

Exchange Rate Volatility as a Strategic Constraint on Tax Revenue Performance: Evidence from European Transition Economies

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Abstract

Background: Tax revenue performance is a central indicator of fiscal capacity and macroeconomic stability, particularly in small and open transition economies. While existing research highlights that macroeconomic volatility can weaken revenue mobilization, empirical evidence on the fiscal consequences of exchange rate volatility in European transition countries remains limited and fragmented. Given rising external exposure, evolving monetary regimes, and ongoing institutional reforms, understanding how exchange rate instability affects tax revenues is of growing policy relevance.

Purpose: The purpose of this study is to examine whether exchange rate volatility undermines tax revenue performance in selected European transition economies. To this end, the paper evaluates the magnitude and robustness of this relationship, while accounting for macroeconomic, fiscal, and structural determinants of tax revenues.

Study design/methodology/approach: The analysis employs a two-way fixed-effects panel framework using annual data for ten European economies over the period 2006-2024. The sample includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Montenegro, North Macedonia, Romania, Serbia, and Slovenia. Exchange rate volatility is measured using an integrated annual indicator derived from daily conditional variances estimated through a volatility model. The empirical specification controls for economic development, growth dynamics, inflation, government expenditure, public debt, trade openness, and production structure. To ensure reliable inference, robust standard errors are applied to address heteroskedasticity, serial correlation, and cross-sectional dependence.

Findings/conclusions: The results indicate a statistically significant and negative relationship between exchange rate volatility and tax revenue performance. Specifically, a 1% increase in exchange rate volatility is

associated with an approximate 0.034 percentage-point decline in the tax revenue-to-GDP ratio. This demonstrates that higher exchange rate instability is associated with lower tax revenues relative to economic output, suggesting that currency volatility acts as a source of fiscal fragility rather than a stabilizing mechanism. Ultimately, the findings underscore the importance of exchange rate stability and coordinated monetary-fiscal frameworks for ensuring predictable and sustainable revenue mobilization in transition economies.

Limitations/future research: The study is limited by its small country sample and the static nature of the empirical framework. Future research could extend the analysis to a broader set of countries, apply dynamic modeling techniques, and explore the asymmetric or nonlinear effects of exchange rate volatility on tax revenues.

Keywords

tax revenue, exchange rate volatility, GARCH, fixed-effects model, European transition economies

Introduction

In a context of growing fiscal pressures, demographic aging, and structural economic change, generating stable and sustainable tax revenue generation is increasingly important for macroeconomic stability and social cohesion (Fortea, 2025). Tax revenue performance represents a relevant indicator of a government's fiscal capacity to sustain public spending, macroeconomic stability, and long-term development. Taxation is closely connected to economic development, as it represents a key source of government revenue that supports public spending and broader development objectives (Bhalla et al., 2022). Therefore, tax revenue performance is a critical measure of a government's ability to collect taxes efficiently and meet its fiscal objectives. As a key revenue stream for governments (Queku et al., 2024), taxation supports critical public investments and infrastructure, while also directing economic development patterns (Akitoby et al., 2020; Abubakari et al., 2024). In an era of global economic uncertainty, optimizing tax structures and addressing key challenges in revenue collection are essential for ensuring fiscal stability and sustainable growth (Đurović Todorović et al., 2024). Tax revenues play a vital role in fostering economic growth and development. The design of a tax system significantly influences both economic growth and income distribution, while a shift toward less distortionary taxes, such as indirect taxation, is often associated with higher efficiency but lower equity (Beljić & Glavaški, 2025). Identifying the key determinants that influence the level of tax revenue is a critical concern in the field of public finance (Ristić Cakić et al. 2025). Beyond their traditional role as a source of government funding, tax revenues serve as a crucial mechanism for income redistribution, economic stabilization, and the

implementation of counter-cyclical policies during periods of economic volatility. Tax revenue capacity is closely associated with state capacity indicators, particularly government effectiveness, implying that improvements in the quality of governance may enhance a country's ability to mobilize additional tax revenues (Afonso et al., 2025).

Tax revenue forms the foundation of public finances, providing the resources needed for governments to fund vital services, invest in infrastructure, and support economic resilience (Đurović Todorović et al., 2025). A stable fiscal framework is essential for preserving macroeconomic balance, with long-term sustainability depending on the consistency of fiscal policy (Mobosi & Okonta, 2025). The government's capacity to sustain stable revenue collection is especially crucial during periods of external shocks, when fiscal adaptability may be a decisive factor in determining whether an economy experiences swift recovery or protracted recession (Adefolake & Omodero, 2022). An unexpected aspect of recent global shocks has been the relative stability of major exchange rates, even during periods of pronounced economic contraction and heightened uncertainty (Balaban et al., 2025a). Tax policies perform not only a fiscal function but also distributive and regulatory roles, directing economic activity by incentivizing desirable behavior and discouraging undesirable forms of economic conduct (Daly, 2023). Barrios (2020) highlights that the effects of tax reforms constitute a key concern in economic policy design and evaluation. Fiscal policy serves as a fundamental pillar of economic functioning, with its implications extending across both public and private sectors through the strategic deployment of taxation and government expenditure mechanisms (Đaković et al., 2022).

Exchange rate exposure represents a critical strategic consideration in financial management,

as its determinants appear to be dynamic and vary significantly across different time periods and industrial sectors (Sayed & Gayathri, 2023).

The relationship between tax revenue and exchange rate volatility is a key aspect of fiscal–monetary policy coordination, particularly in emerging and transition economies. Its relevance has increased in an environment of deeper financial integration and greater exposure of domestic fiscal systems to external shocks.

Theoretically, exchange rate volatility may influence tax revenue by altering the tax base, affecting trade flows, and increasing macroeconomic uncertainty, thereby reducing the predictability of revenue collection.

Despite its importance, this nexus remains insufficiently explored in comparative empirical research, especially within this region. The limited research in this region is particularly concerning given the unique characteristics of these economies, including their recent transition from centrally planned to market-based systems, ongoing institutional development, and varying degrees of European integration.

This study investigates the dynamic interplay between these two macroeconomic variables across ten selected European transition economies (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Montenegro, North Macedonia, Romania, Serbia, and Slovenia) over the period from 2006 to 2024. The selection of these countries is strategically motivated by their shared historical experience of economic transition, their geographic proximity, and their diverse approaches to monetary and fiscal policy. The chosen timeframe encompasses a series of major economic and political episodes that have profoundly shaped the fiscal and monetary architecture of the region. Starting with the pre-crisis stability of 2006–2007, the analysis captures the effects of the global financial crisis (2008–2009), the European sovereign debt crisis (2010–2012), a phase of recovery and EU convergence, and the recent challenges posed by the COVID-19 pandemic and escalating geopolitical tensions, particularly after 2020. This chronological span is particularly valuable as it includes periods of both relative stability and extreme volatility, allowing for a comprehensive assessment of how the tax revenue–exchange rate relationship evolves under different macroeconomic conditions. This extended and turbulent period provides a robust empirical context for examining how tax revenue

systems react to shifts in exchange rate dynamics under changing macroeconomic conditions.

The selected countries represent a diverse group in terms of institutional maturity, economic openness, and monetary regimes. While Slovenia adopted the euro in 2007 and Montenegro uses it unilaterally, other countries retain national currencies and manage their exchange rates with varying flexibility. Hungary operates an inflation-targeting framework with a floating exchange rate, whereas Bulgaria adheres to a rigid currency board regime. Croatia's transition to the euro in 2023 provides an additional layer of complexity, offering insights into how monetary regime changes affect the underlying fiscal dynamics. This diversity creates a quasi-experimental setting for analyzing how different monetary arrangements mediate the effects of currency volatility on fiscal performance. The heterogeneity of the selected countries and institutional frameworks implies that estimated effects should be interpreted as average regional responses rather than country-specific outcomes. This comparative structure allows for identifying common fiscal vulnerabilities while also informing policy design tailored to different monetary regimes and levels of institutional development.

Such transmission mechanisms should be considered within an integrated policy setting, where monetary conditions influence fiscal outcomes and the feasibility of longer-term policy commitments. Exchange rate fluctuations affect tax revenue through both direct and indirect channels. Direct effects include the valuation of foreign currency-denominated liabilities and changes in trade-related taxes, where depreciation increases the domestic value of imports and customs revenues. Indirectly, volatility influences inflation, investment, consumption, and trade, thereby affecting major revenue sources such as income tax, VAT, and customs duties. These effects can be nonlinear and vary across small, open, and externally exposed economies.

The research establishes a theoretical framework showing that various exchange rate management approaches can be understood as equivalent to specific tax policy instruments, drawing on principles similar to the Lerner symmetry theorem. The analysis reveals that dual exchange rate systems effectively operate as distortionary levies on international capital flows, whereas unified pegged exchange rate arrangements function similarly to lump-sum

taxation and subsidy mechanisms. This conceptual equivalence indicates that exchange rate policies should be analyzed within the broader context of public finance theory, with the authors employing a two-nation economic model to illustrate international transmission effects (Frenkel & Razin, 1989). Over the observed period, the examined economies underwent profound transformations: EU accession, structural reforms, institutional modernization, and shifts in fiscal architecture. These changes, coupled with heterogeneous exposure to external shocks, provide fertile ground for exploring the complex and context-specific interactions between exchange rate volatility and fiscal capacity. Rather than a mechanical link, this relationship unfolds within a broader macro-financial ecosystem shaped by national policy choices, institutional credibility, and external vulnerabilities.

This study contributes to the literature by providing a comparative panel analysis of the tax revenue-exchange rate volatility nexus in a region that remains underrepresented in empirical macro-fiscal research. It applies a panel data framework that accounts for country-specific heterogeneity and dynamic adjustment, allowing for both short- and long-term effects to be captured. The results have important implications for fiscal policy design, revenue forecasting, and macroeconomic stabilization in open and institutionally vulnerable economies.

Understanding these relationships is particularly relevant for policymakers aiming to improve fiscal system robustness in the face of exchange rate volatility, while advancing economic integration in a globalized setting. Moreover, this study underscores the necessity of adaptive and countercyclical fiscal frameworks capable of absorbing currency-induced revenue shocks, reaffirming the importance of coordinated macroeconomic governance in transition and post-transition economies.

After this introduction, the next section reviews the theoretical and empirical literature on tax revenue determinants, focusing on exchange rate dynamics and macroeconomic volatility. This is followed by the data and methodology section, including variable measurement and model specification. The next section presents the empirical results with supporting diagnostics. The final sections discuss the findings in relation to existing literature and conclude with policy implications and directions for future research.

1. Literature review

The literature on tax revenue determinants emphasizes the role of macroeconomic, structural, and institutional factors in shaping fiscal outcomes. Garg et al. (2025a) provides a useful framework for understanding tax revenue determinants, highlighting the interaction between economic performance, institutional settings, and policy choices, and offering insights for fiscal policy design and revenue enhancement.

Several macroeconomic variables are commonly analyzed as key drivers of fiscal capacity. Economic growth features prominently in these analyses, with studies investigating its association with revenue generation through changes in taxable income, consumption, and corporate profits (McNabb, 2018; Anastasiou et al., 2024; Đurović Todorović et al., 2024; Ristić Cakić et al., 2025). Similarly, Khujamkulov and Abizadeh (2023) show that economic growth significantly increases the tax revenue-to-GDP ratio in transition economies, further supporting the argument that expanding economic activity strengthens fiscal capacity and revenue mobilization.

The relationship between inflation and tax collection has also been extensively studied, with particular attention to how price level fluctuations may interact with nominal revenue streams (Oz-Yalaman, 2019; Salhi & ElAboudi, 2021; Gnanngnon, 2022; Mirović et al., 2023). The study of Garg et al. (2025b) suggests that inflation may enhance tax collection in the short run through higher nominal revenues, while persistent inflation tends to weaken tax effort over the long run by eroding the effectiveness of the tax system, a finding that aligns with Chamisa and Sunde (2025). Supporting this perspective, Caporale et al. (2024) find a strong long-run association between inflation and tax revenue dynamics across OECD countries, suggesting that inflation remains an important determinant of revenue performance over time.

Labor market conditions, particularly unemployment rates, are frequently included in such models given their relevance to income-based taxation and social security contributions (Celikay, 2020; Mirović et al., 2023). The degree of trade openness is another commonly analyzed factor, especially in contexts where trade taxes constitute a significant revenue source (Gnanngnon & Brun, 2019; Neog & Gaur, 2020; Rahman & Islam, 2026; Kweka, 2024). Similarly, foreign direct investment (FDI) inflows are often

considered for their potential fiscal implications, both through direct taxation channels and broader economic spillovers (Camara, 2023; Gaspareniene et al., 2022; Minh et al., 2022; Nguyen-Phuong et al., 2022; Omodero & Yadoo, 2024). Economic policy uncertainty has also attracted growing attention in the tax revenue literature, given its potential to influence investment activity, economic performance, and ultimately fiscal outcomes (Sakar et al., 2025).

Exchange rate volatility can significantly impact price stability and economic growth, two critical objectives of monetary policy, with unpredictable movements in relative prices potentially leading to price instability, exchange rate instability, and reduced investment (Daniel & Tosin, 2020). The complexity of this relationship is further amplified by the fact that an increase in exchange rate volatility can lead to both positive and negative effects on trade flows, which subsequently impacts government revenue (Uremadu et al., 2017).

Recent empirical evidence from East African economies over the period 1996-2020 demonstrates that exchange rate volatility exerts a significant negative impact on tax revenue in the long run, while short-run effects remain statistically negligible, suggesting that the fiscal consequences of currency instability materialize primarily through sustained exposure rather than immediate fluctuations (Fisseha, 2025). Koçak (2021) investigated the relationship between exchange rate volatility and tax revenues in Turkey using monthly data from 2006 to 2019, employing the ARDL model and Toda-Yamamoto causality test. The results show that exchange rate volatility positively affects tax revenues in the short run (with a significant lagged effect) but has a negative impact in the long run. This finding is particularly significant as it challenges the conventional wisdom that exchange rate volatility is universally detrimental to tax collection. The positive short-term effect can be attributed to the immediate impact of currency depreciation on import duties and the nominal value of trade-related taxes, while the negative long-term effect reflects the erosion of real tax values and reduced economic activity.

Similar evidence is reported by Eng and Lim (2026) for Cambodia, where exchange rate depreciation was found to exert a significant negative effect on tax revenue both in the short run and the long run, while broad money supply positively contributed to revenue performance.

The pioneering work of Agbeyegbe et al. (2006) examined the relationship between exchange rate volatility and tax revenue in Sub-Saharan Africa using GMM for the period 1980-1996. They found that currency appreciation and higher inflation are associated with lower tax revenue and suggested that while trade liberalization alone has limited impact, exchange rate movements can significantly influence tax revenue performance. Empirical evidence from 21 countries in SSA region between 1984 and 2017, using a panel ARDL approach, indicates that exchange rate volatility negatively affects tax revenue performance both directly and indirectly via reduced trade openness (Ofori et al., 2021). This finding is particularly important as it identifies trade openness as a mediating channel through which exchange rate volatility affects fiscal performance. The identification of this indirect channel suggests that the relationship between exchange rate volatility and tax revenue is more complex than previously understood, with exchange rate instability potentially creating a vicious cycle where reduced trade openness further undermines tax collection capacity. This argument is reinforced by Nchofoung et al. (2023), who demonstrate that the fiscal effects of exchange rate misalignment are conditioned by trade openness, suggesting that external sector integration plays a crucial role in shaping the exchange rate-tax revenue nexus.

Country-specific analyses have provided deeper insights into the mechanisms through which exchange rate volatility affects tax collection in individual economies. In the Kenyan context, M'maroo et al. (2024) analyze how real exchange rate depreciation affects domestic tax revenue in Kenya from 2003 to 2023, using a multivariate ARDL model, and find that depreciation significantly reduces tax revenue, particularly with delayed effects. It recommends exchange rate stabilization and trade balance improvements while highlighting the need for future research on fiscal policy shifts and global shocks. The emphasis on delayed effects is crucial for policy design, as it suggests that the full fiscal impact of exchange rate movements may not be immediately apparent, requiring forward-looking fiscal planning. The Kenyan experience is corroborated by earlier research conducted by Rutto (2020), who analyzed how exchange rates influence tax revenue performance in Kenya using annual time series data from 2003 to 2018 within a linear modeling framework. The results indicate

that exchange rate fluctuations are negatively associated with the country's tax revenue collection. The consistency of findings across different time periods and methodological approaches strengthens the evidence base for Kenya's vulnerability to exchange rate-induced fiscal stress. This pattern suggests that structural characteristics of the Kenyan economy, such as its dependence on imported goods and limited tax base diversification, may make it particularly susceptible to exchange rate shocks. Similarly, the Ghanaian experience mirrors these patterns. Ofori et al. (2018) examined how fluctuations in exchange rates influence tax revenue generation in Ghana, using annual data spanning from 1984 to 2014. Employing the autoregressive distributed lag (ARDL) model, their analysis revealed that exchange rate volatility exerts a negative impact on tax revenue both in the short term and over the long run. The persistence of negative effects across both time horizons suggests that Ghana's tax system lacks effective mechanisms to insulate fiscal performance from exchange rate shocks. This finding contrasts sharply with the Turkish experience, highlighting how structural economic differences and institutional capacity can influence the nature of the exchange rate-tax revenue relationship. The Malawian case provides additional insights into the role of exchange rate regimes and policy coordination. Chavula (2024) examines how exchange rate dynamics and regime changes affected tax revenue collection in Malawi from 1990 to 2022 using VAR estimation techniques on time series data. The findings reveal that exchange rate variations and regime shifts significantly impact Malawi's tax revenues, indicating that coordinating tax reforms with foreign exchange policies could enhance domestic revenue mobilization by better taxing foreign currency assets and broadening the tax base. This study is particularly valuable as it explicitly considers the role of exchange rate regimes, moving beyond simple volatility measures to examine structural policy changes. The recommendation for policy coordination represents an important evolution in thinking about how to address exchange rate-induced fiscal volatility.

The relationship between exchange rate volatility and tax revenue is not limited to developing countries, as evidenced by recent research in European transition economies. Mirović et al. (2023) highlight a significant negative relationship between exchange rate

volatility and tax revenue performance in the Baltic countries from 1995 to 2020, indicating that currency instability undermines the government's ability to mobilize fiscal resources. The findings suggest that stabilizing exchange rates is crucial for maintaining consistent and effective tax collection, especially in small, open economies. This evidence is particularly important as it demonstrates that even relatively developed economies with stronger institutional frameworks remain vulnerable to exchange rate-induced fiscal volatility. The Baltic experience suggests that small, open economies may be inherently more susceptible to exchange rate effects regardless of their level of development.

While most empirical studies focus on developing countries, evidence from European economies generally supports the view that exchange rate volatility can negatively affect tax revenue performance. This suggests that the fiscal consequences of exchange rate instability are not limited to a specific region or level of economic development.

A critical examination of the literature reveals distinct temporal and regional patterns in the exchange rate-tax revenue relationship. The consistently negative relationships verified in African studies (Agbeyegbe et al., 2006; Ofori et al., 2021; Ofori et al., 2018; Rutto, 2020; M'maroo et al., 2024; Chavula, 2024) contrast with the more nuanced findings from Turkey (Koçak, 2021), suggesting that structural economic characteristics may mediate this relationship. African economies, characterized by greater dependence on trade taxes and weaker institutional capacity, appear more vulnerable to exchange rate-induced fiscal stress than more diversified economies.

The temporal dimension is also important, with studies documenting asymmetric short- and long-term effects. While exchange rate movements may generate short-term gains in nominal revenues, their medium- to long-term impact is generally negative for fiscal sustainability. This has important policy implications, as short-term revenue effects from depreciation should not be viewed as a stable source of fiscal financing. Overall, the literature broadly agrees that exchange rate volatility tends to undermine tax revenue performance, particularly in developing countries with less diversified tax bases. At the same time, the relationship may not be strictly unidirectional. Cunha et al. (2026) provide complementary

evidence on the reverse relationship, showing that higher tax revenues and fiscal austerity measures contribute to lower exchange rate volatility across 53 countries, suggesting the existence of important feedback effects between fiscal performance and exchange rate stability.

The evidence is most consistent for Sub-Saharan African countries, where multiple studies document negative relationships across different time periods and methodological approaches. However, the Turkish experience demonstrates that the relationship may be more complex in middle-income countries with more sophisticated tax systems. Recent studies have begun to incorporate more sophisticated theoretical frameworks that account for indirect effects of exchange rate volatility on tax revenue, with the work by Ofori et al. (2021) on the mediating role of trade openness representing an important advance in understanding the transmission mechanisms. Similarly, Gnanon (2023) argues that tax structure reforms that shift reliance from trade taxes toward domestic taxes influence real exchange rate dynamics, indicating that fiscal reforms may indirectly affect revenue performance through exchange-rate-related transmission channels.

The policy implications derived from this literature are relatively clear: exchange rate stabilization is important for maintaining fiscal sustainability, particularly in developing countries. The recommendations by M'maroo et al. (2024) for an improved trade balance, alongside those by Chavula (2024) for better coordination between tax and foreign exchange policies, represent important steps toward more integrated policy approaches. However, the practical implementation of such policies remains challenging, given the trade-offs between exchange rate stability and other macroeconomic objectives. Significant gaps remain in understanding the optimal policy instruments for achieving such stabilization while maintaining macroeconomic flexibility, with the field benefiting from more policy-oriented research that can translate empirical findings into practical policy recommendations. Finally, the existing literature suggests that exchange rate volatility generally undermines tax revenue performance, particularly in developing and transition economies, while also revealing important regional and temporal asymmetries.

2. Methodological framework

This study employs a panel data approach to examine the relationship between tax revenue performance and exchange rate volatility in ten CEE countries (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Montenegro, North Macedonia, Romania, Serbia, and Slovenia) over the period 2006-2024. The empirical analysis is based on annual macroeconomic data obtained from the International Monetary Fund (IMF), World Bank (WB), and Organization for Economic Co-operation and Development (OECD) databases, while exchange rate data used for volatility estimation are sourced from Investing.com. The selected countries experienced similar historical and transition processes, while simultaneously exhibiting differences in economic development, institutional capacity and degree of EU integration. Such a sample combines regional similarities with sufficient structural diversity among the observed countries. Given the heterogeneous nature of the sample and the presence of common external shocks, the econometric strategy is designed to control for both country-specific characteristics and time-specific effects.

2.1. Measurement exchange rate volatility

Exchange rate (EXR) volatility is measured using a model-based approach derived from high-frequency data. Specifically, volatility is calculated as the conditional variance of daily exchange rate returns obtained from an estimated GARCH model, following the framework proposed by Bollerslev (1986). The GARCH models are widely employed in the analysis of volatility in high-frequency time-series data (Balaban et al., 2025b; Živkov et al., 2021). McAleer (2005) notes that relatively simple models, including GARCH(1,1), can adequately capture financial volatility, provided that their suitability is assessed through diagnostic testing. This approach allows for time-varying volatility and captures clustering effects commonly observed in exchange rate dynamics. Daily EXR returns are computed as logarithmic differences of the nominal EXR series:

$$r_t = \Delta \ln(EXR_t) \times 100 \quad (1)$$

where EXR_t denotes the nominal exchange rate at time t . The GARCH (1,1) model is estimated for each country using daily data. The

mean equation models daily EXR returns as a constant plus a shock:

$$r_t = \mu + \varepsilon_t \quad \varepsilon_t | \mathcal{F}_{t-1} \sim (0, h_t) \quad (2)$$

where r_t denotes the daily log return of the EXR, μ is the constant mean return, ε_t is the innovation (shock) in return at time t , $\mathcal{F}_{t-1}$ is the information set available at time $t-1$, h_t is the conditional variance of r_t . The variance equation allows volatility to change over time as a function of past shock (ε_{t-1}^2) and past volatility (h_{t-1}).

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (3)$$

where ω is the constant term in variance equation, α is the ARCH parameter that measure the short-run impact of past shocks (effect of squared innovation ε_{t-1}^2), β is the GARCH parameter that capture volatility persistence (effect of past conditional variance h_{t-1}). The estimated GARCH (1,1) models satisfy all required conditions, with non-negative parameters, covariance stationarity, and no remaining ARCH effects or heteroskedasticity in the standardized residuals.

To ensure consistency with the annual frequency of the fiscal and macroeconomic variables, the daily conditional variances derived from the GARCH model are aggregated to the yearly level. Following the financial econometric literature, EXR volatility is measured using an integrated volatility approach based on the aggregation of high-frequency conditional variances (Andersen & Bollerslev, 1998; Andersen et al., 2003). Integrated annual exchange rate volatility is constructed as the square root of the sum of daily conditional variances within each year:

$$\sigma_y = \sqrt{\sum_{t \in \text{year}} h_t} \quad (4)$$

This measure captures the cumulative exchange rate uncertainty faced by the economy over the course of a year, which is particularly relevant given that tax revenues are annual flow variables reflecting the accumulation of economic activity over time. Since the number of trading days is identical across all countries and years in the sample, the resulting volatility measure is comparable across the panel dimension. Although the integrated volatility measure originates in the financial econometrics literature, it provides a theoretically grounded way to summarize time-

varying exchange rate uncertainty over longer horizons.

2.2. Two-way FE fixed-effects with Driscoll-Kraay standard errors

While the primary focus of the analysis is on the effect of exchange rate volatility on tax revenue performance, the empirical framework explicitly controls for a set of macroeconomic and fiscal determinants widely recognized in the public finance literature as relevant drivers of tax revenue outcomes. Tax revenues are influenced by both cyclical and structural factors, including the level of economic development, short-term economic fluctuations, price dynamics, fiscal policy stance, and the structural composition of the economy. Omitting these variables could lead to biased estimates of the exchange rate volatility effect due to omitted variable bias.

Accordingly, the model incorporates GDP per capita as a proxy for the level of economic development and fiscal capacity, GDP growth to capture business cycle effects, and inflation to account for price-level dynamics affecting nominal tax bases. Government expenditure and government debt are included to reflect fiscal policy orientation and sustainability constraints, while trade openness captures the degree of external integration and the relative importance of trade-related tax bases. Finally, the share of industry in GDP is used to proxy the production structure of the economy, as industrial activity is typically associated with higher tax compliance and a broader taxable base. The inclusion of these variables ensures that the estimated effect of exchange rate volatility is interpreted as conditional on a comprehensive macro-fiscal environment rather than as a bivariate relationship.

Model specification can be presented:

$$\begin{aligned} TAXREV_{it} = & \beta_0 + \beta_1 \ln(GDPpc_{it}) + \\ & \beta_2 GDPgrowth_{it} + \beta_3 INF_{it} + \beta_4 GE_{it} + \\ & \beta_5 DEBT_{it} + \beta_6 OPEN_{it} + \beta_7 IND_{it} + \\ & \beta_8 \ln(VOL_{it} + 1) + \gamma_t + \alpha_i + \varepsilon_{it} \quad (5) \end{aligned}$$

where:

i – denotes the countries included in the panel,
 t – denotes time in years,

$TAXREV_{it}$ – tax revenue as a percentage of GDP,

$\ln(GDPpc_{it})$ – log GDP per capita,

$GDPgrowth_{it}$ – annual growth rate,
 INF_{it} – inflation rate,
 GE_{it} – government expenditure as a percentage of GDP,
 $DEBT_{it}$ – government debt as a percentage of GDP,
 $OPEN_{it}$ – trade openness as a percentage of GDP,
 IND_{it} – value added of the industrial sector as a percentage of GDP,
 $ln(VOL_{it} + 1)$ – log transformed exchange rate volatility,
 γ_t – time fixed effects capturing the impact of global shocks,
 α_i – country fixed effects capturing country-specific characteristics,
 ε_{it} – the error term with the Driscoll-Kraay robust standard errors.

3. Empirical results

This section presents the empirical results of the analysis. The discussion proceeds in several steps. First, descriptive statistics are reported to provide an overview of the distributional properties of the variables included in the model. This allows for an initial assessment of variability, asymmetry, and the presence of extreme observations that could affect the stability of the regression estimates. Second, pairwise correlation coefficients are examined to identify potential multicollinearity issues and guide the selection of control variables. Third, formal diagnostic tests are applied to assess multicollinearity, unobserved heterogeneity, serial correlation, and cross-sectional dependence. Finally, the results of the estimated regression models are presented and compared across alternative specifications.

Table 1 Descriptive statistics

Variable	Mean	Median	Max	Min	SD	Skewness	Kurtosis	JB
TAXREXV	19.7	19.7	26.8	14.2	2.4	0.2	2.7	2.1 (0.3)
LnGD Ppc	9.9	9.9	10.8	9.1	0.4	0.05	2.09	6.7 (0.03)
GD P growth	2.6	2.9	13.09	-15.3	3.7	-0.9	6.2	113 (0.0)
INF	3.6	2.5	17.7	-1.6	3.7	1.4	4.7	80.8 (0.0)
GE	41.1	42.8	60.3	28.2	7.1	-0.1	1.9	10.6 (0.0)
DEBT	50.5	51.6	107.3	12.4	20.7	-0.01	1.97	8.3 (0.0)

OP EN	109.6	103.5	186	58	30.1	0.5	2.2	12.7 (0.0)
IND	23.9	24	40.2	11.6	4.6	0.3	4.4	17.9 (0.0)
Ln (VOL + 1)	2.2	2.3	4.0	0.06	0.8	-1.3	5.2	95.1 (0.0)

Source: the authors

Tax revenue exhibits moderate variability with an approximately symmetric distribution, free of extreme values that could undermine the stability of the regression estimates. Specifically, the mean value of tax revenue amounts to 19.75% of GDP, with a standard deviation of 2.44 and a skewness coefficient of 0.22, indicating only mild asymmetry. The kurtosis value of 2.74 is close to that of a normal distribution, while the Jarque–Bera statistic fails to reject the null hypothesis of normality. Government expenditure and government debt display considerable volatility; however, they are retained in their original form due to their analytical relevance. Government expenditure averages 41.08% of GDP with a standard deviation of 7.14, while government debt exhibits a wider dispersion, with a mean of 50.51% of GDP and values ranging from 12.43% to 107.35%. Although both variables deviate from normality, their distributions do not exhibit extreme skewness that would justify exclusion.

GDP per capita and exchange rate volatility were logarithmically transformed in order to reduce skewness and achieve a closer approximation to a normal distribution. Before transformation, GDP per capita showed low variability (standard deviation of 0.39 in logarithmic form) and near-zero skewness (0.05), while its kurtosis value of 2.09 suggested a relatively flat distribution. The relatively low standard deviation of ln(GDPpc) compared to the other variables suggests convergence in income levels among the sample countries over the observed period, although considerable heterogeneity remains in other economic dimensions. In the case of exchange rate volatility, a constant of 1 is added prior to the natural logarithmic transformation. The transformation is applied to mitigate asymmetry and stabilize variance (Wooldridge, 2025), while the addition of the constant allows for the transformation of observations with zero or very low values (Brooks, 2019) without dropping them from the sample. Even after this transformation, ln(VOL+1) exhibits pronounced asymmetry, with a skewness of -1.34 and a kurtosis of 5.19,

reflecting the episodic nature of exchange rate instability in the observed economies.

GDP growth and inflation rates exhibit more pronounced asymmetry, reflecting episodic economic shocks and crisis periods that occurred during the observed timeframe. GDP growth ranges from -15.31% to 13.09% , with a negative skewness (-0.96) and high kurtosis (6.25), while inflation displays a positive skewness (1.36) and an elevated kurtosis (4.69), indicating the presence of extreme observations associated with macroeconomic turbulence. Trade openness and the share of industry in GDP indicate the presence of structural differences among the analyzed economies. Trade openness varies substantially across countries, with values ranging from 58% to 186% of GDP and a standard deviation of 30.16 , while the industrial share of GDP averages 23.90% with a kurtosis of 4.42 , suggesting heterogeneity in production structures. Although certain variables deviate statistically from normality, this does not compromise the validity of the estimates, as Driscoll-Kraay robust standard errors are employed in the fixed-effects panel model, thereby neutralizing the influence of extreme values and ensuring reliable inference. The results of the descriptive statistics indicate that the distribution of the FDI variable is highly skewed and leptokurtic, with the Jarque-Bera test rejecting the null hypothesis of normality and pointing to a frequent occurrence of extreme values. The presence of these extreme observations poses a risk of destabilizing the estimated regression coefficients and generating unreliable standard errors. For this reason, the FDI variable has been excluded from the model.

Table 2 Correlation matrix

	TAX REV	Δ GDP	GDP growth	INF	GE	DEBT	OPEN	IND	Δ VOL
TAX REV	1	0.167	0.026	0.142	0.449	0.283	0.306	0.256	0.225
lnGDPpc	0.167	1	0.050	0.107	0.453	0.298	0.534	0.233	0.286
GDP growth	0.026	-0.050	1	0.156	0.252	0.158	0.056	0.007	0.116
INF	0.142	0.107	0.156	1	0.011	0.126	0.142	0.142	0.002
GE	0.449	0.453	0.252	0.011	1	0.429	0.369	0.136	0.142
DEBT	0.283	0.298	0.158	0.126	0.429	1	0.230	0.259	0.107

OPE N	0.306	0.534	0.056	0.142	0.369	0.230	1	0.033	0.348
IND	0.256	0.251	0.007	0.142	0.136	0.259	0.033	1	0.463
ln VOL	0.225	-0.286	0.116	0.002	0.142	0.107	0.348	0.463	1

Source: the authors

The correlation matrix indicated a high degree of correlation between $\ln_GDPpc$ and variables related to the unemployment rate, the share of agriculture in GDP, and EU membership status. These high correlations reflect fundamental differences in the level of economic development among countries, which lead to potential multicollinearity problems. To avoid multicollinearity issues, variables related to the unemployment rate, the share of agriculture in GDP, and EU membership status were excluded from the model. EU membership status has low within-country variability, which additionally makes it unsuitable for a panel model with fixed effects. $\ln_GDPpc$ was retained as it is a representative indicator of economic development that can potentially have a large impact on tax revenues.

After excluding highly correlated variables, the correlation matrix indicates that multicollinearity is no longer present among the remaining variables, which is further confirmed by the VIF test.

Table 3 VIF test

Variable	VIF
lnGDPpc	2.737758
GDPgrowth	1.205206
INF	1.087314
GE	1.635208
DEBT	1.395872
OPEN	2.524328
IND	1.561306
ln (VOL +1)	2.403338

Source: the authors

Multicollinearity among the independent variables is tested using the Variance Inflation Factor (VIF) test. All obtained values are below the threshold of 5, confirming that there is no issue of severe multicollinearity in the model.

The application of the F-test confirms the joint significance of two-way fixed effects ($F = 12.173$, $p\text{-value} < 2.2e-16$), thereby justifying their inclusion in the model and rejecting the adequacy of the pooled OLS regression, which ignores individual and time-specific effects. The suitability of the fixed-effects (FE) model relative to the random-effects (RE) model is tested using

the Hausman (1978) test. The resulting χ^2 statistic equals 27.257 with a p-value of 0.0005894, confirming that the FE model represents the appropriate specification for the given dataset. In the analysis of tax revenue determinants, a panel dataset covering 10 countries over the period from 2006 to 2024 is employed. As a starting point, a pooled OLS model is estimated to provide an initial overview of the relationships among the variables included in the model; however, this approach ignores unobserved heterogeneity across countries, which may lead to biased estimates (Wooldridge, 2002). To control for time-invariant country-specific characteristics, a fixed-effects model augmented with time fixed effects is applied to account for global shocks. At this stage, a robust specification with standard errors clustered at the country level (clustered SE) is employed. Nevertheless, diagnostic tests indicate the presence of potential econometric issues.

The Wooldridge test for detecting serial correlation ($\chi^2 = 87.147$, p-value < 0.001) and the Pesaran CD test for detecting cross-sectional dependence ($z = -2.747$, p-value = 0.006) confirm that the error terms are not independent either over time or across countries. These results suggest that the initial robust specification with clustered standard errors is insufficient, as it does not address cross-sectional dependence. To resolve these issues, the final model is estimated using the Driscoll-Kraay (1998) approach. This methodology provides consistent estimates that simultaneously account for heteroskedasticity, serial correlation, and cross-sectional dependence (Pesaran, 2004).

Table 4 Applied models

Variable	OLS	Panel FE	FE + Driscoll-Kraay
LnGDPpc	-0.528 (0.652)	-3.056 (2.423)	-3.056** (1.225)
GDPgrowth	0.065 (0.045)	-0.054 (0.055)	-0.054 (0.047)
INF	0.097** (0.043)	-0.124** (0.062)	-0.124 (0.081)
GE	0.127*** (0.027)	-0.069 (0.052)	-0.069 (0.052)
DEBT	0.011 (0.009)	0.027* (0.015)	0.027 (0.019)
OPEN	0.014* (0.008)	-0.028** (0.011)	-0.028* (0.014)
IND	-0.098** (0.042)	-0.067 (0.064)	-0.067 (0.082)
LnVOL	0.019 (0.289)	-3.369*** (1.018)	-3.369*** (1.007)
Constant	119.481*** (6.025)		
Observations	190		
R2	0.299	0.143	
Adjusted R2	0.268	-0.052	
Residual Std. Error	2.088 (df = 181)		
F-stat	9.672***	3.207***	

	(df = 8; 181)	(df = 8; 154)	
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Note: *p<0.1; **p<0.05; ***p<0.01

Source: the authors

The final model results indicate that exchange rate volatility is the most important determinant of tax revenues in the observed countries during the 2006-2024 period. Given that the EXR volatility variable is transformed as $\ln(VOL+1)$, the coefficient of -3.369 represents a semi-elasticity. This means that a 1% increase in $(VOL+1)$ leads to a decrease in the tax revenue-to-GDP ratio of approximately 0.034 percentage points. Since the values of EXR volatility are generally small, a 1% change in $(vol+1)$ behaves almost identically to a 1% change in VOL itself. This allows us to maintain strict mathematical precision without losing the practical economic meaning of the volatility shocks. The log of GDP per capita shows a statistically significant negative effect on tax revenues at the 5% level, with a coefficient of -3.056, implying that a 1% increase in GDP per capita reduces tax revenues by about 3.06 percentage points. Trade openness (OPEN) also exhibits a negative impact on tax revenues with a coefficient of -0.028, significant at the 10% level. Several variables that showed significance in the standard OLS or fixed effects models lost their statistical significance in the final specification. This confirms the importance of applying the Driscoll-Kraay estimator, which eliminates spurious significance caused by spatial dependence and autocorrelation. This method is particularly suitable for panel data with longer time series, as it provides consistent estimates of the covariance matrix (Hoeche, 2007).

4. Discussion

The results indicate that exchange rate volatility weakens fiscal systems by limiting governments' ability to formulate and sustain coherent long-term policies, thereby acting as a strategic constraint on fiscal planning. Stable tax revenues support credible fiscal commitments, continuous public investment, and institutional development, whereas currency instability increases uncertainty and constrains fiscal planning capacity. The empirical results point to a systematic and economically relevant relationship between exchange rate volatility and tax revenue performance in the observed group of European transition economies, highlighting its role as a structural constraint on fiscal capacity. Once unobserved country-specific characteristics,

common time shocks, serial correlation, and cross-sectional dependence are taken into account, exchange rate volatility emerges as a consistently significant factor associated with lower tax revenue ratios. This outcome suggests that fiscal systems in small and open transition economies remain highly exposed to currency instability, even after more than two decades of institutional and structural reforms.

The negative association between exchange rate volatility and tax revenues is in line with a large body of empirical evidence from developing and transition economies. Studies focusing on Sub-Saharan Africa document similar patterns, where exchange rate instability weakens fiscal capacity by disrupting trade flows and narrowing the tax base (Agbeyegbe et al., 2006; Ofori et al., 2021). Comparable results are reported for the Baltic states, where currency volatility has been shown to undermine revenue mobilization despite relatively advanced institutional frameworks (Mirović et al., 2023). The present findings indicate that selected European economies exhibit comparable vulnerabilities, reflecting their openness, exposure to external financing conditions, and incomplete diversification of tax bases.

The magnitude of the estimated coefficient suggests that the fiscal consequences of exchange rate volatility are not merely statistical but economically meaningful. This result supports arguments emphasizing indirect transmission mechanisms, whereby currency instability affects tax revenues through reduced investment, lower trade volumes, and heightened macroeconomic uncertainty. Ofori et al. (2021) highlight trade openness as a key mediating channel, and the observed correlation patterns in this study are consistent with such an interpretation. In highly open economies, volatility in exchange rates may amplify uncertainty in import and export pricing, leading to weaker trade-related tax collection and broader spillover effects on domestic economic activity. The findings differ from those reported for Turkey by Koçak (2021), who identifies a positive short-run effect of exchange rate volatility on tax revenues. The contrast may reflect differences in economic structure, monetary credibility, and tax composition. While short-term nominal valuation effects may temporarily increase revenue from import duties or foreign-currency-denominated transactions, the panel results presented here indicate that, over a longer horizon and across countries, the adverse

effects dominate. This suggests that any short-lived fiscal gains associated with currency depreciation are outweighed by longer-term disruptions to the tax base.

The negative coefficient on GDP per capita deserves particular attention. Although higher income levels are often associated with stronger fiscal capacity, the observed relationship may reflect structural changes accompanying economic development in transition economies. As countries liberalize trade, reduce their reliance on border taxes, and integrate into global markets, tax revenues as a share of GDP may decline during certain stages of development. As economies develop, rising income levels are often accompanied by structural shifts toward services and more internationally integrated activities, which are typically harder to tax and more exposed to profit shifting and tax planning strategies. In addition, improvements in income levels may coincide with the use of tax incentives and preferential regimes aimed at attracting investment, which can weaken the overall tax base. This implies that scale effects of income growth may be offset by compositional and institutional factors associated with structural transformation in transition economies. Similar patterns are discussed by Gnangnon and Brun (2019) and Neog and Gaur (2020), who argue that structural transformation can temporarily weaken measured fiscal performance despite rising income levels. Trade openness also exhibits a negative association with tax revenues in the final specification. This finding aligns with earlier evidence showing that liberalization erodes easily collectible trade taxes and places greater pressure on domestic tax administration (Agbeyegbe et al., 2006). In institutional environments where tax compliance and enforcement remain uneven, the transition toward domestic taxation may result in revenue shortfalls, particularly during periods of external instability. This indicates that, within the sample period, compositional effects of trade liberalization may dominate potential efficiency gains in tax collection associated with greater economic openness.

Several variables that appear significant in simpler model specifications lose their explanatory power once cross-sectional dependence is addressed. This outcome highlights the importance of accounting for common shocks and spillovers in regional panel analyses. As noted by Hoechle (2007), ignoring such dependence may lead to overstated statistical

significance and misleading inferences. The results therefore suggest that exchange rate volatility represents a more robust and persistent determinant of tax revenue performance than conventional macroeconomic indicators such as inflation or short-term growth fluctuations.

Taken together, the findings point to a close interaction between monetary instability and fiscal outcomes. Exchange rate volatility appears to act as fiscal fragility rather than a neutral adjustment mechanism, especially in open, externally exposed economies with evolving institutions, reinforcing its role as a strategic constraint.

Conclusion

This study shows that exchange rate volatility represents a structural constraint on fiscal policy rather than temporary macroeconomic disturbance. Governments in transition economies rely on predictable revenue streams to support institutional development, public investment, and economic convergence. Persistent currency instability weakens these objectives by reducing fiscal predictability and increasing uncertainty in policy planning.

This paper examined the relationship between exchange rate volatility and tax revenue performance in ten European transition economies over the period 2006–2024. Using a fixed-effects panel framework with Driscoll-Kraay standard errors, the analysis shows that exchange rate volatility is systematically associated with lower tax revenues as a share of GDP. The result remains robust after controlling for key macroeconomic, fiscal, and structural factors and after addressing serial correlation and cross-sectional dependence. The evidence indicates that currency instability continues to pose a significant constraint on fiscal capacity in transition economies. Exchange rate volatility affects tax revenues not only through direct valuation effects but also through broader macroeconomic channels that influence trade, investment, and economic confidence. These mechanisms appear to dominate any short-term revenue gains that may arise from nominal exchange rate movements.

The results carry several implications for economic policy. First, they suggest that exchange rate stability has fiscal relevance beyond its traditional role in price stability and external balance. Monetary frameworks that reduce excessive volatility may contribute indirectly to more predictable and sustainable revenue collection. In practical terms, central banks should

prioritize exchange rate stabilization through credible monetary policy frameworks, adequate foreign exchange reserve management, and interventions aimed at limiting excessive short-term currency fluctuations.

Second, the negative association between trade openness and tax revenues points to the importance of strengthening domestic tax systems in liberalized economies. As reliance on trade taxes diminishes, effective value-added taxation, income taxation, and enforcement mechanisms become increasingly important for maintaining fiscal stability. Governments should therefore broaden domestic tax bases, reduce tax exemptions, expand digital tax administration systems, and strengthen tax compliance mechanisms to offset potential revenue losses associated with trade liberalization.

The findings also highlight the need for closer coordination between fiscal and monetary authorities. Exchange rate management, tax policy, and public expenditure planning are closely interconnected, particularly in economies with limited fiscal buffers and high exposure to external shocks. A fragmented policy approach may amplify vulnerability, whereas coordinated macroeconomic management can enhance fiscal resilience. Specifically, governments could consider implementing countercyclical fiscal buffers during periods of exchange rate stability to cushion revenue shortfalls during volatile episodes. Additionally, tax systems could be designed with built-in stabilizers that automatically adjust to exchange rate movements, such as indexation mechanisms or flexible tax brackets. For example, governments may establish fiscal stabilization funds, increase precautionary budget reserves, and develop medium-term revenue forecasting frameworks that explicitly incorporate exchange rate risk. Furthermore, tax authorities should regularly conduct stress-testing exercises to evaluate the potential fiscal impact of major exchange rate shocks.

From a strategic management standpoint, the findings imply that fiscal capacity should be treated as a strategic resource rather than a purely technical outcome of macroeconomic conditions. Exchange rate volatility introduces strategic uncertainty that affects governments' ability to commit credibly to long-term development strategies, public investment programs, and institutional reforms. In this context, revenue predictability becomes a prerequisite for strategic planning, while currency instability constrains

strategic discretion. Effective management of exchange rate risk, combined with resilient tax system design, can therefore enhance the strategic alignment between monetary conditions, fiscal policy, and long-term governance objectives. Policymakers should therefore integrate exchange rate risk assessments into national development strategies, public investment planning, and medium-term fiscal frameworks to improve the consistency and sustainability of long-term policy goals. These findings suggest that exchange rate stability should be considered not only a macroeconomic objective but also a strategic governance instrument that supports effective resource allocation and long-term public sector performance.

An important contribution of this study is the application of an integrated volatility measure that is fully consistent with the annual nature of fiscal outcomes. By aggregating daily GARCH-based conditional variances into an integrated annual indicator, the analysis captures the cumulative exchange rate uncertainty faced by the economy over the fiscal year. This approach provides a conceptually coherent and economically meaningful measure for explaining variations in tax revenues in a panel setting.

Several limitations should be acknowledged. First, the analysis is based on a relatively small cross-section of countries, which may limit the external validity of the results. Second, although the FE framework controls for time-invariant country-specific characteristics, the static nature of the panel model does not fully address potential endogeneity between tax revenues and key macroeconomic variables. Third, the analysis relies on an aggregate measure of exchange rate volatility and does not distinguish between short- and long-run exchange rate movements. Future research could expand the panel by including a larger number of countries and a longer time horizon. In addition, employing dynamic panel estimators would allow for a more rigorous treatment of persistence and endogeneity in tax revenues. Finally, future studies could decompose exchange volatility to better capture the transmission channels between exchange rate volatility and tax revenues.

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Use of Artificial Intelligence (AI) Tools

The following AI tools were used during the preparation of this manuscript: [ChatGPT]. AI was used solely for language editing/grammar checking. All intellectual content, arguments, findings, and conclusions are the sole work of the authors.

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