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Impact of Digitalization on the Shadow Economy and the Budget Deficit - An Exploratory Analysis of EU Member Countries

Abstract. *The paper examines the relationship between the digitalization of public administration, the shadow economy, and the budget deficit, using panel data for a group of 24 European Union Member States over the period 2003–2022. Digitalization is captured through the E-Government Development Index (EGDI), which reflects the level of development of digital public services, ICT infrastructure, and human capital readiness. The empirical analysis is conducted in two stages. In the first stage, fixed-effects panel models are estimated, allowing for the control of unobserved and time-invariant heterogeneity effects across countries. In the second stage, we used unconditional quantile regression with fixed effects to capture potential heterogeneous effects of digitalization across the distribution of the shadow economy and the budget deficit. The results indicate a significant relationship between the level of digitalization and the size of the shadow economy, as well as important differences depending on countries' positions within the distribution of the shadow economy. In the case of the budget deficit, the relationship with digitalization appears less pronounced and dependent on the macroeconomic context. The conclusions show that the digitalization of public administration is a relevant factor in the analysis of the shadow economy, with implications for the design of public policies to strengthen governance and fiscal performance.*

Keywords: *shadow economy, fiscal balance, digitalization, quantile regression.*

JEL Classification: H26, H62, O33.

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1. Introduction

In recent decades, contemporary economies have known profound structural transformations under the accelerated impact of digitalization, shaping the transition from the “new economy” to what the specialized literature increasingly refers to as the smart economy. This emerging stage is characterized by the extensive integration of advanced digital technologies, such as Big Data analytics, artificial intelligence, automated algorithms, and interconnected smart devices, into economic, administrative, and institutional processes, with significant effects on allocative efficiency, transparency, and the capacity for economic governance. In this context, digitalization is no longer the only driver of economic growth or technological innovation, but increasingly becomes an important public policy tool, with direct implications for the functioning of the state, particularly with regard to tax administration and the sustainability of public finances. By increasing transaction traceability, automating administrative processes, and reducing informational asymmetries, digitalization has the potential to limit the scale of the shadow economy and strengthen the tax base, thereby influencing the level of budgetary revenues and the dynamics of the budget deficit.

To monitor the structural progress associated with the digitalization process, a series of composite indicators have been developed, used both in international comparative analysis and in the formulation of public policies. Among these, the Digital Economy and Society Index (DESI) and the E-Government Development Index (EGDI) are particularly relevant. The DESI index primarily captures the level of digital infrastructure and the penetration of digital technology use in the private sector, structured around dimensions such as connectivity, human capital, use of digital services, and the integration of technology in business activities. By contrast, the EGDI index assesses the level of digital governance development, focusing on the quality and availability of digital public services, supporting infrastructure, and the population’s capacity to access and use these services.

From the perspective of analyzing the impact of digitalization on the shadow economy and the budget deficit, the choice of the digitalization indicator is important. Although DESI provides a synthetic overview of economic digitalization, it is relatively limited in assessing administrative efficiency, particularly fiscal and budgetary efficiency. In this regard, EGDI is more appropriate for the purpose of the analysis, as it is centered on public administration, including the institutional mechanisms through which digitalization can support to reduce the shadow economy, increase tax compliance, and, implicitly and mitigate the budget deficit. Moreover, EGDI benefits from a high degree of methodological harmonization and long time data availability, which makes it suitable for an econometric panel analysis.

The shadow economy remains a complex phenomenon with profound economic and social implications, being associated with significant losses of fiscal revenues,

distortions in market functioning, erosion of tax bases, and a weakening of the state's capacity to finance public goods and services. At the same time, persistent budget deficits constrain the room for maneuver in fiscal policy and may amplify macroeconomic vulnerabilities, especially during periods of economic uncertainty and budgetary strain.

Within this framework, the paper aims to investigate the relationship between digitalization, the shadow economy, and the budget deficit for a group of 24 Member States of the European Union over the period 2003–2022. The contributions of the study are manifold. First, the paper provides an integrated analysis of the relationship between digitalization, the shadow economy, and the budget deficit, going beyond the fragmented approaches existing in the specialized literature. Second, digitalization is captured through the EGDI index, which is widely used in the international literature to assess digital governance, thereby enhancing the robustness and relevance of the analysis. Last but not least, from a methodological perspective, the study employs fixed-effects panel regressions, complemented by unconditional quantile regressions with fixed effects, allowing for the identification of heterogeneous effects of digitalization across the distribution of the shadow economy and the budget deficit.

The structure of the article is as follows: the next section presents the theoretical framework and the review of the specialized literature, followed by a description of the data and the methodology employed; subsequently, the empirical results are presented and discussed, and the final section formulates the conclusions and public policy recommendations.

2. Literature Review

State-of-the-art defines the shadow economy as the set of economic activities deliberately developed outside the legal framework, with the purpose of avoiding taxation and compliance with existing regulations (Schneider & Enste, 2000, 2002; Schneider & Williams, 2013). This general approach emphasizes the structural nature of the shadow economy and its direct relevance for the fiscal performance of the state. From a methodological perspective, the difficulties associated with the collection of direct data have led to the widespread use of indirect estimation methods, the most commonly employed being the MIMIC (Multiple Indicators, Multiple Causes) approach, which allows for the harmonization and international comparability of shadow economy estimates (Schneider et al., 2010; Medina & Schneider, 2018).

Several contributions (Tanzi, 1999; Schneider & Buehn, 2017) highlight the persistent and cyclical character of the shadow economy, particularly in contexts marked by institutional, administrative, and fiscal deficiencies. Empirical analyses of the determinants of this phenomenon emphasize the role of the tax burden, labor market rigidities, and, in particular, the quality of institutions. Comparative studies conducted on large country samples indicate that the shadow economy remains a persistent phenomenon, even during periods of economic expansion, and that its

variation between advanced and emerging economies is largely explained by differences in institutional quality, governance, and administrative capacity (Elgin & Öztunali, 2012; Medina & Schneider, 2018; IMF, 2019).

This perspective is reinforced by institutional approaches to fiscal performance and state functioning (North, 1990; Acemoglu & Robinson, 2012), which show that revenue collection levels and the size of the shadow economy are not determined exclusively by the level of economic development, but also by the state's capacity to design, implement, and enforce effective rules. Within this theoretical framework, the digitalization of public administration can be interpreted as a mechanism for strengthening institutional capacity, through which the state enhances its monitoring, control, and fiscal-budgetary administration functions.

The literature review regarding the digitalization in the governmental domain emphasizes the dimension of institutional transformation, highlighting the potential of digital technologies to simplify interactions between the state and taxpayers, reduce bureaucracy, and increase the transparency of administrative processes (Heeks, 2006; Dunleavy et al., 2006; Margetts & Dunleavy, 2013). In this context, the literature provides a clear distinction between the indicators used to capture the dimension of digitalization: DESI, which is primarily oriented toward competitiveness and general digital transformation, and EGDI, which explicitly captures the availability of online public services, digital infrastructure, and the human capital required for their use (United Nations, 2022, 2024). As mentioned earlier, this distinction is important for the objective of the present study, as the analysis focuses on the impact of digitalization on the shadow economy and the budget deficit. The use of EGDI is justified both by its explicit orientation toward the digital capacity of the state, as the main channel through which tax compliance and the reduction of the shadow economy can be influenced, and by the methodological advantages associated with data availability and comparability (Heeks, 2006; Keen & Slemrod, 2017; Okunogbe & Santoro, 2023).

With regard to the interaction between digitalization and tax administration, the literature suggests that digitalization represents an effective administrative policy instrument, particularly in areas such as value-added tax, electronic invoicing, and digital reporting, contributing to the reduction of tax evasion and to the increase in voluntary compliance (Pomeranz, 2015; Keen & Slemrod, 2017; Okunogbe & Santoro, 2023). These mechanisms operate through improved transaction traceability and the reduction of informational asymmetries between taxpayers and authorities.

Although the literature increasingly highlights the impact of digitalization on tax revenue collection, empirical evidence regarding the direct link between digitalization and the size of the shadow economy remains limited and heterogeneous. Most studies focus on average effects, without capturing structural differences across economies or the potential heterogeneous effects of digitalization that vary with the shadow economy's scale.

The link between digitalization and the budget deficit is even less explored in the specialized literature. The budget deficit is generally treated as a complex

macroeconomic outcome, determined by the economic cycle, the structure of public expenditures, institutional rigidities, and political constraints, suggesting that the impact of digitalization is rather indirect, operating through the channel of revenue mobilization and increased tax compliance (Keen & Slemrod, 2017; Okunogbe & Santoro, 2023). Some analyses by the International Monetary Fund and the World Bank suggest that the use of digital technologies at the governmental level can create fiscal space by increasing collection efficiency and reducing revenue losses; however, the effects on the budget deficit depend on how these additional revenues are used or absorbed into expenditures (IMF, 2019; World Bank, 2025). In this context, the question remains open as to whether digitalization exerts a systematic impact on the budget deficit or whether its effects are predominantly structural and mediated by other institutional factors.

Identifying the factors that can simultaneously reduce the shadow economy and to improve fiscal performance, reflected in a lower budget deficit, represents a relevant research direction from both academic and public policy perspective. In this logic, the paper proposes an integrated analysis of the relationship between the digitalization of public administration, the shadow economy, and the budget deficit within a group of European Union Member States, seeking to provide clarification regarding the existence of a systematic relationship between the level of administrative digitalization and the size of the shadow economy, the association between digitalization and fiscal performance as measured by the budget deficit, and whether these relationships differ across the distribution of the shadow economy, suggesting heterogeneous effects among economies with different levels.

3. Empirical Analysis

3.1 Data Description

This study covers the period 2003–2022. A detailed description of the variables, their definitions, and the data sources is provided in Table 1. The dependent variables are the shadow economy and the budget deficit, both measured as a percentage of GDP. The explanatory variables are structured into three groups. First, the key variable of interest is the EGDI (E-Government Development Index), a composite index of digital governance development that captures online public services, ICT infrastructure, and human capital. Second, a set of macroeconomic control variables is included, such as public debt, economic growth, inflation, unemployment, and trade openness. Third, institutional and governance-related factors are taken into account by indicators of financial openness, control of corruption, regulatory quality, and political stability, which may jointly influence the size of the shadow economy, the budget deficit, and the effectiveness of public policies.

Table 1. Variable description and data sources

Variables	Symbol	Description	Data source
<i>Dependent variable</i>			
Shadow Economy	Shadow	It refers to legal market-based production activities that are deliberately concealed from public authorities to evade taxes, social security contributions, or regulatory requirements. It is measured as a percentage of annual GDP using MIMIC-based estimates	Schneider, F. (2022)
Fiscal Balance	Balance	It represents the difference between government revenue and government expenditure. We express the value as percentage of GDP relate it to the size of the economy.	Eurostat Database
<i>Independent variable</i>			
Index EGDI	EGDI	Index of digitalization at the level of government administration, with values between 0 (low) and 1 (high)	United Nations E-Government Knowledgebase
Public debt	Debt	It refers to the stock of government contractual liabilities outstanding at a given date, including domestic and foreign deposits, debt securities, and loans, measured on a gross basis at the end of the fiscal year.	Eurostat Database
Economic growth	Growth	The annual percentage change in real gross domestic product (GDP)	TheGlobalEconomy
Inflation rate	Inflation	It is measured by the consumer price index (CPI) and captures the annual percentage change in the average cost of a representative basket of goods and services	TheGlobalEconomy
Unemployment rate	Unemployment	It refers to the share of the labor force that is without work but available for and seeking employment.	TheGlobalEconomy
Trade openness	Trade	Exports plus imports as percent of GDP	TheGlobalEconomy
Financial openness	Financial	It is measured by the Chinn–Ito index, which captures the extent of restrictions on cross-border financial transactions based on IMF exchange arrangement data, with higher values indicating greater financial openness.	TheGlobalEconomy
Control of corruption	Corruption	It captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as capture of the state by elites and private interests.	TheGlobalEconomy
Regulatory quality index	Regulatory	It captures perceptions of the ability of the government to formulate and implement sound policies and	TheGlobalEconomy

		regulations that permit and promote private sector development.	
Political Stability Index	Stability	It is measured by the Political Stability and Absence of Violence/Terrorism index, which captures perceptions of the likelihood of government destabilization or politically motivated violence, based on composite indicators from multiple international sources.	TheGlobalEconomy

Source: Authors' processing.

As a first step of the empirical analysis, we examine the stationarity properties of the data using the Levin–Lin–Chu (LLC) panel unit root test, which is well-suited for panels with a moderate time dimension and a relatively larger cross-sectional dimension, as in our sample of 24 countries observed over 20 years. Testing for unit roots is essential to avoid spurious regression results and to ensure the validity of subsequent panel estimations. The results of the LLC tests are reported in Table 2.

Table 2. Unit root test

Variable	LLC test statistic (t*)	p-value
Shadow	-2.7855	0.0027
Balance	-5.2628	0.0000
EGDI	-2.6218	0.0044
Debt	-3.1254	0.0009
Growth	-5.6098	0.0000
Inflation	-7.5017	0.0000
Unemployment	-5.4946	0.0000
Trade	-4.6021	0.0000
Financial	-3.0175	0.0013
Corruption	-2.2559	0.0120
Regulatory	-2.8480	0.0022
Stability	-3.9244	0.0000

Source: Authors' processing.

The Levin–Lin–Chu test results reported in Table 2 indicate that all variables are stationary at conventional significance levels. Furthermore, we examine the correlation structure among the explanatory variables, as illustrated in Figure 1. The correlation matrix indicates no strong pairwise associations among the macroeconomic and fiscal controls, suggesting limited multicollinearity. Higher correlations are observed only among the institutional and political indicators, namely control of corruption, regulatory quality, and political stability, reflecting their common governance component. To avoid redundancy and ensure stable inference, these institutional variables are introduced separately or in alternative regression specifications.

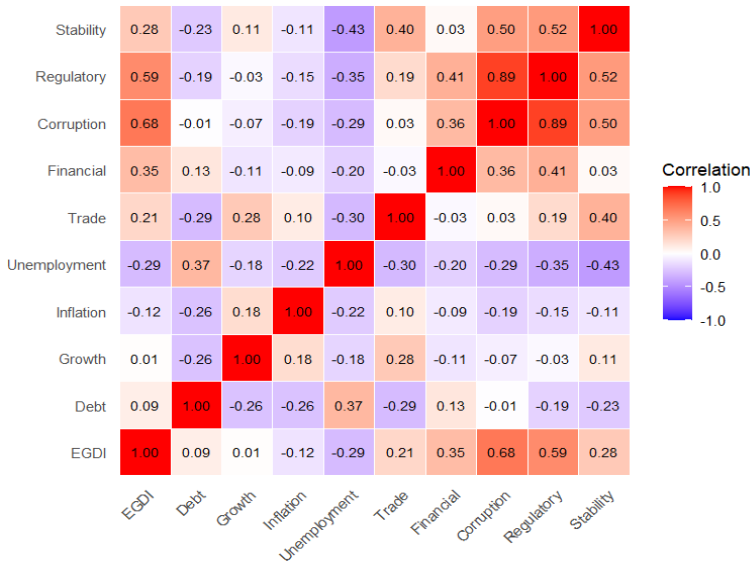


Figure 1. Correlation matrix
 Source: own processing.

3.2 Linear specification

We begin the empirical analysis by estimating baseline panel regressions with country fixed effects. This specification allows us to control for unobserved, time-invariant heterogeneity across countries that may jointly influence digitalization, fiscal outcomes, and the size of the shadow economy. Fixed effects are particularly appropriate in our context, given persistent cross-country differences in institutional quality, economic structure, and governance. Table 3 reports the results for alternative specifications, in which the shadow economy and the fiscal balance are treated as dependent variables, while institutional indicators are introduced separately to mitigate multicollinearity concerns.

Table 3. Panel FE estimates (p-values in parentheses)

Variable	Shadow	Shadow	Shadow	Balance	Balance	Balance
EGDI	-0.07169 (0.000)	-0.0810 (0.000)	-0.0682 (0.000)	0.0470 (0.032)	0.0422 (0.061)	0.0468 (0.035)
Debt	-0.030 (0.000)	-0.032 (0.000)	-0.029 (0.000)	-0.024 (0.020)	-0.022 (0.037)	-0.020 (0.054)
Growth	0.063 (0.000)	0.056 (0.001)	0.055 (0.001)	0.275 (0.000)	0.270 (0.000)	0.273 (0.000)
Inflation	0.081 (0.020)	0.070 (0.041)	0.092 (0.007)	-0.013 (0.849)	-0.002 (0.977)	0.007 (0.917)
Unemployment	0.125 (0.000)	0.106 (0.000)	0.147 (0.000)	-0.091 (0.076)	-0.087 (0.101)	-0.074 (0.157)

Variable	Shadow	Shadow	Shadow	Balance	Balance	Balance
Trade	-0.058 (0.000)	-0.056 (0.000)	-0.054 (0.000)	0.016 (0.100)	0.020 (0.044)	0.020 (0.051)
Financial	-0.237 (0.172)	-0.205 (0.229)	-0.195 (0.254)	-0.338 (0.311)	-0.249 (0.456)	-0.248 (0.458)
Corruption	-0.736 (0.077)	—	—	-1.958 (0.015)	—	—
Regulatory	—	-1.880 (0.000)	—	—	-0.938 (0.319)	—
Stability	—	—	1.232 (0.001)	—	—	0.017 (0.981)
Intercept	33.399 (0.000)	35.617 (0.000)	30.794 (0.000)	-4.059 (0.060)	-5.171 (0.036)	-6.812 (0.001)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R ² (overall)	0.268	0.307	0.157	0.109	0.230	0.267
F / Wald χ^2	87.5	91.6	90.3	19.5	18.7	18.5
Obs	453	453	453	453	453	453

Source: Authors' processing.

The data show that, across all specifications in which the shadow economy is treated as the dependent variable, the EGDI coefficient is negative and statistically significant at the 1% level, indicating that higher levels of digitalization in government administration are systematically associated with mitigation of the shadow economy activity. Regarding the budget deficit, EGDI has a positive effect, suggest that digitalization contributes to its improvement.

3.3 Unconditional Quantile Regression

One way to assess heterogeneous distributional effects of digitalization on the shadow economy and fiscal outcomes is through Conditional Quantile Regression (CQR), which allows the impact of EGDI to vary across different points of the conditional distribution of the dependent variable. At any level τ , across the distribution of y , given a set x , the conditional quantile $Q_y(\tau|x)$ shows $\inf\{k: T(k|x) \geq \tau\}$ where $T(*|x)$ represents the conditional distribution function. In a panel data framework, the most common approach is the CQR with fixed effects (Koenker, 2004):

$$Q_{y_{i,t}}(\tau|x_{i,t}) = \alpha_i + x_{i,t}^T \beta^{CQR}(\tau). \quad (1)$$

In Eq. (1), $i = \overline{1, N}$ and $t = \overline{1, T}$, represent countries and years, $y_{i,t}$ is the dependent variable, $x_{i,t}$ denotes the covariates, $\beta^{CQR}(\tau)$ is the common slope coefficient while α_i is a location shift parameter.

However, when assessing the effectiveness of government digitalization policies, relying on Conditional Quantile Regression may yield coefficients that do not fully capture how explanatory variables, including EGDI, affect the distribution

of the shadow economy and fiscal outcomes across quantiles. To address this limitation, Firpo et al. (2009) propose Unconditional Quantile Regression (UQR), which is implemented by computing a recentered influence function (RIF) that is defined independently of covariates and subsequently regressed on the set of explanatory variables:

$$RIF(y_{i,t}; v(F_{y_{i,t}})) = v(F_{y_{i,t}}) + IF(y_{i,t}; v(F_{y_{i,t}})). \quad (2)$$

In Eq. (2), $F_{y_{i,t}}$ represents the CDF of $y_{i,t}$ while $v(F_{y_{i,t}})$ quantifies the marginal impact on the parameter of the distribution $F_{y_{i,t}}$ when removing or adding a variable. The influences function (IF) measures the impact of a particular variable on a distributional statistic:

$$IF(y_{i,t}; v(F_{y_{i,t}})) = \lim_{\varepsilon \rightarrow 0} \left(\frac{v[(1 - \varepsilon)F_{y_{i,t}} + \varepsilon G_{y_{i,t}}] - v(F_{y_{i,t}})}{\varepsilon} \right). \quad (3)$$

In Eq. (3), $0 \leq \varepsilon \leq 1$ and $G_{y_{i,t}}$ denotes the distribution that puts mass at the value $y_{i,t}$. The expected value of the RIF is $v(F_{y_{i,t}})$, as the expected value of the $IF(y_{i,t}; v(F_{y_{i,t}}))$ is zero. In addition, if we select the τ^{th} quantile as the statistic of interest and choose to estimate the density functions for each quantile, the RIF is given by:

$$\begin{aligned} RIF(y_{i,t}; q_{\tau}; F_{y_{i,t}}) &= q_{\tau} + IF(y_{i,t}; q_{\tau}; F_{y_{i,t}}) \\ &= q_{\tau} + \frac{\tau - \mathbb{I}\{y_{i,t} \leq q_{\tau}\}}{f_{y_{i,t}}(q_{\tau})}. \end{aligned} \quad (4)$$

In Eq. (4), q_{τ} is the τ^{th} quantile of the unconditional distribution of $y_{i,t}$, $f_{y_{i,t}}(q_{\tau})$ represents the PDF of $y_{i,t}$ evaluated at the τ^{th} quantile using a Kernel-density estimation, while $\mathbb{I}\{y_{i,t} \leq q_{\tau}\}$ is an indicator function showing whether $y_{i,t}$ falls below the τ^{th} quantile or otherwise. Thus, the UQR estimator is:

$$RIF(y_{i,t}; q_{\tau}; F_{y_{i,t}}) = x_{i,t}^T \beta^{UQR}(\tau). \quad (5)$$

Following Borgen (2016), we also include country fixed effects to control for unobserved, time-invariant country-specific characteristics. The estimation results are presented in Figure 2.

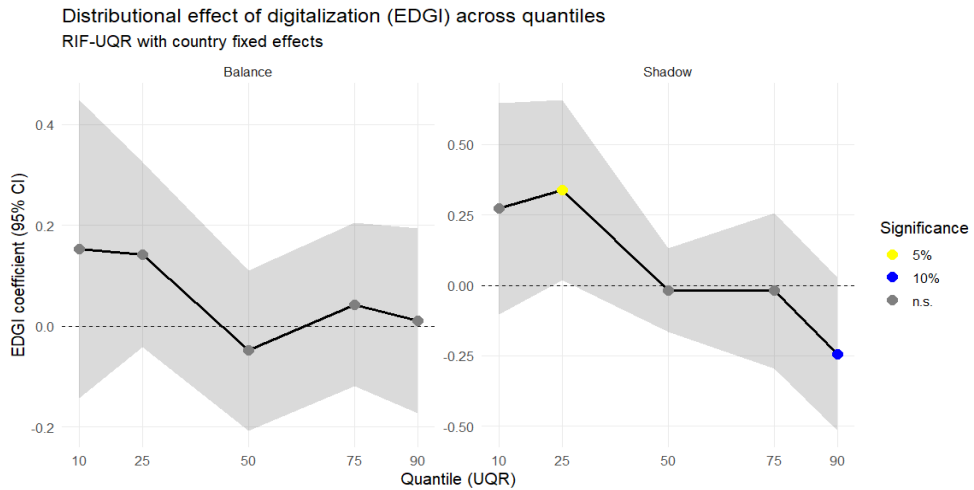


Figure 2. UQR estimates

Source: Authors' processing.

The Unconditional Quantile Regression analysis highlights an asymmetric impact of digitalization on the shadow economy. Specifically, at lower quantiles, corresponding to economies with a relatively low level of the shadow economy, digitalization is associated with a temporary increase in shadow economy activity, reflecting compliance costs, administrative frictions, and improvements in detection mechanisms. By contrast, in the upper quantiles, where the shadow economy is structurally high, digitalization exerts a negative and statistically significant effect, reflecting its role as an instrument of formalization and the strengthening of fiscal discipline.

In contrast, for the budget deficit, the results do not indicate a systematic and robust impact of digitalization across the distribution, suggesting that the effects of digitalization are not enough to influence fiscal performance within a quantile regression framework, which appears to be primarily driven by broader macroeconomic and institutional factors.

4. Results and Discussion

4.1 In the case of the fixed-effects estimations

The results of the fixed-effects estimations indicate a negative and statistically significant relationship between the digitalization of government administration, as captured by the EGDI index, and the size of the shadow economy. The stability of the coefficient suggests a direct effect of digitalization on the shadow economy that is not captured by variables that measure the quality of governance. This key finding indicates that the expansion of administrative digitalization significantly reduces opportunities to engage in shadow-economy-specific activities.

The macroeconomic control variables generally produce effects consistent with theoretical expectations. Economic growth is positively associated with the shadow economy, a result that can be interpreted through scale effects, in the sense of an expansion in the overall volume of economic activity. The unemployment rate exhibits a positive effect on the shadow economy, reflecting labor market rigidities, while public debt shows a statistically significant negative effect, suggesting the presence of fiscal adjustment and disciplining mechanisms.

The institutional indicators included in the analysis generate heterogeneous effects on the shadow economy. Thus, control of corruption and regulatory quality are, in some specifications, associated with a reduction in the shadow economy, although their statistical significance fluctuates. This reflects the conceptual overlap among different dimensions of governance and justifies their separate treatment in alternative specifications. Political stability generates a positive effect in certain models, suggesting that a stable political climate may stimulate overall economic activity, including segments of the shadow economy, in the absence of effective control mechanisms. This effect diminishes substantially with the inclusion of digitalization and other control variables, indicating a limited and context-dependent role.

Regarding the budget deficit, the results indicate a positive association between digitalization and fiscal performance, with the EGDI coefficient positive and statistically significant in most specifications. It is observed, however, that the significance and magnitude of this coefficient are more sensitive to the inclusion of institutional variables compared to the shadow economy. This suggests that the impact of digitalization on the budget deficit is indirect. Although, reducing the shadow economy may expand the tax base, the final effect on fiscal performance depends on additional factors, such as the structure of public expenditures, debt dynamics, and the economic cycle.

Conversely, economic growth exhibits a positive and robust effect on the budget deficit, confirming its central role in fiscal consolidation, while public debt shows a significant negative impact, reflecting persistent budgetary constraints. The remaining macroeconomic variables display less consistent effects.

4.2 In the case of unconditional quantile estimations with fixed effects

In order to capture possible differential effects of digitalization, unconditional quantile regression was also used. The results show a clear asymmetry in the impact of digitalization on the underground economy. Thus, in the lower quantiles of the shadow economy distribution, the EGDI coefficient is positive, suggesting that, in countries with low levels of the shadow economy, digitalization may be associated with transitory effects or improved detection mechanisms. In contrast, for the median and upper quantiles, digitalization has a significant negative effect, indicating a high capacity to reduce the underground economy in economies where it is persistent. In the case of the budget deficit, the quantile regression does not reveal a significant impact of digitalization across the entire distribution. This suggests that

digitalization does not substantially change the distribution of fiscal outcomes, which remain dominated by macroeconomic factors.

5. Conclusions

The paper analyzed the impact of public administration digitalization on the size of the underground economy and fiscal performance, measured by the budget deficit, using panel data for 24 European Union member states, over the period 2003–2022. The empirical results highlight the existence of a negative and statistically significant relationship between the level of public administration digitalization and the size of the underground economy, the stability of the coefficient associated with digitalization in different specifications, suggesting that the expansion of digital public services and the consolidation of digital administrative infrastructure systematically reduce the opportunities for carrying out activities specific to the underground economy. This result gives digitalization a relevant explanatory role for the variations in the underground economy across the analyzed states and indicates the need to accelerate digitalization, especially in economies characterized by high and persistent levels of the underground economy. Regarding fiscal performance, the relationship between digitalization and the budget deficit proves to be more nuanced. Although the coefficient associated with digitalization is generally positive in fixed-effects specifications, its sensitivity to the inclusion of institutional variables suggests a predominantly indirect impact, mediated by other structural factors. The results indicate that digitalization contributes to improving fiscal performance mainly through the revenue mobilization channel, while the aggregate budgetary position remains conditioned by the dynamics of public debt, the expenditure structure and the business cycle. In this context, digitalization policies can maximize their effectiveness by integrating them into a broader framework of fiscal-budgetary reforms, ensuring the capitalization of additional revenues generated by reducing the underground economy. The distributional analysis based on the regression on unconditional quantiles reveals significant heterogeneous effects of digitalization on the underground economy, with the negative impact being more noticeable in the upper quantiles of the distribution, corresponding to economies with a high level of the underground economy. In the lower quantiles, the effects of digitalization are smaller or transitory, reflecting compliance costs and improved detection mechanisms. In the case of the budget deficit, the quantile results do not indicate a systematic impact of digitalization on the distribution of fiscal performance. These findings support the need to calibrate digitalization policies according to the initial level of the underground economy, administrative capacity and the degree of institutional maturity, as well as to complement them with administrative simplification measures and support for taxpayers, especially in economies with a lower underground economy. Overall, the results confirm the role of digitalization within the public administration as an effective tool to reduce the underground economy, especially in economies with a higher level of underground economy, while the impact on the budget deficit is more limited and dependent on

the macroeconomic and institutional context. The analysis presents certain limitations related, in particular, to the use of aggregate indicators to measure the underground economy and digitalization, as well as the focus on a relatively homogeneous sample of European Union Member States, which limits the generalizability of the results to emerging economies. These limitations do not diminish the relevance of the conclusions, but rather emphasize the exploratory nature of the study and open perspectives for future research, oriented towards the use of more granular indicators, the expansion of the area of analysis, and the application of more robust causal identification strategies, capable of clarifying the mechanisms through which digitalization influences the underground economy and fiscal performance.

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