The Influence of the Shadow Economy and Corruption on Public Debt in European Union Countries pre and post Covid-19

Asmaa El-Naser
"Transilvania" University of Brasov, Romania
asmaa.el-naser@unitbv.ro

Abstract

This study aims to analyze the influence of the shadow economy and corruption on public debt in EU countries pre- and post-COVID-19, during 2003-2021, focusing on the challenges arising from recovery efforts after the COVID-19 pandemic. Using the GMM model, the results indicate that the informal economy has a negative impact on public debt in most models, while corruption increases the accumulation of debt. GDP per capita also negatively impacts debt, while unemployment rates are positively associated with an increase in debt due to social expenditures. Inflation and investment negatively impact debt, while population growth and trade exhibit complex effects. The study recommends stimulating the transition to the formal economy, improving transparency and combating corruption, enhancing economic growth, controlling inflation, supporting public investment, and promoting international trade to address public debt challenges.

Key words: informal economy, corruption, public debt, GDP, GMM model
J.E.L. classification: H63, E62, O11, D73, O52

1. Introduction

In the wake of the recent economic crisis, countries worldwide have witnessed a notable upsurge in their public debt levels particularly following the global economic crisis of 2008. This trend is especially pronounced among advanced nations. It is essential to highlight, as pointed out by a referee, that the considerable increase in public debt, particularly after the 2007/08 crisis, can be largely attributed to the nationalization of private debt. Several countries, such as Japan, Greece, and Italy, have surpassed a debt ratio of 1.0. This persistent growth in public debt has raised serious concerns about fiscal sustainability and its potential impact on the economy. Scholars like Reinhart and Rogoff (2010) have suggested a recommended threshold for public debt, emphasizing the need for countries to stay below it to avoid the risk of default. The concerns surrounding the rapid escalation of public debt levels likely stem from the perceived potential for adverse effects on economic growth. Given that governments strive for sustainable growth as a primary objective, researchers have shown keen interest in studying public debt levels and their consequences on diverse economies. Researchers arguably consider public debt a necessary condition for achieving sustainable growth (Kim et al., 2017).

In recent decades, countries, both developed and developing, have been contending with significant challenges arising from public debt and the shadow economy. The expansion of the shadow economy, which encompasses unreported employment, production, and exchange activities beyond government oversight, has become a pressing concern for policymakers due to its impact on macroeconomic stability (Schneider, 2000:81).

Despite efforts and notable difficulties in curbing its growth, the shadow economy remains an emerging issue of high priority for policymakers. This concealed sector continues to constitute a substantial and expanding portion of global economic activity. Alongside this, public debt poses another critical challenge that compounds the complexities faced by governments. Regardless of a country's developmental stage, most nations have experienced the consequences of their borrowing policies. This is particularly true in transition countries, where fragile market structures contribute to volatile economic performance. The repayment of public debt and the subsequent rise in

government spending further magnify the dimensions of this problem, especially in underperforming economies.

Corruption represents one of the most serious challenges facing economic development and financial stability in countries. Corruption is defined as the exploitation of public authority for personal gain, and it is a phenomenon that affects various aspects of political, social, and economic life. In the economic context, public debt is considered one of the areas most affected by corruption, as it leads to increased financial burdens on countries due to the mismanagement of resources and their waste on ineffective projects or their exploitation for the benefit of individuals or narrow groups. The relationship between corruption and public debt manifests in several forms, including unjustified increases in government spending, decreased efficiency in collecting public revenues, and higher borrowing costs due to deteriorating confidence in the economy. Additionally, corruption hinders investment and reduces economic growth, which in turn exacerbates the public debt problem and weakens countries' ability to meet their financial obligations and achieve fiscal sustainability.

While there is a substantial amount of research exploring the relationship between the shadow economy, corruption, and public debt, a significant deficiency persists in the literature regarding European Union (EU) nations. Insufficient research persists regarding the impact of the shadow economy and corruption on public debt within EU nations, which exhibit markedly diverse political, economic, and institutional frameworks. Furthermore, the evolving landscape of the EU, particularly in light of recent developments such as the economic impacts of the COVID-19 pandemic, highlights the necessity for additional inquiry to deepen our comprehension of the specific mechanisms by which the shadow economy and corruption may affect public debt levels in EU nations. Therefore, it is essential to conduct further empirical studies to address this research gap and yield meaningful insights into the complex interplay between the shadow economy, corruption, and public debt within the context of the EU.

This paper seeks to explore the influence of the shadow economy and corruption on public debt within EU nations, beginning with the subsequent pivotal question: How do the shadow economy and corruption influence public debt within the member states of the European Union? The objective is to measure the impact of the shadow economy on the growth of public debt while considering the diverse economic resilience and governance structures within the EU. Furthermore, the research examines the influence of corruption in intensifying public debt, especially in periods of increased economic pressure. The research aims to offer empirical insights and policy recommendations, thereby guiding policymakers in devising effective strategies to tackle these challenges and promote sustainable economic recovery and governance integrity throughout EU member states.

2. Literature review

Research indicates the substantial and interrelated impacts of the shadow economy and corruption on public debt levels in EU nations. Empirical evidence indicates that both factors contribute to rising public debt, with the shadow economy exerting a more significant influence than corruption, as evidenced in Spain (Gonzalez-Fernandez and González-Velasco, 2014). Analysis across various countries indicates that corruption amplifies the effects of government expenditure and the shadow economy on debt levels (Cooray et al., 2017). The financial systems of the EU influence net receiver countries, which typically exhibit weaker incentives to tackle shadow economic activities than net contributors. This disparity negatively impacts public revenues and debt management (Herwartz and Theilen, 2013).

In transition economies within the EU, the relationship between corruption and public debt demonstrates a bidirectional causal link, wherein enhanced governance and diminished corruption correspond with improved fiscal outcomes (Ozturk, 2021).

In African nations, both factors exhibit a positive and significant correlation with increasing public debt, with causality indicating their role as drivers (Owusu-Nantwi and Owusu-Nantwi, 2021).

In Arab countries, corruption exacerbates debt in low-democracy contexts, with larger shadow economies enhancing this impact (Baklouti and Boujelbene, 2021). The shadow economy

exacerbates the negative effects of corruption on public debt, suggesting a complementary relationship between these elements (Dumitrescu et al., 2021).

In recent decades, there has been an increasing focus among researchers and scholars on the study of the shadow economy. Several studies have concentrated on measuring its extent across various countries and regions, demonstrating the significance of this research interest (Giles, 1999; Schneider, 2005; Orviská et al., 2006; Tafenau et al., 2010). This field of research has received heightened focus owing to the substantial effects the underground economy exerts on the public finances of a country or region. A comprehensive analysis of the shadow economy allows authorities to implement suitable economic policies, thereby mitigating potential distortions.

Theoretical research has examined the causes and consequences of the underground economy (Schneider and Enste, 2000). The underground economy influences public finances through its effects on both expenditure and revenue. The shadow economy adversely impacts public finances by diminishing tax revenues and requiring supplementary measures to offset the revenue deficit. This may lead to a transition from the formal to the informal sector, exacerbating public finances (Arrazola et al., 2011). The underground economy can result in misguided expansionary policies stemming from distorted indicators, including the underestimation of GDP and the overestimation of unemployment. Moreover, an expansion of the informal economy results in increased social transfers, subsequently raising levels of public expenditure. The shadow economy has a dual detrimental effect on a nation's public finances by diminishing revenues and artificially increasing expenditures. This belief underscores the role of the underground economy in exacerbating the decline of public finances (Yereli et al., 2007), with a primary effect on debt levels. Authorities need to understand the dynamics of the informal economy and develop suitable public policies to mitigate debt and improve revenue. Marcos and Carmen (2014) identified a significant positive correlation between the size of the shadow economy and regional public debt. Moreover, misaligned tax policies and inadequate governance linked to the expansion of the shadow economy lead to ineffective debt management, especially within currency unions where common monetary frameworks exacerbate vulnerabilities (Prinz and Beck, 2012).

The influence of corruption on public debt differs according to economic development, with advanced economies experiencing more significant increases due to their larger fiscal structures and greater dependence on institutional governance (Benfratello et al., 2018). Poor governance and ineffective tax administration exacerbate the impact of corruption, with studies indicating that mitigating corruption may reduce public debt by as much as 2% in certain OECD nations (Monte and Pennacchio, 2020). Corruption imposes direct costs on borrowing by negatively affecting bond ratings and increasing interest premiums, which ultimately jeopardizes fiscal sustainability (Depken and Lafountain, 2006). Corruption continues to be a widespread issue globally (Goel and Nelson, 2010). The media presents numerous corruption stories daily, which are intensified by the ongoing financial crisis.

Transparency International, the entity that generates a prominent corruption index, characterizes corruption as the misuse of entrusted power for individual benefit. A different definition describes it as the misuse of public authority for personal gain, bypassing established regulations (Jain, 2001). Addressing corruption necessitates a thorough comprehension of its fundamental causes (Dong and Torgler, 2011).

The literature includes studies examining corruption and its determinants. Treisman (2000) analyzes the factors that contribute to corruption in detail. His arguments suggest that the extent of corruption is contingent upon the equilibrium between the costs incurred from participating in corrupt activities and the benefits obtained from such actions. The costs encompass social and psychological factors, including culture and religion, alongside the risks associated with punishment or detection, reflecting the deterrent effect. Benefits correlate with national characteristics, including the extent of government intervention and the degree of political stability. Public expenditure serves as an economic indicator frequently linked to corruption. Del Monte and Papagni (2007) analyze the factors influencing corruption across 20 Italian regions from 1963 to 2001, employing the incidence of crimes against public administration as an indicator of corruption.

The findings indicate that government expenditure and regional development levels affect the prevalence of corruption, in addition to cultural and political factors. Mauro (1998) analyzes public expenditure components utilizing diverse country samples and data sourced from other researchers. The findings indicate that corruption is associated with decreased education expenditure in the analyzed countries. Mauro posits that specific categories of public expenditure are more vulnerable to illegal rents and bribery, particularly highlighting technology-intensive items as especially prone to these offenses.

Benfratello et al. (2015) found that public sector corruption is associated with rising government debt. The effect varies across income-related sample splits, being more pronounced in advanced economies and less significant in less-developed countries. Yasmin (2021) identified a positive correlation between corruption and the accumulation of public debt in Asian and African nations, noting that this correlation is more pronounced in the African region. The research emphasizes the moderating effect of institutional quality on the relationship between corruption and debt. Existing literature has examined the relationship between corruption in the public sector and public debt through multiple studies. Elgin and Uras (2013) include variables related to corruption in their examination of the shadow economy and public debt. The study specifically incorporates indicators for corruption control and bureaucratic quality. The findings indicate a notable positive correlation between institutional quality and levels of public debt. They similarly observe an inverse relationship between debt levels and corruption control.

An extensive body of literature examines the factors influencing public debt, starting with Barro (1979). Barro's research, under the assumption of a benevolent government and utilizing a tax-smoothing framework, suggested that governments manage budget surpluses and deficits to mitigate sudden fluctuations in tax rates. This viewpoint indicates that the accumulation of public debt is primarily influenced by political and institutional factors. This perspective posits that public debt is a consequence of political dynamics (Alesina and Perotti, 1994). Battaglini and Coate (2008) proposed an alternative political economy theory of fiscal policy, emphasizing that policy decisions are determined by a legislature instead of a benevolent planner. This framework posits that if corruption increases the value of public goods, it will lead to a rise in debt, taxes, and public expenditure on goods and services.

Additional research has identified corruption as a major factor contributing to elevated public debt levels. Corruption manifests in multiple forms, resulting in diminished economic growth and heightened public debt. It enables individuals to access resources from central and local governments, leading to the distribution of public resources to those proficient in obtaining them rather than to the most capable entrepreneurs. This subsequently increases the cost of business operations and diminishes the effectiveness of business decisions. Tanzi and Davoodi (2002) asserted that corruption hinders growth by obstructing the development of small- and medium-sized enterprises, which has significant implications for public finances. Entrepreneurs are required to allocate time to engage in bribery, hindering the complete realization of the growth potential inherent in these enterprises.

3. Reasearch methodology

This study examines the influence of the shadow economy and corruption on public debt in EU countries, characterized by varied political, economic, and institutional contexts that have yet to be thoroughly analyzed. This study emphasizes the necessity of understanding the specific mechanisms by which the shadow economy and corruption affect public debt levels, particularly in light of the evolving context of the EU and significant events such as the COVID-19 pandemic.

The analysis utilizes the Generalized Method of Moments (GMM) and encompasses data from 27 EU member states: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden, covering the period from 2003 to 2021. This study employs the GMM framework established by Nguyen, T.A.N., and Nguyen, K.M. (2022) to analyze public debt as the dependent variable. The independent variables considered are the shadow economy, corruption, GDP per capita, gross fixed capital formation, population growth, trade openness, inflation, and unemployment rates.

Table 1 delineates the variables included in our model, along with their acronyms, units, and data sources utilized to elucidate the correlation between shadow economy, corruption, and public debt.

Table no 1. The variables that were utilized in the model

Name of Variables	Abbreviation	Unit	Source
Dependent variables			
Public debt	DEBT	%GDP	Eurostat 2003-2021
Independent variables			
Shadow Economy	SE	%GDP	European Parliament 2003-2021
Corruption	CPI	Score	Transparency International 2003-2021
Gross domestic product per capita	GDP	constant 2015 US$	World Bank 2003-2021
Unemployment rate	U	% the labor force	Eurostat 2003-2021
Inflation rate	INF	%Average Consumer Price	Eurostat 2003-2021
Gross fixed capital formation	GCF	%GDP	Eurostat 2003-2021
Population growth	POP	%Annual	World Bank 2003-2021
Openness of trade	TRD	%GDP	World Bank 2003-2021

Source: processed by author

The effect of public debt and institutional quality on economic growth has been analyzed by looking at the following model:

$$DEBT_{it} = \beta_0 + \beta_1 SE_{it} + \beta_2 CPI_{it} + \beta_3 GPD_{it} + \beta_4 U_{it} + \beta_5 INF_{it} + \beta_6 GCF_{it} + \beta_7 POP_{it} + \beta_8 TRD_{it} + \varepsilon_{it}$$

In the regression equation, *DEBT* is the public debt-to-GDP ratio, and the subscripts I and t represent the number of the countries and periods covered for the study respectively (I= 1-27 and t= 2003-2021). *SE* corresponds to the estimation of the shadow economy; *CPI* is the approximation of Corruption; *GDP* is – a proxy used for economic growth; *U* is the unemployment rate and *INF* is the inflation rate. *GCF* is the gross fixed capital formation is a percentage of GDP- a proxy for the investment in physical capital. POP is the population growth, TRD is the trade as a percentage of GDP and ε_{it} is the random variable.

This study examines the Shadow Economy (SE), defined as the regional value of the informal sector, positing a direct relationship between the volume of the shadow economy and public debt (Nguyen, T.A.N. and Nguyen, K.M., 2022). Corruption Perceptions Index (CPI) published by Transparency International. The corruption estimate ranges from 0 (totally corrupt) to 10 (not corrupt). Cooray et al. (2017) found that higher levels of corruption and a larger shadow economy contribute to an increase in public debt.

The regression analysis utilizes GDP per capita growth as a metric to evaluate the impact of economic growth on public debt.

Imran (2016) posits that enhanced economic growth leads to increased domestic revenue, thereby diminishing the necessity for borrowing. (U) represents the unemployment rate as indicated by the data. Unemployment leads to an increase in government spending on social benefits such as unemployment benefits, while at the same time, it reduces tax revenues due to the decrease in the number of workers and their incomes. This leads to an exacerbation of the budget deficit and an increase in public debt (Jahoda and Godarová, 2016).

The inflation rate (INF) is utilized to assess its effect on public debt. According to Imran (2016), rising inflation reduces the value of debt by offsetting increases in interest rates. Gross fixed capital formation (GCF) encompasses all types of investment in physical capital, including land improvements, equipment, and machinery acquisitions, construction of infrastructure such as roads and railways, and the establishment of educational and healthcare facilities, as well as residential and industrial buildings. It is frequently utilized as an indicator of the level of investment in physical capital within growth literature.

Law and Singh (2014), along with Belguith and Omrane (2017), indicate that gross fixed capital formation exerts a negative and significant influence on public debt. The population growth rate (POP) denotes the rate of increase in the number of individuals within a population. Jalles (2011) discusses population growth, indicating that in aging societies, it exacerbates the burden on public finances through increased health, pension, and social costs, which in turn contributes to elevated public debt levels (Ihori et al., 2006).

The trade-to-GDP ratio (TRD) reflects the significance of international trade within a nation, calculated by dividing the total monetary value of imports and exports by GDP over a specified period, usually one year. Furthermore, openness may diminish the efficacy of fiscal spending through its interaction with public debt levels, indicating that economies with high openness could encounter limitations in utilizing debt for economic stimulation (Deskar-Škrbić & Šimović, 2017). This study utilizes dynamic panel GMM estimators as proposed by Arellano and Bond (1991) and further developed by Blundell and Bond (1998). This technique is chosen for its capacity to tackle the concurrent presence of bias and country-specific effects.

Table 2 presents the essential descriptors of the variables utilized across all EU27 countries from a statistical viewpoint.

Table no 2. Descriptive statistics EU27 countries

Variable	Obs	Mean	Std. dev.	Min	Max
DEBT	621	59.92	35.70	3.8	212.4
SE	540	19.46	7.25	6.1	35.9
CPI	615	33.96	30.47	2.6	92
GDP	621	2.32	4.04	-14.46	23.30
U	621	8.68	4.44	1.9	27.5
INF	621	2.88	3.67	-1.7	45.7
GCF	621	22.28	4.18	10.68	54.27
POP	621	0.2150	0.9027	-6.18	3.93
TRD	621	121.1	64.07	14.23	388.1

Source: processed by author

Table 2 presents descriptive statistics for a set of economic variables for the 27 EU member states, reflecting significant disparities in economic and political performance across these countries. The average public debt (*DEBT*) is 59.92% of the GDP with a significant standard deviation, indicating a notable disparity in debt levels among the countries. The average size of the shadow economy (*SE*) is 19.46%, reflecting the scale of informal activities in the economy. The Corruption Perception Index (*CPI*) indicates a wide variation in the level of corruption, with an average of 33.96. Economic growth (*GDP*) shows an average of 2.32%, with significant variation between countries, while the unemployment rate (*U*) averages 8.68%. Inflation (*INF*) has an average of 2.88%, reflecting relative stability. Gross Capital Formation (*GCF*) averages 22.28% of GDP, and population growth (POP) shows slight changes with an average of 0.2150%. Finally, trade (*TRD*) records an average of 121.1% of GDP, reflecting varying levels of trade openness among countries.

4. Findings

Table 3 shows the correlation matrixes of the whole EU region, Public debt (*DEBT*) shows a positive correlation with the corruption index (*CPI*) at (0.2026), indicating that higher levels of debt may be associated with higher levels of corruption. In contrast, public debt is negatively correlated with the shadow economy (SE) (-0.1276), which means that countries with high debt may rely less on the informal economy. GDP per capita (*GDP*) is negatively correlated with public debt (-0.2549) and the shadow economy (-0.2055), reflecting that higher output may coincide with reduced debt and informal economies. The unemployment rate (*U*) is positively correlated with public debt (0.3203) and the shadow economy (0.2762), indicating that unemployment increases reliance on debt and the informal economy. Inflation (*INF*) shows a positive correlation with GDP (0.1923) and a negative correlation with corruption (-0.1915).

As for trade (*TRD*) and investment (*GCF*), they are negatively correlated with public debt (-0.2723 and -0.4790 respectively), indicating that high debt may limit business and investment activity. Population growth (*POP*) is positively correlated with trade (0.4015) and negatively with GDP (-0.2570). The results reflect a complex interaction between economic and social variables.

This study utilized three modeling approaches for statistical analysis: Pooled OLS, Random Effects Model (REM), and Generalized Method of Moments (GMM). These methods are frequently employed in the analysis of panel data. Each model has limitations; therefore, the panel-corrected standard errors model (PCSE) was selected for all 27 EU countries due to its advantages in addressing potential heteroscedasticity and autocorrelation issues in the data.

The analysis for all 27 European countries commenced with a Pooled OLS utilizing data from 2003 to 2021.

The Breusch-Pagan/Cook-Weinsberg and White tests were employed to evaluate heteroskedasticity in the sampled data. The test yielded a *p-value* of 0.0813 and 0.0000, respectively.

The OLS model is appropriate; however, the data exhibits indications of heteroskedasticity. The multicollinearity assessment, utilizing variance inflation factors, yields an average of 1.42 across all variables, with no individual values exceeding 5. Consequently, the dataset exhibits no multicollinearity.

The Breusch and Pagan Lagrangian test for random effects in the panel yields a *p-value* of 0.0000, indicating that the use of the Random Effects Model (REM) is preferable to Pooled ordinary Least Squares (Pooled OLS) in this sample. REM demonstrates a random variation across countries, with unobserved variables being uncorrelated with the independent variables.

The Hausman test was applied to the data set to evaluate the superior fit between Random Effects Model (REM) and Fixed Effects Model (FEM). The *p-value* indicates that the REM model is a better fit, as it is 0.7044, which exceeds the threshold of 0.05. The data underwent testing with the Wooldridge and Pesaran tests, yielding a *p-value* of 0.0000 (indicating autocorrelation) and 0.404 (indicating no cross-dependency), respectively. Thus, the panel data exhibits evidence of autocorrelation and cross-dependency.

The Ramsey RESET test for robustness indicates a *p-value* of 0.0000, which is less than 0.05. To address the previous issue, panel-corrected standard errors (PCSE) were employed, as the number of observations exceeded the period.

The GMM model was subsequently employed.

According to Table 4, we noticed that in most models, the shadow economy (*SE*) shows a negative impact on public debt, as the shadow economy reduces debt, except for the GMM model which shows a positive impact. This may indicate the indirect effects of the COVID-19 pandemic on increasing governments' reliance on public debt due to the slowdown of the informal economy.

The Corruption Perception Index (*CPI*) shows a positive effect in almost all models, indicating that corruption can increase public debt, as a lack of transparency may lead to the accumulation of debt. In contrast, GDP per capita (*GDP*) is negatively correlated with debt in most models, meaning that countries with higher output tend to reduce public debt. However, the GMM model shows a very significant effect (-1.4845), which may be a result of the negative economic impacts caused by the COVID-19 pandemic.

The unemployment rate (*U)* shows a positive effect in most models, reflecting that an increase in unemployment may lead to an increase in public debt due to rising social expenditures, except in the GMM model where it shows a weak negative effect.

Inflation (*INF*) has a negative impact in all models, meaning that inflation may reduce public debt in some cases due to the erosion of currency value.

Investment (*GCF*) also shows a negative impact on public debt in all models, indicating that increased investments may reduce the need for borrowing.

Population growth (*POP*) shows a complex effect: in some models, it is positively correlated with public debt, while in others, it shows a negative effect, reflecting the economic challenges resulting from an increasing population.

Finally, trade (*TRD*) shows a negative impact in some models, indicating that an increase in trade may lead to a reduction in public debt, while the GMM model shows a positive impact, which may be due to the pandemic's effects on international trade activities.

Table no. 3 Correlation matrix EU27

	DEB	SE	CPI	GDP	U	INF	GCF	POP	TRD
DEBT	1.0000								
SE	-0.1276***	1.0000							
CPI	0.2026***	-0.4090***	1.0000						
GDP	-0.2549***	0.2055***	-0.0772**	1.0000					
U	0.3203***	0.2762***	-0.1434***	-0.0663*	1.0000				
INF	-0.1298***	0.1779***	-0.1915***	0.1923***	-0.1249***	1.0000			
Trd	-0.2723***	-0.1730***	0.2269***	0.1028**	-0.3229***	-0.0240*	1.0000		
Gcf	-0.4790***	0.0664*	-0.2055***	0.2448***	-0.3030***	0.1910***	-0.0313*	1.0000	
Pop	0.0083*	-0.4835***	0.1367***	-0.2570***	-0.3366***	-0.1750***	0.4015***	0.0329*	1.0000

Source: processed by author

Table no 4. P-values indicating the statistical significance of the analyzed variables

Dependent variable DEBT				
Independent variables	**Pooled OLS**	**REM**	**PCSE**	**GMM**
SE	-0.5109*** (0.2163)	-1.2576*** (0.2905)	-0.3565* (0.2254)	0.5037*** (0.3271)
CPI	0.1674*** (0.0456)	0.1721*** (0.0.0229)	0.0628*** (0.0206)	-0.0571*** (0.0197)
GDP	-0.1933* (0.3280)	-0.2510** (0.1256)	-0.3370*** (0.0731)	-1.4845*** (0.0507)
U	1.9941*** (0.3442)	1.3316*** (0.1787)	1.5693*** (0.2853)	-0.4833* (0.2590)
INF	-0.0936* (0.4570)	-0.0426* (0.1771)	-0.1741* (0.1287)	-0.5813*** (0.2235)
GCF	-3.2369*** (0.3274)	-1.3851*** (0.1671)	-0.3733*** (0.1711)	-0.6111*** (0.2318)
POP	4.7864*** (1.7822)	-8.0918*** (0.9082)	-1.5055*** (0.6076)	-9.8855*** (3.2137)
TRD	-0.1755*** (0.0222)	0.0433* (0.0307)	-0.0502*** (0.0253)	0.0836* (0.0457)
_cons	141.09 (10.51)	-95.80 (9.31)	68.83 (7.19)	8.86 (13.61)
Obs.	540	540	540	540
Prop	0.0000	0.0000	0.0000	0.000
F-statistic	46.65	Wald chi2(8) = 821.45	Wald chi2(8)= 149.24	Wald chi2(9)= 17359.36
R-squared	0.4128	0.2022	0.3394	
Sargan test				0.002
Hansen test				0.114

Source: processed by author

5. Discussion

The empirical results of our study provide useful insights into the shadow economy and corruption affecting public debt in EU countries, especially in light of the ongoing challenges related to post-pandemic recovery efforts.

Current research showed that the informal economy (SE) has a negative impact on public debt in most models, indicating that reducing the informal economy could lower debt levels. However, the GMM model results show a positive impact, which may reflect the indirect effects of the COVID-19 pandemic on increasing government reliance on public debt due to the slowdown of the informal sector. This observation aligns with the findings of the study by González-Fernández and González-Velasco (2014), which found that the informal economy negatively affects public debt in most cases, although the indirect effects of the pandemic may explain this discrepancy.

The positive relationship between corruption and public debt, as shown in the Corruption Perception Index (CPI), aligns with the study by Kuri et al. (2017), which demonstrated that corruption enhances the impact of government spending and the informal economy on debt accumulation. Herwartz and Thielen (2013) argued that net revenue beneficiary countries in the European Union face weaker incentives to combat informal activities, which exacerbates public debt due to lower revenues.

The negative relationship between GDP per capita and public debt in most models means that countries with higher economic productivity tend to reduce public debt, supported by previous studies such as Ozturk (2021), where higher productivity alleviates financial pressures. Conversely, the unemployment rate (U) shows a positive effect on public debt, which aligns with the findings of Owusu-Nantwi and Owusu-Nantwi (2021), who found that an increase in unemployment leads to higher social expenditures, and consequently, an increase in public debt. The negative impact of inflation (INF) on public debt aligns with the theory that inflation erodes the value of debt, which is also supported by the study by Marcus and Carmen. (2014). Investment (GCF) also shows a negative impact on public debt in all models, which aligns with studies indicating that increased investments reduce the need for borrowing (Arazola et al., 2011).

Moreover, the complex relationship between population growth (POP) and public debt, with varying effects across models, reflects the economic challenges highlighted by Benferatillo et al. (2015), where demographic changes can exacerbate or alleviate financial burdens. Finally, trade (TRD) shows a negative impact on public debt in some models, which aligns with the findings of Dumitrescu et al. (2021), who noted that increased trade can reduce financial pressure. However, the GMM model shows a positive impact, which may be a result of the pandemic's effects on international business activities.

6. Conclusions and policy implication

The empirical results of our study provide useful insights into the shadow economy and corruption affecting public debt in EU countries, especially in light of the ongoing challenges related to post-pandemic recovery efforts. According to our results, we noticed that in most models, the shadow economy (*SE*) shows a negative impact on public debt, as the shadow economy reduces debt, except for the GMM model which shows a positive impact. This may indicate the indirect effects of the COVID-19 pandemic on increasing governments' reliance on public debt due to the slowdown of the informal economy.

The Corruption Perception Index (*CPI*) shows a positive effect in almost all models, indicating that corruption can increase public debt, as a lack of transparency may lead to the accumulation of debt. In contrast, GDP per capita (*GDP*) is negatively correlated with debt in most models, meaning that countries with higher output tend to reduce public debt. However, the GMM model shows a very significant effect, which may be a result of the negative economic impacts caused by the COVID-19 pandemic.

This study presents several recommendations for policymakers in EU countries to tackle the challenges of public debt, particularly in the context of post-COVID-19 recovery.

Efforts must be intensified to diminish the informal economy, as findings suggest that curtailing informal activities could aid in reducing public debt levels. The pandemic has adversely affected the informal economy; however, enhancing policies that promote the transition to the formal economy could potentially decrease the necessity for public borrowing. Furthermore, enhancements in transparency and anti-corruption measures are necessary, as the study findings indicate that corruption contributes to the rise in public debt accumulation. Institutional reforms and improved financial oversight may mitigate this impact.

Economic policies must prioritize the stimulation of economic growth, given the negative correlation between per capita GDP and public debt. Addressing unemployment issues is essential, as they contribute to increased social expenditures and rising debts. This can be achieved through the adoption of policies aimed at enhancing the labor market and stimulating investment.

Maintaining control over inflation levels is crucial, as the study indicates that inflation can mitigate debt by diminishing the value of currency. Also, public investment in productive sectors warrants support, as the study indicates that such investment diminishes the necessity for public

borrowing. Economic policies must consider the impacts of population growth and trade on public debt, emphasizing the enhancement of international trade and the improvement of economic efficiency to tackle the challenges posed by population growth.

7. References

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