.1811 *** (0.0000)	0.4679 (0.6801)	0.7780 ** (0.0379)
M2	4	−3.1812 *** (0.0007)	−1.5841 * (0.0066)	0.5084 *** (0.0000)
UNM	4	−3.4185 (0.7288)	−0.7073 (0.2397)	0.7875 * (0.0529)
INV	4	−2.1284 ** (0.0167)	−1.8820 ** (0.0299)	0.7552 *** 0.0156
IMP	4	−9.5321 *** (0.0000)	−5.0881 *** (0.0000)	0.0414 *** (0.0000)
EXP	4	−3.7148 *** (0.0001)	−5.2347 ** (0.0000)	0.2074 *** (0.0000)
GR	4	−1.5387 * (0.0619)	−1.5493 * (0.0606)	0.7347 *** (0.0063)
GE	4	−3.8082 *** (0.0001)	−1.1784 (0.1193)	0.5744 *** (0.0000)

**Notes:** Values in parentheses are *p*-values. \*\*\*, \*\*, and \* indicate rejecting the null nonstationary hypothesis at the 1%, 5%, and 10% levels, respectively.

**Table 4.** Results of panel unit root test—first differences.

<b>H<sub>0</sub>: Panels Contain Unit Roots</b>				
<b>H<sub>a</sub>: Panels Are Stationary</b>				
<b>Variable</b>	<b>Number of Panels</b>	<b>LLC Test</b>	<b>Brt Test</b>	<b>Ht Test</b>
Δ TXR	4	−4.8195 *** (0.0000)	−5.8730 *** (0.0000)	0.0075 *** (0.0000)
Δ GDP	4	−7.2780 *** (0.0000)	−6.4281 *** (0.0000)	0.2548 *** (0.0000)
Δ POP	4	−2.4376 *** (0.0072)	−2.8207 *** (0.0024)	−0.0065 *** (0.0000)
Δ INF	4	−4.6765 *** (0.0000)	−2.7489 *** (0.0030)	−0.0133 *** (0.0000)
Δ M2	4	−4.6549 *** (0.0000)	−4.3061 *** 0.0000	−0.3771 *** (0.0000)
Δ UNM	4	−1.8201 *** (0.0034)	−0.8526 *** (0.0069)	0.3405 *** (0.0000)
Δ INV	4	−7.7416 *** (0.0000)	−4.5809 *** (0.0000)	0.0453 *** 0.0000
Δ IMP	4	−3.4021 *** (0.0000)	−3.0623 *** (0.0011)	−0.4996 *** (0.0000)
Δ EXP	4	−9.3957 *** (0.0000)	−7.2126 ** (0.0000)	−0.4006 *** (0.0000)
Δ GR	4	−3.5392 *** (0.0002)	−4.8237 *** (0.0000)	−0.1802 *** (0.0000)
Δ GE	4	−6.1265 *** (0.0000)	−3.9551 *** (0.0000)	−0.2395 *** (0.0000)

**Notes:** Values in parentheses are *p*-values. \*\*\*, \*\*, and \* indicate rejecting the null nonstationary hypothesis at the 1%, 5%, and 10% levels, respectively.

**Table 5.** Multicollinearity test.

Variable	VIF	1/VIF
GR	3.32	0.3008
GE	3.28	0.3047
INV	1.88	0.5331
M2	1.79	0.5584
POP	1.75	0.5699
GDP	1.74	0.5762
INF	1.64	0.6099
EXP	1.44	0.6950
UNM	1.32	0.7563
IMP	1.22	0.8219
Mean value	1.94	

Table 6 shows a comparative review of the static and dynamic models that were used to examine the effects of the selected variables on the tax revenues in the VG countries from 1994 to 2018. As we can see, EU enlargement is the dummy variable, which was included to identify the potential effect of the VG countries joining the European Union. The results of the static models recorded significant GDP, population, inflation, M2 growth, unemployment, import, government revenue, and government expenditure effects on the tax revenues. The only difference is that the RE model shows that the influence of investment on the tax revenue is significant at the level of 10%. The findings of the Hausman test prove that the FE model is appropriate, with an R-square value of 0.515. The results of the DOLS (Dynamic Ordinary Least Squares) model imply that the GDP, population, imports, government revenue, and EU enlargement significantly affect the tax revenues, where only imports have a negative effect on the tax revenues. The results of the Hausman test confirmed that the PMG model is appropriate for tax revenue modeling in the observed countries. In the short term, the GDP and population are significant for tax revenues and cause higher changes, where 1% growth enhanced the tax revenue by 0.14% and 2.93%. The inflation rate has a significant effect on the tax revenue in the short term, as well as in the long term. The effect of inflation on the tax revenue is higher in the short term, where growth of 1% decreased the tax revenue by 0.037%. On the other hand, unemployment is a significant factor for tax revenue in the long term, where a 1% decrease caused an increase in the tax revenue of 0.15%. Government revenue is more significant in the long term, where a 1% change in the tax revenue caused an increase of 0.77%. Finally, the results have confirmed that EU enlargement is significant for tax revenue in the short term and long term, while the effects of joining the European Union are higher in the short term.

Analyzing the PMG results by country, we can see that lagged tax revenue had a significant effect on the tax revenues in all the countries for the observed period. Also, the gross domestic product had a significant effect on the tax revenues in Hungary and Poland, while inflation significantly affected the tax revenues in Poland and Slovakia. Further, M2 was significant for tax revenue only in Poland, where growth of 1% of M2 decreased the tax revenue by 0.07%. Unemployment was a significant factor for the tax revenues in the Czech Republic and Hungary, where 1% growth decreased the tax revenues by 0.17% and 0.03%. The tax revenues of the Czech Republic, Hungary, and Poland are significantly affected by EU enlargement, while this is not the case for Slovakia. The results show that a variable population is a significant factor only in Poland, while imports do not significantly affect the tax revenues in the observed countries. The investment share of the GDP is significant for the tax revenue in the Czech Republic, where 1% growth in investment increased the tax revenues by 0.11% and 0.39%. Variable exports are important for Hungary and Poland, where 1% growth enhanced the tax revenues by 0.03% and 0.01% (Table 7). Finally, government revenue and government expenditure have significant impacts on the tax revenues in the Czech Republic and Poland, with one difference: government

expenditure has a higher effect on the tax revenue in Poland, while government revenue causes a higher change in the tax revenue in the Czech Republic.

**Table 6.** Different panel modeling of tax revenue.

Model	Static Models			Dynamic Models—LR			Dynamic Models—SR		
Variable	RE	FE	DOLS	PMG	MG	DFE	PMG	MG	DFE
$\Delta$ GDP	1.241 (0.000)	1.519 (0.000)	<b>0.525</b> <b>(0.004)</b>	<b>0.042</b> <b>(0.034)</b>	<b>0.318</b> <b>(0.006)</b>	<b>0.011</b> <b>(0.004)</b>	<b>0.139</b> <b>(0.016)</b>	<b>0.191</b> <b>(0.004)</b>	<b>0.194</b> <b>(0.001)</b>
$\Delta$ POP	3.901 (0.000)	5.660 (0.000)	<b>0.496</b> <b>(0.007)</b>	<b>0.610</b> <b>(0.011)</b>	0 (0.677)	0.127 (0.677)	<b>2.94</b> <b>(0.048)</b>	0 (0.677)	0.423 (0.596)
$\Delta$ INF	−0.654 (0.043)	−0.672 (0.009)	−0.355 (0.008)	− <b>0.001</b> <b>(0.048)</b>	−0.045 (0.503)	−0.001 (0.947)	− <b>0.037</b> <b>(0.046)</b>	−0.201 (0.086)	−0.004 (0.780)
$\Delta$	−2.204 (0.000)	−0.733 (0.037)	−0.712 (0.025)	−0.021 (0.014)	−0.023 (0.538)	−0.004 (0.716)	−0.001 (0.914)	−0.056 (0.087)	0.003 (0.960)
$\Delta$ UNM	−2.310 (0.000)	−2.609 (0.000)	−0.981 (0.057)	− <b>0.151</b> <b>(0.004)</b>	−0.073 (0.579)	−0.011 (0.463)	− <b>0.145</b> <b>(0.038)</b>	− <b>0.468</b> <b>(0.044)</b>	0.359 (0.180)
$\Delta$ INV	1.289 (0.066)	0.562 (0.433)	0.451 (0.470)	<b>0.031</b> <b>(0.048)</b>	0.024 (0.774)	0.021 (0.256)	0.014 (0.659)	0.131 (0.435)	0.017 (0.488)
$\Delta$ IMP	0.574 (0.229)	0.882 (0.046)	− <b>0.647</b> <b>(0.000)</b>	− <b>0.001</b> <b>(0.006)</b>	0.067 (0.251)	0.001 (0.877)	−0.003 (0.548)	−0.047 (0.443)	−0.001 (0.570)
$\Delta$ EXP	0.043 (0.926)	0.684 (0.122)	0.167 (0.534)	0.009 (0.118)	0.031 (0.665)	0.003 (0.637)	0.001 (0.928)	0.012 (0.799)	0.001 (0.837)
$\Delta$ GR	0.566 (0.015)	0.451 (0.033)	<b>2.135</b> <b>(0.003)</b>	<b>0.054</b> <b>(0.007)</b>	0.190 (0.161)	0.001 (0.953)	<b>0.771</b> <b>(0.021)</b>	0.136 (0.381)	0.002 (0.412)
$\Delta$ GE	0.747 (0.038)	0.889 (0.004)	<b>1.447</b> <b>(0.041)</b>	0.026 (0.014)	0.076 (0.206)	0.023 (0.254)	0.013 (0.698)	0.341 (0.533)	0.002 (0.917)
EU enlargement	4.218 (0.000)	4.421 (0.000)	<b>17.02</b> <b>(0.002)</b>	<b>0.115</b> <b>(0.004)</b>	1.056 (0.118)	0.022 (0.894)	<b>0.131</b> <b>(0.050)</b>	1.398 (0.207)	0.011 (0.949)
$\Delta$ LAGTXR	-	-	<b>0.786</b> <b>(0.000)</b>	<b>1.004</b> <b>(0.000)</b>	<b>1.023</b> <b>(0.000)</b>	<b>0.998</b> <b>(0.000)</b>	<b>0.004</b> <b>(0.002)</b>	<b>0.189</b> <b>(0.012)</b>	0.009 (0.520)
R-squared	0.714	0.515	0.923	-	-	-	-	-	-
Hausman test	0.000 FE is an appropriate model			0.971 PMG is an appropriate model			0.984 PMG is an appropriate model		

**Table 7.** PMG models by country.

Country/Variable	Czech Republic	Hungary	Poland	Slovakia
$\Delta$ GDP	0.039 (0.121)	<b>0.012</b> <b>(0.001)</b>	<b>0.091</b> <b>(0.001)</b>	0.002 (0.932)
$\Delta$ POP	1.450 (0.241)	2.101 (0.706)	<b>1.659</b> <b>(0.042)</b>	2.481 (0.106)
$\Delta$ INF	−0.240 (0.165)	−0.011 (0.409)	− <b>0.077</b> <b>(0.003)</b>	− <b>0.061</b> <b>(0.045)</b>
$\Delta$ M2	0.045 (0.434)	−0.004 (0.686)	− <b>0.007</b> <b>(0.048)</b>	0.008 (0.489)
$\Delta$ UNM	− <b>0.170</b> <b>(0.027)</b>	− <b>0.027</b> <b>(0.045)</b>	−0.637 (0.114)	−0.026 (0.412)
$\Delta$ INV	<b>0.108</b> <b>(0.002)</b>	0.002 (0.949)	<b>0.391</b> <b>(0.003)</b>	0.014 (0.604)
$\Delta$ IMP	0.007 (0.648)	0.018 (0.114)	0.786 (0.869)	0.002 (0.803)
$\Delta$ EXP	0.019 (0.113)	<b>0.031</b> <b>(0.000)</b>	<b>0.017</b> <b>(0.025)</b>	0.009 (0.336)
$\Delta$ GR	<b>0.225</b> <b>(0.000)</b>	0.024 (0.455)	<b>0.041</b> <b>(0.013)</b>	0.048 (0.214)
$\Delta$ GE	<b>0.058</b> <b>(0.006)</b>	0.001 (0.997)	<b>0.104</b> <b>(0.008)</b>	0.006 (0.828)
EU enlargement	<b>0.097</b> <b>(0.046)</b>	<b>0.176</b> <b>(0.009)</b>	<b>0.359</b> <b>(0.031)</b>	0.209 (0.114)
$\Delta$ LAGTXR	<b>0.015</b> <b>(0.035)</b>	<b>0.016</b> <b>(0.000)</b>	<b>0.002</b> <b>(0.002)</b>	<b>0.003</b> <b>(0.043)</b>

## 5. Conclusions

The tax revenue performance refers to the assessment of how well a government is collecting taxes and meeting its revenue targets. The issue of the tax revenue performance represents one of the most essential topics for policymakers worldwide. Identifying and recognizing the neuralgic components in revenue collection is certainly one of the biggest challenges for any fiscal authority. This is especially expressed in the turbulent economic conditions that are increasingly present at the international level. Therefore, an optimally set tax structure can provide significant benefits for the budget and the country's economic prosperity. We examined the effects of the macroeconomic determinants on the tax revenues in VG countries (the Czech Republic, Hungary, Poland, and Slovakia) from 1994 to 2023. The empirical analysis included static and dynamic models, such as the FE and RE models and PMG, MG, and DFE models, to precisely identify the tax revenue determinants in the selected countries. In this research, we examined the effects of the gross domestic product, population, inflation, M2, unemployment, investment, government revenue, government expenditure, and EU enlargement on the tax revenues in the observed period. Within the static models, the Hausman test showed that the FE model is adequate and shows significant gross domestic product, population, unemployment, investment, and EU enlargement effects on the tax revenue. Among the dynamic models, the PMG model is an appropriate model, showing the significant effects of the tax revenue lagged value, gross domestic product, population, unemployment, government revenue, and EU enlargement on the tax revenue. In the short term, growth of the gross domestic product and population by 1% changes the tax revenue by 0.14% and 2.93%. This means that the hypotheses H1.1 and H1.2 can be accepted, which state that the gross domestic product and population have significant positive impacts on the tax revenue. The inflation rate has a significant negative effect on the tax revenue in the short and long terms. The effect of inflation on the tax revenue is higher in the short term, where growth of 1% decreased the tax revenue by 0.037%. This means that the hypothesis H1.3 can be partially accepted because the variable M2 does not have a significant impact on the tax revenues in the observed countries. Also, the results show that EU enlargement is significant for tax revenue in the short term, as well as in the long term. This implies that the hypothesis H1.8 can be accepted, which states that EU enlargement has a significant positive effect on the tax revenues in VG countries. The effects of investment, imports, and exports are not significant for the tax revenues in the observed period, which implies that the hypotheses H1.5 and H1.6 cannot be accepted. Unemployment has a significant negative impact on the tax revenues in the observed countries, which implies that the hypothesis H1.4 can be accepted. Unemployment growth of 1% decreases the tax revenue by 0.15% in the long term and by 0.13% in the short term. Finally, government revenue is significant for tax revenue only in the long term, where 1% growth increases the tax revenue by 0.77%. This means that the hypothesis H1.7 can be partially accepted because the effect of government expenditure is not significant.

This empirical analysis provides information support and guidelines for policymakers in VG countries and enables the identification of the determinants that are important to the tax revenue levels in these economies. We compared the different impacts of the selected variables, the gross domestic product, population, inflation rate, and unemployment rate, representing the most important macroeconomic determinants, in the context of the tax revenue performances in VG countries. Thus, we can conclude that higher GDP and population levels generate more tax revenue, while the inflation rate and unemployment rate erode the tax revenue base. These findings imply that tax revenue structures should be designed according to the macroeconomic environment to avoid harmful effects on the revenue mobilization. Finally, policymakers must create and design tax structures that are adjustable to various macroeconomic scenarios, as well as potential crisis moments. As with any empirical research, there are certain limitations related to this study. One limitation of this study is the absence of non-economic, institutional, and social determinants, such as government stability, the tax administration capacity, tax evasion, corruption, and urbanization, which could affect the tax revenue levels. Also, this research did not include

actual global crisis moments, such as the COVID-19 pandemic and the war conflict in Ukraine, which will be the subject of future analysis. Future research could focus on post-Soviet countries and their comparison with European Union countries to complete the implications of the tax revenue determinants in Western and Eastern European areas.

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