

Determinants of the VAT Compliance Gap in the European Union: The Role of Shadow Economy and Fiscal Pressure

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Abstract. *A gap exists between the theoretical potential for revenues generated by Value Added Taxes (VAT), as well as actual collected amounts, known collectively as the "Value-Added Tax (VAT) Gap." The VAT Gap is composed of two main types of gaps. First, the Policy Gap represents revenue lost due to purposeful legislative fiscal decisions. Second, the Compliance Gap represents revenue loss stemming from intentional or unintentional failures in taxpayer compliance with tax laws. Most notably, these failures include administrative errors, insolvent businesses, and illegal evasion of taxes which are primarily influenced by shadow economy behaviors. The focus of this research is on determining the factors contributing to the European Union (EU) Member State's VAT Compliance Gap over the years 2013 through 2023. In particular, this research will investigate how informal economic behavior and governing structures produce compliance related revenue shortages as well as examine cross country differences in compliance patterns. Panel Data Regression Models using systematic methods to select models will be used to analyze the data. Comparisons between Fixed Effects and Random Effects specifications will be made based upon variance decomposition patterns which indicate that most shadow economy variations occur at a cross-country level rather than an intra-country level over time. Therefore, this suggests the use of a Random Effects Specification. The results provide evidence of a statistically significant positive relationship between shadow economy and the VAT Gap. Additionally, it was found that increasing standard VAT rates lead to an increase in noncompliance with VAT regulations; therefore, there appears to be some limitation to generating additional revenue via increasing VAT rates. These findings illustrate a considerable degree of cross-country heterogeneity in compliance patterns among EU member states. Furthermore, these findings support previous studies regarding compliance issues with respect to VAT. Overall, the findings suggest that integrated policies designed to reduce shadow economies through increased enforcement capabilities, enhance institutional capacity, develop and implement digital tax administration platforms and*

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create real time e-invoicing platforms can help improve compliance with VAT regulations and improve fiscal sustainability among all EU member states.

Keywords: VAT compliance gap, shadow economy, panel data, European Union, standard VAT rates.

Introduction

One of the main ways for member states to collect public revenue in the European Union and support long-term fiscal sustainability is through Value Added Tax (VAT). Although there has been a considerable amount of effort to create a harmonized system of collecting VAT, the European Union continues to lose a large portion of potential revenue due to non-compliance. The loss of revenue resulting from non-compliance can be represented by the VAT Compliance Gap. The VAT Compliance Gap represents the difference between the theoretical VAT liability if all members of society were compliant with the VAT regulations and the actual amount of revenue collected.

The persistence and heterogeneity of this gap across EU countries suggest that structural economic and institutional factors play a decisive role in shaping tax compliance outcomes.

Some of the variables commonly cited in the literature as contributing to the level of VAT non-compliance include the size and proportion of the shadow economy. The shadow economy refers to unofficial or unreported economic activities that do not follow either legal reporting requirements or official invoicing. As such, informal economic activity will contribute to a reduction in the VAT base. In addition, fiscal pressures, especially those associated with higher statutory VAT rates may cause businesses and consumers to move transactions away from officially reported taxable transactions and toward unofficial or unreportable transactions within the shadow economy.

However, based upon differences in institutional quality across countries, the degree to which these effects occur varies. For example, high levels of effective government can lead to lower levels of evasion, but at the same time led to a shift in the composition of non-compliance among more advanced administrative environments.

This study examines the determinants of the VAT Compliance Gap in the European Union - 27 countries - during the period 2013-2023 and focuses on whether the shadow economy, fiscal pressure and institutional differences across countries explain why some countries face larger problems with VAT non-compliance than others. This study addresses two questions. First, to what extent does the shadow economy impact VAT non-compliance in EU Member States? Second, to what extent is this relationship moderated by government effectiveness?

Two specific hypothesis tests will be conducted: (H1) The shadow economy is positively related to the VAT Compliance Gap; and (H2) Government effectiveness moderates the relationship between the shadow economy and VAT Compliance Gap.

Using a panel data set and applying systematic comparison of pooled OLS, fixed effects, and random effects models, this study controls for informal economic activity's predominantly cross-country character.

Following this introduction, the second part of this paper includes a review of the existing literature on VAT compliance, shadow economy behavior, and institutional influences. The third part describes the methodological choices regarding data source, variable construction, and statistical strategy.

The fourth part summarizes the empirical findings and conducts additional robustness checks. Finally, the fifth part includes conclusions about policy implications, limitations, and suggestions for further research.

Literature review

The literature defines the VAT compliance gap as a key indicator of an efficient tax system in terms of how much the theoretical amount of VAT which would have been collected if all taxpayers were fully compliant with existing rules compared to what is collected by tax authorities. These differences result in significant amounts of lost revenue due to a variety of reasons such as tax fraud; tax evasion; use of tax laws for unintended loophole purposes; insolvent or bankrupt businesses; administrative errors and/or intentional but non-deliberate omission of information (European Commission, 2025)

The two main types of VAT Revenue Losses have been defined as the Compliance Gap and the Policy Gap. The Compliance Gap represents non-compliance with the current Tax Obligations while the Policy Gap includes the revenue lost from policy choices which create a narrower tax base and/or reduce VAT liability on part(s) of the tax base (European Commission, 2025).

The formally defined VAT Compliance Gap is determined by the difference in amount of money between the VAT Total Tax Liability (VTTL) and the actual amount of money that is collected in VAT (European Commission, 2025).

The European Commission uses the Top-Down Consumption Side Approach to estimate its VAT gap; this is recognized internationally as the most accurate method for determining a country's VAT gap. This approach utilizes National Accounts Data along with a Detailed Model of VAT Rules applied to all products/sectors to calculate the VTTL.

The VAT compliance gap in the European Union is influenced by several factors. A study on VAT compliance across EU member states indicates that the main determinants are; the size of the shadow economy, VAT revenues as a percentage of GDP, economic prosperity and press freedom. (Cuceu et al., 2024)

The results from an econometric model indicate that there was a positive correlation between the size of the shadow economy and the VAT compliance gap. Conversely, there was a negative correlation between VAT revenue as a percentage of GDP and the VAT compliance gap. Additionally, an increase in final consumption expenditure of households and non-profit institutions increased the VAT compliance gap. In contrast, an increase in GDP per capita, VAT as a percentage of GDP, and the number of VAT rates decreased the VAT compliance gap (Zídková, 2014).

An important finding in this context is the strong relationship between the shadow economy and VAT compliance. The shadow economy can be regarded as an important barrier to economic development (Tudose & Clipa, 2016). As well as having a direct effect on tax revenues, the shadow economy also impacts upon the efficiency of VAT collection. This trend can clearly be observed in Romania, which has one of the highest levels of shadow economy in Europe. The shadow economy accounted for around 28% of GDP in 2015 (Davidescu et al., 2024). Therefore, its effects on sustainable development indicators such as VAT compliance are very significant.

Shadow economy is an example of many structural barriers that are negatively impacting the collection of Value Added Tax (VAT) by the European Union, as it can be described as all economic activity which remains unrecorded by governments due to reasons related to money, regulations, or institutions (Schneider & Asllani, 2022). Prior studies have estimated the annual loss of VAT revenue driven by the shadow economy to be approximately EUR 132 billion (or roughly 14%) of total collected tax revenue (Frunza, 2017); however, while there may have been some variation in how compliant countries were during this time period, the shadow economy continues to contribute significantly to these gaps. The overall size of the shadow economy has also remained consistent in terms of its contribution to gross domestic product (GDP) throughout

the EU; the average was reported to be approximately 17.3% of each country's GDP in 2022 (Schneider & Asllani, 2022).

The transmission mechanism was classified by Hasíková and Hanousek (2025) as a "negative spillover effect." When agents participate in shadow economy activity, to avoid paying income taxes or labor costs, it can be expected that they will likely also be involved in Value-Added Tax (VAT) non-compliance. Underground transactions have no way of producing an invoice, so when an agent engages in informal economic activities for purposes of avoiding income taxes or labor costs, there is a high probability that the agent will also be involved in VAT non-compliance. Additionally, the empirical data exhibited near unitary elasticity. This means that if the amount of shadow economy transfers increases by one percent, then it is estimated that the amount of VAT non-compliance will nearly equally increase. Finally, Schneider and Buehn (2012) found that the tax burden, including indirect taxation, has been identified as a primary driver, shaping variation in the shadow economy, thus creating a cyclical process whereby the higher the VAT rate, the greater the incentive for individuals to be engaged in the shadow economy and ultimately reduce the tax base.

The MIMIC (Multiple Indicators-Multiple Causes) approach is used as the typical empirical measurement technique, where informality is considered a latent variable (Medina & Schneider, 2018). Zidková (2014) reported that the share of the shadow economy and the standard value-added tax (VAT) rate are positively related to the VAT gap based on an initial analysis. Cuceu et al. (2024) later validated these findings using data from all 27 European Union member states, especially identifying that New Member States from Central and Eastern Europe experience a significantly larger effect than other member states. Balios et al. (2024) found substantial quantitative proof of these differences when they provided general fixed-effect model estimates and further determined that most of this difference was due to less-developed economies. However, Hasíková & Hanousek (2025) showed that while there is indeed a significant but relatively small effect from fraud; many other researchers show different sizes for the effect size of this type of fraud, which indicates that a new assessment is needed (Frunza, 2017).

However, while there have been numerous publications on the subject, the majority of studies have assumed that there was a consistent, linear relationship between the institution environment and tax evasion. Based on Frunza's (2017) classification of fraud into different types, it is argued here that the informal sector does not affect all countries equally. Therefore, this study will test if government effectiveness influences the shadow economy through a moderation term (interaction term) allowing for varying marginal effects of informality over the whole range of institutional qualities within the EU-27.

Theoretical discussions surrounding both VAT Gaps and Tax Revenue are based upon two models: The Collection Efficiency Model and The Laffer Curve. From one side a high percentage of VAT Revenues to Gross Domestic Product (GDP) is seen as a measure of an administration's ability to collect tax revenues voluntarily. A negative relationship has also been demonstrated by Cuceu et al. (2024) between VAT Revenues and the Compliance Gap; i.e. those countries able to produce greater tax revenues (Sweden, Netherlands etc.) appear to have smaller compliance gaps. These relationships have been associated with advanced monitoring systems and digital technologies, as well as IT investment, bureaucratic reduction and other factors. (Ciobanu et al., 2022)

In contrast, the notion of a "limit of bearability" was proposed based upon the Laffer Curve (Guiu, 2024), which asserts that there is an optimal rate at which it will be profitable for all taxpayers to comply with tax laws voluntarily. Beyond this point, when the burden of taxation reaches a certain level, rational actors will move towards evading the tax system to increase their

net profits. Therefore, the relationship may become nonlinear as the higher the VAT standard rate increases beyond this threshold, so too does the incentive for taxpayers to seek shelter within the shadows of the economy (Schneider & Asllani, 2022).

The "Fiscal Exchange Hypothesis" was empirically verified (Hasíková & Hanousek, 2025) to show that societies' willingness to pay taxes is contingent upon how well they perceive the government institutions providing them services to function and control against corruption. The relationship between controlling corruption and the performance of the tax revenues was further supported by empirical studies (Bati, 2025). Finally, a detection bias was demonstrated. Tax administrations that are very efficient can measure both theoretical taxpayer liability and the size of the underground economy much more accurately than less efficient administrations. Consequently, in countries with strong formal systems, the actual VAT gap appears greater because these governments have more accurate data regarding what should exist (Poniatowski et al., 2020).

In those jurisdictions characterized by higher levels of government efficiency, the relationship between the shadow economy and the officially recorded VAT gap will likely be more evident because administrative systems able to efficiently detect and document fraud are capable of recording economic activities that remain hidden in less effective institutions. Emerging markets with lower quality governance tend to have a greater portion of their shadow economy utilized for survival purposes than do mature economies with better quality governance, which has been cited in the literature as being associated with a smaller fiscal effect on governments (Davidescu et al., 2024). Fraud schemes like MTIC scams aim to maximize tax losses through every unit of illegal activity targeted at the VAT system in these types of environments (Poniatowski et al., 2020).

Despite an extensive volume of research in the area surveyed above, there are also two distinct but related limits to the current literature that are addressed in this study. First, almost all of the existing empirical research has assumed a one-to-one, linear correspondence between the Shadow Economy and the VAT Compliance Gap. Consequently, it is often assumed that the effect of informality on the size of the VAT compliance gap is equal across all institutional contexts. However, the type of informal economic activities differs significantly among countries with high levels of governance compared to those with low levels. Second, when researchers have used the Fixed Effects (FE) estimator to estimate their models after obtaining a statistically significant result from a Hausman test for identification purposes, they generally control for between-country variability through including country specific intercept terms. However, given that over 97.3% of the total variance in the Shadow Economy occurs in the cross-section, fixed effects estimation methods essentially remove the major structural source of VAT compliance variations across EU member states. In contrast to previous studies, this study will address these two limitations by using a Random Effects model and adding a moderation interaction term (Shadow $\times$ Government Effectiveness).

Methodology

Theoretical underpinnings have identified links between the informal sector and fiscal non-compliance. To analyze differences across Member States, two hypotheses have been proposed for testing structural heterogeneity.

Hypothesis 1 (H1): The size of the Shadow Economy will positively affect the size of the VAT Compliance Gap. H1 tests the negative spillover mechanism (Hasíková & Hanousek, 2025). By avoiding taxes or social insurance contributions by entering the shadow economy, economic actors cannot issue VAT invoices because this would expose them to being detected. Thus, rather than existing separately from the formal sector, the shadow economy diminishes the size of the formal VAT base. As such, it is anticipated that the positive coefficient of H1 will reflect the near

unit elasticity reported in many previous studies where an increase in one percent of the shadow economy results in a similar proportionate decrease in VAT compliance. These findings also demonstrate empirically that the shadow economy has become a major cause of loss in revenue due to VAT (Balios et al., 2024; Cuceu et al., 2024).

Hypothesis 2 (H2): Institutional Quality (Government Effectiveness) will condition the relationship between Shadow Economy Size and VAT Gap. Although research shows that better institutions tend to lead to lower rates of evasion (Majerová, 2016), the relationship between the shadow economy and the VAT gap suggests there may be large amounts of cross-country variability that may complicate predictions based solely on a linear model. Research has demonstrated that the type of impact of informality can differ significantly depending on whether an economy is developing or is an emerging economy within the EU (Davidescu et al., 2024; Balios et al., 2024). For example, "Black Market Trading" tends to occur in developing countries whereas "Missing Trader Intra-Community" (MTIC) fraud occurs in advanced countries and exploits both their financial infrastructure and high levels of intra-community trade (Frunza, 2017). Therefore, whether institutional quality moderates the effects of the shadow economy on the VAT gap was examined using an interaction term (Shadow x GovEff). This equation form enables an examination of how systematic variations in institutional quality affect the marginal effects of shadow economy size on the VAT gap. Rather than attempting to specify a priori either direction of potential moderation, the interaction terms allow the data to determine whether institutional capacity serves as a buffer against additional losses due to evasion or if it exacerbates those losses. An unbalanced panel dataset for all 27 Member States of the EU (EU-27) for 2013 – 2023 forms the basis for estimating these models. A total of 295 observations were available for use in the analysis since no data existed for Croatia and Cyprus for 2013. Although there were some minor missing values at the beginning of time series data for other Member States, this dataset still had enough degrees of freedom for estimation purposes and provided adequate coverage during early years.

Table 1. Description of variables

Category	Variable Name	Definition	Source
Dependent	VAT Compliance Gap	The difference between the theoretical VAT revenue (VTTL) and the actual VAT revenue collected. Formula: $VAT\ GAP = \frac{VTTL - ACTUAL\ VAT}{VTTL} * 100$	European Commission (2025)
Main independent	Shadow Economy	All economic activities hidden from official authorities for monetary, regulatory, and institutional reasons.	Schneider & Asllani (2022)
Moderator	Government Effectiveness	Measures the quality of public services, civil service independence from political pressure, and the credibility of government commitments.	World Bank (WGI)
Control	VAT Revenues	Actual VAT collected by the government as a share of GDP.	European Commission (2025)
Control	Standard VAT Rate	The statutory VAT rate applied to the majority of goods and services (taxation base).	European Commission (TAXUD)

Source: Authors' own research.

VAT Revenues (% of GDP) is sourced from European Commission 2025, this variable proxies the effective fiscal burden and the reliance of the state on consumption taxes. Standard VAT Rate: Data are obtained from the European Commission's "Taxation Trends in the European

Union". In the empirical model, this variable is also included in its squared form (VAT_Standard_sq) to test for potential non-linear relationships, such as the Laffer curve effect, where excessive rates might discourage compliance. Government Effectiveness: An index sourced from the World Bank's Worldwide Governance Indicators (WGI). This variable measures the quality of public services and the independence of the civil service. Missing values for 2023 were addressed using the Last Observation Carried Forward (LOCF) method. It is used both as a direct control and in an interaction term with the shadow economy (Shadow x GovEff) to test whether institutional quality shapes the impact of informality on tax compliance.

The methodology employs simple and multiple regression modeling using Ordinary Least Squares (OLS) for panel data, alongside Fixed Effects (FE) and Random Effects (RE) models. To ensure the robustness of the empirical findings, rigorous post-estimation diagnostic tests are performed, including the Hausman test. These diagnostics are utilized to assess the consistency of the estimators and to determine the necessity of applying corrections for potential heteroscedasticity or serial correlation (Balios et al., 2024; Cuceu et al., 2024).

The general linear panel data model for N cross-sectional units observed over T time periods is specified as follows:

$$y_{it} = \alpha + X'_{it} \beta + u_{it},$$

where y denotes the dependent variable for cross-sectional unit i ($i = 1, \dots, N$) at time period t ($t = 1, \dots, T$), α is the overall intercept, X represents the $K \times 1$ vector of explanatory variables, β is the corresponding $K \times 1$ vector of slope coefficients to be estimated, and u is the composite error term. The composite error can be decomposed as $u = \mu + \varepsilon$, where μ captures the time-invariant unobserved individual heterogeneity specific to each cross-sectional unit, and ε is the idiosyncratic disturbance that varies across both units and time periods.

The FE estimator treats the individual-specific component μ as a fixed parameter to be estimated for each unit. This specification permits arbitrary correlation between μ and the regressors X , which constitutes the principal advantage of the FE approach (Wooldridge, 2010). The FE model is expressed as:

$$y_{it} = \alpha_i + X'_{it} \beta + \varepsilon_{it},$$

where α_i absorbs the overall intercept together with the unit-specific effect into a single entity-specific intercept. Estimation proceeds via the within transformation, which eliminates the unobserved heterogeneity by subtracting the entity-specific time-averaged values from each observation:

$$(y_{it} - \bar{y}_i) = (X_{it} - \bar{X}_i)' \beta + (\varepsilon_{it} - \bar{\varepsilon}_i).$$

Because α_i doesn't vary within each unit, the demeaning step removes it, and as a result the OLS estimates of β are still consistent, as the strict exogeneity assumption holds $E(\varepsilon | X, \mu) = 0$ (Baltagi, 2021).

The RE estimator treats the individual-specific component μ as a random variable drawn from a probability distribution so the model retains the original specification:

$$y_{it} = \alpha + X'_{it} \beta + \mu_i + \varepsilon_{it},$$

with the distributional assumptions $\mu \sim \text{IID}(0, \sigma_\mu^2)$ and $\varepsilon \sim \text{IID}(0, \sigma_\varepsilon^2)$, where both components are mutually independent. The assumption of the RE model is $E(\mu | X) = 0$, that is, the individual effects are uncorrelated with the explanatory variables (Wooldridge, 2010). Under this assumption, the RE estimator applies a partial demeaning transformation using the quasi-demeaning parameter θ :

$$\theta = 1 - \sqrt{(\sigma_\varepsilon^2 / (T\sigma_\mu^2 + \sigma_\varepsilon^2))}.$$

When $\theta = 0$, the RE estimator reduces to pooled OLS; when $\theta = 1$, it converges to the within (FE) estimator and if the orthogonality condition holds, the RE estimator is more efficient than FE because it exploits both within-unit and between-unit variation in the data (Baltagi, 2021).

The choice between the FE and RE specifications is made using Hausman specification test, under the null hypothesis $H_0: E(\mu | X) = 0$, both FE and RE estimators are consistent, but the RE estimator is efficient, and under the alternative hypothesis $H_1: E(\mu | X) \neq 0$, the FE estimator remains consistent while the RE estimator becomes inconsistent. The test statistic is constructed as:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' [Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})]^{-1} (\hat{\beta}_{FE} - \hat{\beta}_{RE}) \sim \chi^2(K)$$

where the coefficient vectors are obtained from the FE and RE estimations, respectively, $Var(\cdot)$ denotes the estimated variance-covariance matrices of the respective estimators, and K is the number of time-varying regressors. The test statistic follows a chi-squared distribution with K degrees of freedom under the null hypothesis and a statistically significant test statistic (p-value < 0.05) leads to the rejection of H_0 , indicating that the RE assumptions are violated and that the FE estimator should be preferred (Hausman, 1978; Baltagi, 2021).

The final set of control variables was chosen to provide the maximum explanatory power while still maintaining diagnostic requirements, so the candidate models were required to hold the primary regressor at a significance level (p-value < 0.05), then all regressors' Variance Inflation Factor should not exceed 10.

$$VAT_{GAP_{it}} = \beta_0 + \beta_1 Shadow_{it} + \beta_2 VATRev_{it} + \beta_3 VATrate^2 + \beta_4 (Shadow \times GovEff)_{it} + \varepsilon_{it},$$

where $VAT_{GAP_{it}}$ represents the VAT compliance gap for country i in year t , β_0 represents the intercept term, β_1 through β_4 capture the coefficients of the explanatory variables, ε_{it} represents the error term. The fixed effects specification extends the pooled OLS model by allowing for unobserved country-specific heterogeneity through the inclusion of an individual intercept term α_i , which captures time-invariant characteristics specific to each country.

$$VAT_{GAP_{it}} = \alpha_i + \beta_1 Shadow_{it} + \beta_2 VATRev_{it} + \beta_3 VATrate^2 + \beta_4 (Shadow \times GovEff)_{it} + \mu_{it} + \varepsilon_{it}$$

In the random effects model, the unobserved country-specific effect μ_i is treated as random and uncorrelated with the explanatory variables and the composite error term is made up from the individual-specific effect μ_i and the idiosyncratic error ε_{it} .

$$VAT_{GAP_{it}} = \beta_0 + \beta_1 Shadow_{it} + \beta_2 VATRev_{it} + \beta_3 VATrate^2 + \beta_4 (Shadow \times GovEff)_{it} + \mu_{it} + \varepsilon_{it}$$

Results and discussions

After the overview, the analysis looks at how the variables are related and how informality and institutional settings interact to affect tax compliance, interpreting through the literature and highlighting their theoretical meaning and practical relevance.

Table 2. Descriptive statistics

Variable	Mean	Median	Max	Min	Std Dev	Skewness	Kurtosis	Jarque Bera	Prob	Obs
VAT Compliance Gap	12.21	10.10	40.58	-3.23	8.50	1.01	0.42	52.72	0.000	295
Shadow Economy	17.97	17.90	33.93	6.10	6.93	0.12	-1.10	15.78	0.000	297
VAT Revenue Perc GDP	7.84	7.69	13.43	3.34	1.61	0.67	2.05	74.49	0.000	297
VAT Standard_sq	469.49	441.00	729.00	225.00	104.73	0.50	-0.16	12.83	0.002	297
Shadow x GovEff	15.50	16.09	34.27	-8.98	7.57	-0.61	0.68	24.32	0.000	297

Source: Authors' own research.

Summary statistics for the variables included in the final model are presented in Table 2. The VAT compliance gap was averaged at 12.21% (SD = 8.50%) with an overall range of -3.23% to 40.58%. The size of the shadow economy in terms of percentage of GDP was averaged at 17.97% (SD = 6.93%), with a total range of 6.10% to 33.93%. VAT revenue percentages were averaged at 7.84% of GDP (SD = 1.61%). Cross country variations are very limited regarding the statutory standard VAT rate, as well as the narrow band of statutory rates that are permissible by EU's harmonization requirements. The interaction term Shadow $\times$ GovEff displays negative skewness (-0.61) which illustrates the inverse cross sectional relationship between informality and institutional quality.

Figure 1 shows country-specific median compliance gaps for all member states during 2013–2023. Countries like Sweden and Luxembourg have median compliance gaps less than 5%, while countries such as Romania and Greece have median compliance gaps greater than 20%. The majority of Northern and Western European countries illustrate low levels of compliance gap, however, a number of Central and Eastern European Member States also exhibit high compliance gaps. These outlier countries were Belgium, Spain and Ireland. All three of these outlier countries experienced one year with an atypical level of compliance which was likely attributed to either changes in how data was measured or policy interventions affecting the data. Box widths vary considerably across countries: Romania, Greece, Lithuania and Poland display relatively wide boxes indicating a bigger sensitivity to business cycle fluctuations and policy changes, while Sweden, Netherlands and Austria show narrow boxes reflecting stable compliance performance over time.

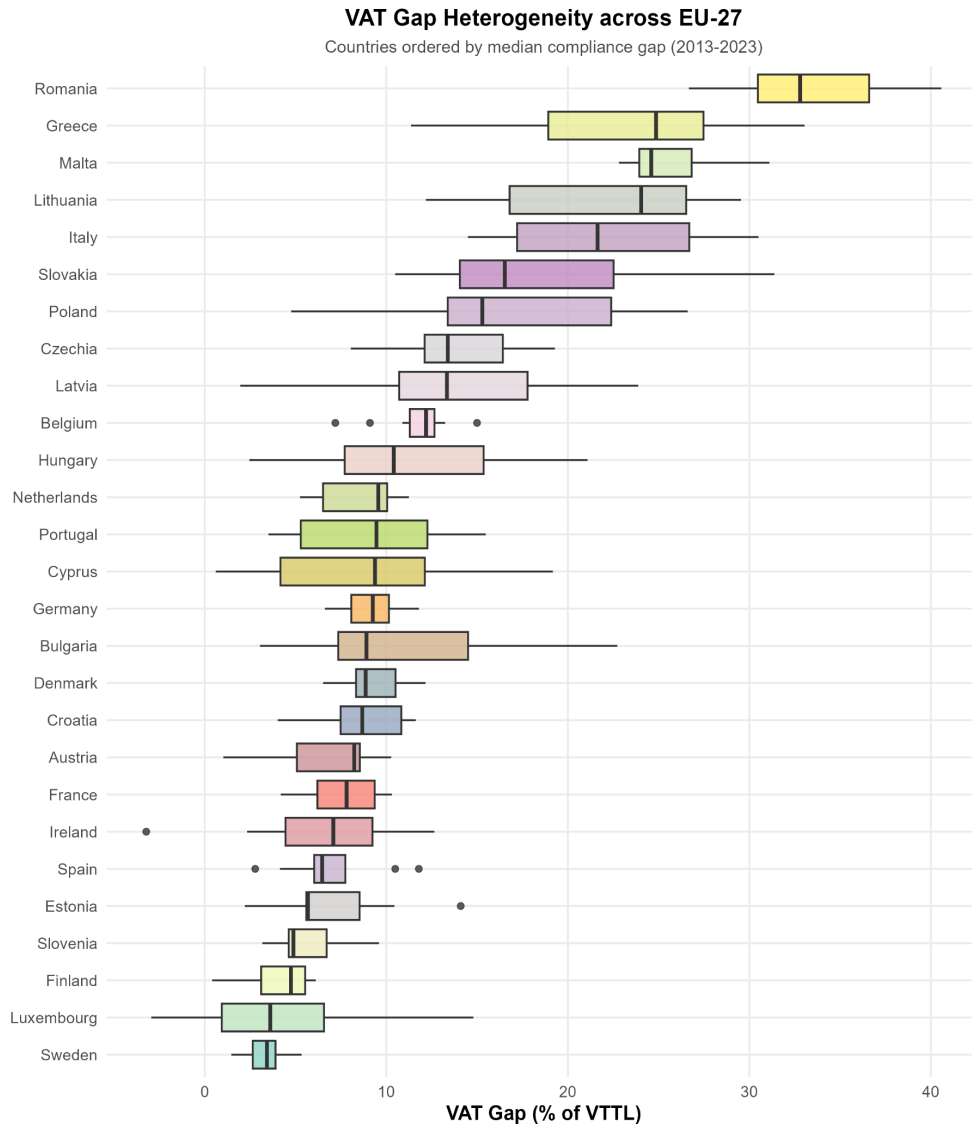


Figure 1. VAT Gap heterogeneity across EU-27

Source: Authors' own research.

The univariate regressions in Table 3 show that the shadow economy is the main predictor, explaining approximately 20% of VAT Gap variance ($R^2 = 0.198$, $\beta = 0.547$, $p < 0.01$) and in isolation the positive direction is theoretically grounded and remains into the multivariate specifications. The Standard VAT Rate yields a weakly significant negative coefficient, a counter-intuitive sign that warrants a different interpretation so without controls, the effect of fiscal pressure is masked by omitted structural conditions, producing a sign that reverses in the multivariate models. VAT Revenues are negatively associated with the compliance gap, consistent with prior expectations. Together these baselines confirm that the determinants of non-compliance interact in ways that require a multivariate framework.

Table 3. Univariate Regression Models

Variable	(1)	(2)	(3)	(4)
Shadow Economy	0.547***	–	–	–
	(0.064)			
VAT Revenue (% GDP)	–	-1.282***	–	–
		(0.303)		
VAT Standard ²	–	–	-0.009 *	–
			(0.005)	
Shadow × Gov Eff	–	–	–	-0.353***
				(0.063)
R ²	0.198	0.058	0.012	0.097
Adjusted R ²	0.193	0.051	0.005	0.091
N observations	295	295	295	295

Source: Authors' own research.

Table 4 presents the pooled OLS estimates where all four regressors are significant at the standard significance level ($p=0.05$) and the shadow Economy has a positive coefficient, confirming that the informal sector acts as a brake on public revenue collection, consistent with previous studies (Zídková, 2014; Frunza, 2017) and the VAT Revenues have a negative coefficient, and the squared VAT rate a positive one consistent with a Laffer curve effect so the interaction term Shadow × Government Effectiveness is negative, in a cross-sectional OLS framework, governance attenuates the shadow economy's impact on the compliance gap but this estimate is biased by uncontrolled country heterogeneity.

Table 4. OLS Model

Independent Variable	Coefficient	Std. Error	<i>p</i> -value
Intercept	18.652***	(2.255)	<0.001
Shadow Economy (% GDP)	0.729***	(0.061)	<0.001
VAT Revenue (% GDP)	-2.605***	(0.304)	<0.001
VAT Standard Rate ²	0.008*	(0.004)	0.057
Shadow x Gov Effectiveness	-0.189***	(0.052)	<0.001
R ²	0.422		
Adjusted R ²	0.412		
F-statistic	53.015		
F-statistic Probability	0.000		
Observations	295		

Source: Authors' own research.

The RE model in Table 5 shows similar results for the main independent variables, with Shadow Economy and VAT Revenues preserving their signs and significance, the squared VAT rate coefficient is larger, reinforcing the non-linear rate effect and the interaction term reverses sign from negative to positive.

Table 5. Random Effects Model (RE)

Independent Variable	Coefficient	Std. Error	p-value
Intercept	16.286***	(4.840)	0.001
Shadow Economy (% GDP)	0.742***	(0.126)	<0.001
VAT Revenue (% GDP)	-4.430***	(0.486)	<0.001
VAT Standard Rate ²	0.031***	(0.009)	<0.001
Shadow × Gov Effectiveness	0.184**	(0.072)	0.011
R ² Overall	0.307		
R ² Within	0.298		
R ² Between	0.272		
F-statistic	128.722		
Observations	295		

Source: Authors' own research.

The FE model in Table 6 shows that the Shadow Economy loses statistical significance. VAT Revenues remain robustly negative, and the squared VAT rate remains positive, consistent with the Laffer curve hypothesis (Guiu, 2024). The interaction term is positive and larger than in the RE model. This disappearance shows the FE estimator's limitation with quasi-time-invariant variables.

Table 6. Fixed Effects Model (FE)

Independent Variable	Coefficient	Std. Error	p-value
Shadow Economy (% GDP)	0.284	(0.205)	0.167
VAT Revenue (% GDP)	-5.439***	(0.591)	<0.001
VAT Standard Rate ²	0.042***	(0.012)	<0.001
Shadow x Gov Effectiveness	0.323***	(0.085)	<0.001
R ² Within	0.266		
R ² Between	0.008		
F-statistic	34.129		
Observations	295		

Source: Authors' own research.

Table 7 shows how the three methods are related, the coefficient for the shadow economy is always statistically and economically significant, but in FE it becomes non-significant due to the nature of the variance of the variables in the model. The majority of the variation in the shadow economy occurs on a cross-section basis rather than over time, thus the FE method captures this structural information by absorbing it into each countries specific intercept terms. This leaves little to no within country variation with which to measure the coefficients. Thus, the RE method is the most appropriate way to test H1, given its ability to exploit both between and within variation and is prioritized over the Hausman recommendation (Cuceu et al., 2024).

The interaction term between government effectiveness and the shadow economy is negative in OLS ($\beta = -0.189$) however in both panel estimators the effect is positive (RE: $\beta = 0.184$; FE: $\beta = 0.323$). The reason for the difference between OLS and panel estimators is that OLS does not control for country-specific omitted variables. Therefore, there is an omitted variable bias in the estimation, where there is a spurious relationship created through a cross-sectional correlation of high levels of governance and lower levels of compliance gaps. Thus, in well-governed economies, cash-based evasion will be reduced significantly and replaced by higher impact fraud, such as MTIC fraud. These types of schemes produce large VAT losses relative to informal economic activity (Frunza, 2017) Therefore, institutional efficiency produces a filter that eliminates petty forms of evasion, while allowing more severe forms of evasion to persist.

The VAT Revenue coefficient remains strongly negative across all specifications. However, when comparing the results from OLS and panel estimators, it can be seen that the magnitude of the effect is almost doubled in panel estimators, with estimates ranging from approximately -4.4 to -5.4, versus approximately -2.6 in OLS. This suggests that cross-sectional regressions underestimate the contribution of collection efficiency to compliance gap reduction.

Table 7. Comparison between OLS, RE, FE

Variable	Pooled OLS	Random Effects	Fixed Effects
Intercept	18.652***	16.286***	—
	(2.255)	(4.840)	
Shadow Economy	0.729***	0.742***	0.284
	(0.061)	(0.126)	(0.205)
VAT Revenue (% GDP)	-2.605***	-4.430***	-5.439***
	(0.304)	(0.486)	(0.591)
VAT Standard ²	0.008*	0.031***	0.042***
	(0.004)	(0.009)	(0.012)
Shadow x Gov Eff	-0.189***	0.184**	0.323***
	(0.052)	(0.072)	(0.085)
R ² (Overall/within)	0.422	0.307	0.266
Observations	295	295	295

Source: Authors' own research.

The possible violation of typical Panel Data Assumptions is addressed through Robust Standard Error Corrections. In addition to Heteroscedasticity and Temporal Dependence, the Driscoll-Kraay standard errors (Driscoll & Kraay, 1998), for the Fixed Effects (FE) and Random Effects (RE) Models can correct for Arbitrary Cross-Sectional and Temporal Dependence. Additionally, Cluster-Robust Standard Errors, at the Country Level are used in the Pooled OLS Specification, in order to capture Within-Country Correlation over Time Periods. Regardless of Heteroscedasticity, Autocorrelation, or Cross-Sectional Dependence, the Diagnostic Tests confirm the Valid Statistical Inference, since the Breusch-Pagan Test indicates Heteroscedasticity; the Breusch-Godfrey Test identifies Serial Correlation; and the Pesaran CD Test identifies Cross-Sectional Dependence in the Panel Specifications. However, the Main Coefficients remain Statistically Significant after applying these Corrections, which supports the Robustness of the findings listed in Table 8.

Table 8. Diagnostic tests

Diagnostic Test	Pooled OLS	Random Effects	Fixed Effects
1. Heteroscedasticity (Breusch-Pagan)	<i>p</i> -value <0.001	<i>p</i> -value <0.001	<i>p</i> -value <0.001
2. Autocorrelation (Breusch-Godfrey)	<i>p</i> -value <0.001	<i>p</i> -value <0.001	<i>p</i> -value <0.001
3. Cross-sect Dependence (Pesaran CD)	-	CD = 14.14	CD = 12.20
4. Multicollinearity (VIF max)	VIF = 1.63	VIF = 1.63	VIF = 1.63
5. Normality (Jarque-Bera)	<i>p</i> -value = 0.1867	<i>p</i> -value = 0.0002	<i>p</i> -value = 0.0009

Source: Authors' own research.

The F-test rejects homogeneity across countries ($p < 0.001$); the Breusch-Pagan test also identified non-zero variance among country-specific effects ($p < .001$). These results reject the appropriateness of using pooled least squares regression. The Hausman test also preferred fixed effect estimation over random effects ($p < .001$), although this finding was considered to be a limitation of the study. Fixed-effect estimation eliminated 97.3 percent of the structural variance from the primary variable; hence, fixed-effect estimation did not allow identification of the major hypothesis tested in the paper. In accordance with recommendations made by both Bell and Jones (2015) and Bartels (2008) the Random Effects model will be used to estimate the model because the majority of the variance of the primary variable is attributable to cross-section variations. Moreover, Driscoll-Kraay Robust Standard Errors will be applied to correct for any possible violation(s) to the assumptions underlying panel regression analysis (i.e., serial correlation, cross-sectional dependence and/or heteroscedasticity) (Baltagi, 2008; Wooldridge, 2010).

Although the Hausman test result is acknowledged, it is viewed within the context of the characteristics of the sample. Bartels (2008) and Bell & Jones (2015) have demonstrated that Random Effects is generally preferable to Fixed-Effects models when the researcher is interested in identifying cross-sectional structural differences rather than unit-specific changes through time. Although the failure to pass the Hausman test may be due in part to a well-known flaw of this test in detecting small correlations as statistically significant at high values of N , it does not imply an endogeneity problem that renders Random Effects estimates nonsensical (Wooldridge, 2010). Using Driscoll-Kraay Robust Standard Errors provides with additional protection against a

principal source of error related to using Random Effects, namely the potential for cross-sectional dependence, heteroscedasticity and/or serial correlation. Consequently, while interpreting coefficients as representing conditional correlations and not causal estimates of relationships (as explained below in the Limitations section).

Table 9: Model specification tests

Test	Statistics	<i>p</i> -value
F-test	F = 25.864 (df=26, 264)	<0.001
LM test (Breusch-Pagan)	$\chi^2 = 534.392$ (df=1)	<0.001
Hausman test	$\chi^2 = 33.719$ (df=4)	<0.001

Source: Authors' own research.

Both hypotheses receive empirical support, though the nature of that support differs in instructive ways.

The results of this research support Hypothesis 1 and are generally consistent with the existing body of research on the relationship between tax compliance and the shadow economy. The relationship between the VAT compliance gap and the shadow economy yields a near-unit elasticity in the RE specification. In other words, as the amount of shadow economy activity increases, so too does the amount of tax lost due to evasion of VAT. As noted by Hasíková & Hanousek (2025) and others, including Zidková (2014); Frunza (2017) and Balios et al. (2024), this finding supports a long-held understanding among researchers that the informal economy is the largest single cause of losses to governments in terms of taxes owed through the VAT. The lack of statistical significance found in the Fixed Effects specification for the shadow economy variable suggests an estimation constraint for cross-sectionally dominant variables, as established in the model selection discussion above, rather than an absence of economic causality.

H2 is similarly confirmed by the evidence. However, unlike previous research (Majerová, 2016), the estimated interaction terms show that stronger institutions do not always act as a uniform buffer against the fiscal consequences of shadow activities. In countries where government bureaucracies have sufficient administrative capability, petty cash-based evasion may be replaced by higher value evasion that has significant adverse effects on public finances. This represents a similar interpretation to the typology distinguishing between low value black market trade in developing economies versus medium-high value MTIC type fraud in developed economies (Frunza, 2017); and consistent with the positive (though statistically insignificant) Government Effectiveness coefficients found in Hasíková and Hanousek's (2025) baseline FE models. Collectively, these findings indicate that strong institutions will suppress evasion by increasing the moral and institutional costs of evasion (Hasíková & Hanousek, 2025). On the other hand, improved administrative efficiency appears to reconfigure evasion patterns without eliminating them.

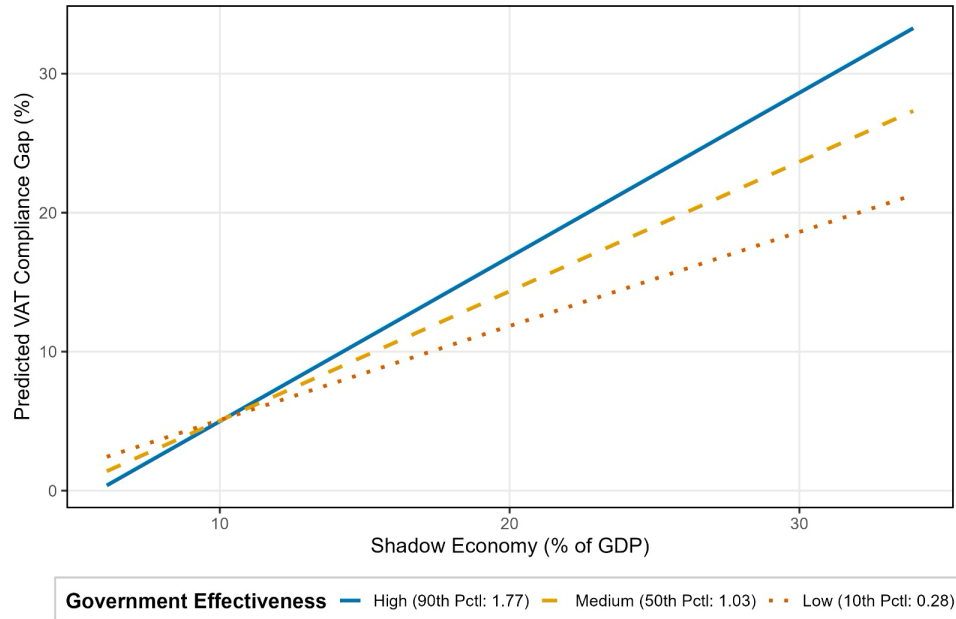


Figure 2. Marginal effects of shadow economy on VAT compliance gap by government effectiveness level

Source: Authors' own research.

Figure 2 represents the estimated marginal effects of the shadow economy on the VAT compliance gap under three different institutional regimes based on the Random Effects model where all other control variables are set equal to their sample means. The three solid black lines illustrate the relationship between the shadow economy and the VAT compliance gap at low (10th percentile, GovEff = .28), medium (50th percentile, GovEff = 1.03), and high (90th percentile, GovEff = 1.77) levels of government effectiveness. In each case, the relationship is positive; however, the slope of the relationship becomes steeper as institutional quality increases, which is consistent with the positive interaction term of 0.184 from the RE model. The observed gradient supports the filter mechanism mentioned above. That is, in countries characterized by high-quality institutions, sophisticated evasion strategies yield significantly greater VAT losses per unit of informal economic activity than would be anticipated in countries characterized by lower quality institutions.

To make this interaction effect more concrete, consider the following marginal effects interpretation anchored to sample means. In the RE model, the marginal effect of the shadow economy on the VAT compliance gap is given by:

$$\frac{\partial VAT\ Gap}{\partial Shadow\ Economy} = 0.742 + 0.184 \times Government\ Effectiveness$$

Therefore, the fiscal impact associated with an equivalent-sized shadow economy is greater in high-governance environments than in low-governance environments. For example, when using the sample mean for Government Effectiveness (WGI Scale value = ~0.69), this results in a marginal effect estimate of ~0.87 percentage point of GDP per one percent increase in shadow economy size. When considering a country at the 25th percentile of governance (GovEff ~0.22), the marginal effect estimate decreases to ~0.70. Conversely, when estimating the marginal effect

for a country at the 75th percentile of governance (GovEff ~ 1.44), the marginal effect increases to ~ 1.01 . These estimates provide evidence supporting the idea that as institutional quality increases, so does the fiscal impact associated with an equivalently sized shadow economy, consistent with the complexity filter mechanism discussed above.

Conclusion

This paper assesses the influence of several structural factors on the VAT Non-Compliance Gap based on a 10-year panel data set of all 27 EU countries from 2013 to 2023. A multivariate analysis model is used to assess how the shadow economy, macroeconomic environment, and institutional quality affect the level of non-VAT compliance. Empirical results confirm the first hypothesis; i.e., the size of the shadow economy has a strong, highly significant, and predominant effect on VAT loss. The elasticity of VAT loss to the shadow economy is nearly unitary, suggesting that the shadow economy reduces the size of the VAT base at a rate that is close to one-to-one, thereby confirming the negative spill-over effects among the formal and informal economies.

A second key contribution of this study is the identification of the regulatory function of institutional quality. While past studies show that high-quality governmental institutions can reduce evasion, they do not demonstrate whether such institutions also alter the effect of informality on VAT loss. The static panel models reveal a statistically significant and positive coefficient on the interaction term between government effectiveness and informality. That is, when there is good governmental performance, the additional increase in informality produces larger increases in VAT loss. The results demonstrate that methodological differences in the estimation approach produce large differences in estimated parameters. For example, mechanically selecting the fixed-effect (FE) model removes 97.3% of the cross-sectional variance of the shadow economy's structural impacts, justifying the random-effects (RE) model. As a result, the use of an RE model provides estimates of informality's magnitude across a wide range of fiscal cultures. The results have important policy implications. Closing the VAT Compliance Gap will require a dual policy strategy: addressing the size of the shadow economy, while strengthening institutions. These recommendations apply directly to EU country policies toward both developing their economy and enhancing their governance capacity, because these two are the most important system-wide influences on the VAT gap (Pastusiak et al., 2022). Governments can pursue a dual strategy to formalize informal businesses, including lowering taxes, streamlining tax codes, and decreasing compliance burdens, which would encourage informal firms to register formally and operate transparently (Wijaya & Surbakti, 2024; Bati, 2025). Beginning with the tax collection process itself, developing a modern and efficient tax administration system by implementing digital technologies is critical. There are numerous ways to develop a modernized tax administration system including utilizing Artificial Intelligence ("AI") and Big Data analysis to analyze taxpayer activity during an audit. Modernization of the tax administration systems also includes the implementation of fully-integrated digital platforms and payment options that encourage taxpayers to utilize non-cash transaction methods instead of relying upon cash-based transactions (Guiu, 2024; Balios et al., 2024; Schneider & Asllani, 2022). Additionally, there will be a need to create a transnational legislation that will allow for multi-state audits so that all member states can work together to address international MTIC-type fraud networks and other international fraud schemes (Balios et al., 2024). In many cases, countries with well-developed administrative environments can eliminate minor levels of evasion while leaving larger-scale cross border schemes intact.

The above-mentioned panel study has various methodological limitations that prevent the causal interpretation of the findings. One limitation is the issue of "simultaneity" where the

relationship between the shadow economy and VAT gap creates simultaneity issues. Larger shadow economies result in reduced formal taxable income, increased compliance gaps, while higher VAT gaps lead to additional incentives to migrate into the informal sector. Due to this bidirectional causality relationship, it is likely that the coefficients estimated will represent associations rather than definitive causal relationships. Therefore, without some form of exogenous shock to the size of the shadow economy (i.e. some type of natural experiment or some type of unrelated policy reform), establishing causal direction remains impossible.

Measurement errors further complicate issues with estimating the shadow economy. Estimates of the shadow economy are based on both MIMIC Models and Currency Demand Approaches (Schneider & Asllani, 2022) that rely upon Indirect Inference methods and thus include a high degree of uncertainty. A classical measurement error would bias the coefficients towards zero and could be an explanation of the statistically insignificant fixed effects. The fact that the shadow economy has 97.3 percent variance across countries and almost no variance within countries creates concern regarding potential omission of time invariant confounding variables (i.e., tax culture or historical institutions). The contrast between the significant Random Effects (RE) and the statistically insignificant Fixed Effects (FE) estimates is consistent with quasi-time-invariant predictor; however, it does raise the question of whether the estimated correlations represent causal relationships or simply cross-national differences due to omitted variables.

Despite these issues, the interaction term between shadow economy and government effectiveness has lower risk of confounding by levels compared to main effect estimates, since it identifies how relationships vary with institutional quality as opposed to providing unconditional effect estimates. Therefore, the associations identified between shadow economies and VAT gap are to be interpreted as conditional correlations. Thus, while the results demonstrate that countries with larger informal sectors generally tend to experience greater revenue loss from VAT gaps, they do not shed light on whether the relationship is spurious, causal or reciprocal. Further research incorporating instrument variables, quasi-experiments, or microdata may help establish stronger causal links.

The previous section identified several limitations of this study, which represent avenues for further development. An immediate area where the methodology of this study could be improved upon involves integration of new estimation techniques and/or measurements. Specifically, using total energy consumption as an alternative proxy for the size of the shadow economy could alleviate some of the concerns associated with sensitivity of selecting a particular set of variables in MIMIC models (Achim et al., 2024). Additionally, applying a dynamic panel estimator such as GMM to examine bidirectional causality in this context could yield a more robust statistical approach (Bati, 2025).

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