

Does Information and Communication Technology Influence the Shadow Economy? A Panel Data Analysis for EU Countries

Adrian BOJAN*

Babes-Bolyai University, Cluj-Napoca, Romania

**Corresponding author, adrianbojan9@yahoo.com*

Monica Violeta ACHIM

Babes-Bolyai University, Cluj-Napoca, Romania

monica.achim@econ.ubbcluj.ro

Abstract. *Information and communication technology (ICT) adoption has emerged as a driving force in reshaping tax systems and global economic practices. This study addresses the implications of digitalization in reducing tax avoidance in the European Union (EU) Member States, where the time frame of analysis spans over a 10-year period between 2013 and 2022. This research aims to highlight correlations between tax avoidance and digitization. The means used for this cross-sectional and temporal dataset are based on the application of a regression on panel data, where we used the dependent variable tax avoidance represented by the shadow economy and the proxy for ICT services as independent variable. The study extends the literature by analyzing the influence of ICT on the shadow economy in the European Union and the contribution brings the innovative use of Internet server security and Internet access as factors influencing the shadow economy for this sample, through the System GMM method. We emphasize the results by replacing the shadow economy estimated using the classic MIMIC method with that estimated using the abnormal energy consumption method for robustness checks. The results confirm that increasing digitalization in EU countries leads to a reduction of the shadow economy, where the worst performing economies are in the South-East of the European Union. Finally, this study provides recommendations for increasing investments in the ICT services sphere and for developing effective tax policies to increase tax transparency.*

Keywords: shadow economy, tax avoidance, digitalization, ICT.

Introduction

Historically, we see that tax evasion is a persistent problem globally, often due to tax administrations lacking the necessary information (Alstadsæter et al., 2022). There is considerable evidence to suggest that heterogeneity in tax compliance behavior is persistent and pervasive, as the higher the tax rate, the greater the frequency of tax evasion (Silveira et al., 2025). Consequently, it negatively affects compliance among those who regularly pay their taxes (Amoh et al., 2023). The size of the shadow economy is a key factor in estimating the extent of tax evasion, which informs decisions on appropriate control measures (Medina & Schneider, 2019). There are many synonyms in the literature, e.g. illegal, unreported, underground, black market, informal economy, undeclared or unrecorded activities, and similar, but the most widespread is the term "undeclared economy" in the European Union.

In contrast, if we look at the factors driving societal development, we identify digitalization as a valuable aspect that brings profound changes in social life, influencing including politics and economics, and falling within our field of interest. On the other hand, digital technologies promise benefits for increasing economic prosperity (Andrushchenko et al., 2022). Where another

perspective suggests that ICT expansion as a component of digitalization plays a significant role in economic expansion (Baliamoune, Mina N., 2002).

The link between the two phenomena is important to analyze because access to technology and digitalization improves the ability of governments to reduce tax evasion, mainly by increasing the flow of information to governments, but which can also be harmful because it creates other forms of tax avoidance (Alm, 2021). Where the easiest way to combat this becomes over-taxation to raise money for the state budget, authors such as (Viren, 2015) state that most European countries could eliminate current deficits without having to increase taxes or cut spending, only requiring improvements in collection systems. Information and communication technologies (ICT) contribute significantly to promoting sustainable fiscal growth by improving revenue collection mechanisms (Wang & Li, 2024). Thus digitalization measures are seen as an efficient solution because they reduce the involvement of the human factor (Nozim Muminov et al., 2020). These arguments outline the research idea of the study, whereby the influence of ICT services is consistent in shaping the size of the shadow economy and achieving the Sustainable Development Goals (SDGs) (Yan et al., 2024).

The main objective is to analyze the influence of ICT on the shadow economy in EU member countries over a 10-year period, using digitalization proxies in a panel data based econometric approach to determine the extent to which digitalization contributes to the reduction of undeclared activities. In order to achieve the objective, we used proxies for ICT households level of internet and the System Generalized Method of Moments (System GMM) method to estimate the model, suitable for correcting autocorrelation and using lagged values. And to validate the results we changed the ICT proxy to secure internet servers and added another form of shadow economy based on a different estimation approach for abnormal energy consumption, right dependent variable.

Following the results we found that a short run of the coefficients suggests the existence of positive but also negative effects in terms of the influence of ICT on the shadow economy, explained by the existence of a U-shaped. But the use of alternative estimation for the long run coefficients turns out to be more relevant and indicates that ICT are significant and contribute to the reduction of the shadow economy. The overall idea inclines towards providing solid recommendations that governments should invest in digital platforms, as the consequences of the shadow economy bring a negative effect on tax revenues (Mazhar & Méon, 2017). The originality of the paper stands out through the use of households for internet access compared to the analysis applied at the level of individuals (Boitan & Ştefoni, 2023; Elgin, 2013; Remeikienė et al., 2022) and an innovative contribution by extending the analysis to secure internet servers. Few studies address the impact of ICT on the shadow economy in the EU, therefore the paper comes to fill the gap in the literature and analyze the shadow economy from two different angles.

The rest of the paper is organized as follows: the first part is dedicated to the literature review to deepen the scope of the shadow economy phenomenon with digitalization, and the next part explains step by step the applied methodology together with the description of the variables. The next section presents the main results following the use of internet access, then the robustness tests are applied and finally the alternative estimation of the long run coefficients. The discussions comparing the results with the literature and the conclusions represent the final parts of the paper.

Literature review

1. The shadow economy: key drivers

One approach presents that the digital shadow economy encompasses those illegal activities, such as the provision of digital services and the sale of goods/services online; informal space where entities violate regulations to gain benefits (Remeikiene et al., 2017). The shadow economy is used in the literature as a percentage of GDP and was estimated based on the idea that it is a latent variable (not directly observable), but can be inferred from the relationship between its causes (determinants) and its effects (measurable indicators). Among the causes of shadow economy we mention the following: government efficiency, tax revenue/tax freedom, international trade and unemployment rate. As a result, the effects are: GDP growth rate, labor force participation rate and abnormal energy consumption (Achim et al., 2024; Medina & Schneider, 2018; Yamen et al., 2023).

The adoption of digitalization by citizens and businesses has a stronger effect on reducing tax evasion than its implementation at the government level. Furthermore, the results show that the level of corruption influences how digitalization affects tax evasion (Yamen et al., 2023). It has been shown that there is a negative correlation between card use and tax evasion, as the use of cards for cash withdrawals contributes to increasing the affordability of cash facilitating tax evasion (Immordino & Russo, 2018), but government support for the development of digital payments infrastructure becomes ineffective in a context where the shadow economy is dominant (Marmora & Mason, 2021). In contrast other research shows that, apart from transaction size and consumer preferences for ease of use, cash usage is strongly correlated with demographics and POS characteristics such as merchant card acceptance and location (Bagnall et al., 2016).

In the same way, the digital shadow economy refers to global networks that operate on closed internet platforms and facilitate electronic criminal activities, such as attacks on banking institutions, payment card fraud, identity theft, and other types of unauthorized online access (Remeikiene et al., 2017). Sometimes they are right on the edge of legality, other times they operate in parallel with legal activities and often pre-empt them. Individuals with a high level of education and solid business experience frequently operate in this environment. The roots of the shadow economy are: massive taxation, corruption and inefficient governmental activities, and the national culture affects the shadow economy at different levels and there is a dynamic relationship between different layers of culture (Amoh & Ali-Nakyea, 2019; Buszko, 2018; Mohammadi Khyareh, 2019). A similar study shows that the most serious consequences are associated with corruption, diminished innovation and creativity, reduced competitiveness at both the macroeconomic and microeconomic levels, and decreased budget revenues. This affects the financing of education and leads to a deterioration in the quality of public institutions (Buehn et al., 2013). The results presented in the literature, provide evidence that there is a significant and negative relationship between the adoption of digitalization and the shadow economy, where it has been shown that in countries with lower levels of corruption digitalization measures are more effective, telecommunication infrastructure together with government online services reduce the level of financial crime (Haruna & Alhassan, 2022; Yamen et al., 2023), and the diffusion of ICTs especially mobile phones and the internet lead to a reduction in informal activities (Adalbert Abraham Ghislain, 2022; Boitan & Ștefoni, 2023).

Smith states that cybercrime is carried out with the help of the internet and is an activity carried out remotely to procure various resources illegally (Smith, 2015), while other research states that traditional models for determining the shadow economy do not include the contribution of the digital shadow economy to the total size of the shadow economy, which prevents its accurate

estimation (Gasparėnienė & Remeikienė, 2016). The number of ATMs uses and number of payment terminals as forms of digitalization of finance have led to the decrease of fraud in Ukraine, namely to the level of 14.43% of GDP, which is 55.8% less (Bozhenko et al., 2024). An example is the case of China where digital regulatory systems in more efficient administration of much stricter social security contributions force entities to resort to reducing tax burden by decreasing the number of employees and wages (Yu & Li, 2024), just as an increase in the unemployment rate suggests the expansion of the shadow economy in developing countries (Sahnoun & Abdennadher, 2019). The share of the female population has a negative and highly statistically significant coefficient contributing to the reduction of the shadow economy (Sacchi et al., 2022), but a positive correlation between femininity vs masculinity and the shadow economy has been determined and that well-educated individuals are the most willing to handle their affairs as well as possible (Buszko, 2018) and similarly, wealthy individuals have technologies, expertise and resources that can facilitate them to avoid or reduce tax liabilities (Amoh & Ali-Nakyea, 2019). At the opposite pole, using a panel dataset for 142 countries, Uyar shows that low levels of digitalization in education in some countries make the link between education quality and tax evasion insignificant, while high levels of digitalization in education keep this relationship significant (Uyar et al., 2024). The study on trends in the formation of tax literacy and tax culture of the society revealed that in Russia the obligation to pay taxes is not perceived as a civic responsibility. In this context, improving the level of tax literacy and tax culture, along with the implementation of modern digital and analytical tools by the administration, is the foundation for creating the loyalty of society to the tax system (Galeeva et al., 2022). On the other hand, an increase in government spending and bank lending tends to favor the expansion of the shadow economy (T. K. P. Tran, 2021), while foreign investment and industrial productivity improve the control of the growth of the shadow economy and bad loans (Syed et al., 2021). Related studies show an inverse relationship between research and development (R&D) spending and the size of the shadow economy, suggesting that R&D investment reduces economic informality and increases productivity.

The shadow economy is estimated to shrink by 36.09% for each additional unit allocated to R&D, while a higher share of R&D in GDP is associated with a significant reduction in the size of the shadow economy, especially in countries with low levels of investment and dependence on resource rents (Amanova, 2022; Nevzorova et al., 2018). Measures taken by different countries to combat tax avoidance are identified along with the protection assuring for the taxpayers' rights (Put, 2020). Between 2008 and 2010, the US signed bilateral agreements with six tax havens (Switzerland, Luxembourg, Liechtenstein, Malta, Monaco, Liechtenstein, Malta and Panama) for the exchange of information on request. In 2010, FATCA required foreign banks to report accounts held by US taxpayers and required them to annually declare foreign accounts exceeding USD 10,000. In the UK, the Requirement to Correct (RTC) rule has given taxpayers time to regularize their financial situation, including offshore assets. In other countries, such as Russia and Poland, information exchange systems between banks and tax authorities, together with the use of digital cash registers, have reduced the shadow economy, minimizing direct contact with officials and preventing corruption. Compared to the European Union, where cash payments exceeding €10,000 will be banned under Regulation (EU) 2024/1624 (Nozim Muminov et al., 2020; Omar et al., 2021). Although Regulation No. 549/2013 of the European Parliament and of the Council of May 21, 2013, on the European System of National and Regional Accounts does not impose an obligation to measure the shadow economy within the European System of National Accounts, this has attracted the attention of stakeholders.

2. The role of digitalization in shaping the shadow economy

Following a systematic literature review, we identified two main groups in terms of the influence of digitalization on the shadow economy. The first group provides evidence that digitalization negatively shapes the shadow economy, as public policies do not pay more attention to implementing more rigorous oversight mechanisms, the use of the internet by companies will continue to perpetuate the expansion of shadow activities, especially in Eastern European countries (Mara, 2025). E-government initiatives need time to become effective and contribute to reducing the shadow economy significantly (Doan et al., 2025). Thus, financial technology is seen as ineffective as it unfavorably reduces the influence of financial development on shadow activities (Rahman et al., 2023). For Southeast Asian countries the literature suggests that digital financial utilization enhances the possibilities for shadow economy development (Sulistiyowati, L. N., 2022).

The digitalization phenomenon is presented as a two-edged sword because in the second group, an analysis applied to three types of countries (G20, developing and developed countries) finds a positive effect, i.e. ICT reduces shadow economy following negative regression results, in all three economies (Silalahi, P., 2022). ICT contributes to reducing the share of shadow economy in GDP, but can also create financial instability (Verma et al., 2024). In the same vein, an analysis applied to a sample of 185 countries validates the idea that the growth of technology leads to a reduction in the extent of financial crime (Achim et al., 2021). Another study shows that digital adoption contributes to the reduction of the shadow economy (Amzuică et al., 2023), and the expansion and development of information and communication technologies (ICT) reduce the size of the shadow economy and can help reduce the use of cash, thus facilitating more effective monitoring of financial transactions, demonstrating that ICT systems are a good tool for reducing the shadow economy (Ajide & Dada, 2022). The most noticeable progress in ICT is observed in Slovakia and Romania, while a somewhat more modest development characterizes Croatia, Latvia, Lithuania and Bulgaria which is also found in Ajide's study (Remeikienė et al., 2022). The use of the Internet has two opposite effects on the size of the shadow economy: on the one hand, it stimulates productivity, contributing to its reduction, and on the other hand, it facilitates tax evasion, leading to the growth of the shadow economy. In developing economies, the positive effect of productivity growth predominates, while in advanced economies the negative impact of tax evasion is stronger. Where we formed the research hypothesis for this study:

Hypothesis: A higher level of information and communication technology drives down the percentage of the shadow economy.

Thus, the influence of the internet varies with GDP per capita and this effect is consistent across different institutional settings. Remarkably, technology is not uniformly used in the shadow economy, with a U-shaped relationship between internet use and the size of the shadow economy. The same U-shaped pattern can also be observed in digital financial development, where new forms of tax evasion are emerging, although payment transparency is increasing (Elgin, 2013; Lv et al., 2024; Nguyen et al., 2024). The digital contributions, using the EGDI indicator, in reducing the shadow economy are confirmed by Brici's research which states that Pandemic was the factor of a rapid adoption of digitalization (Brici & Achim, 2023), similar to the results obtained by Veiga where the EGDI index seems to have a more significant impact on the size of the shadow economy in high-income countries, which suggests that the effectiveness of e-government in reducing the shadow economy becomes evident only after countries reach a certain level of economic development and progress in e-government (Veiga & Rohman, 2017), on the other hand it is also

shown that digitalization alleviates tax rigidity and occurs in firms with weaker control system (Zhou et al., 2022).

Methodology

1. Description of the variables

The variables used in the research, which are essential for our analysis, are presented below in table no.1. They have been selected to reflect the key aspects of the topic under study and to provide a clear understanding of the economic phenomena under investigation.

Table no. 1. Presentation of variables

Variables		Description	Source
Dependent variable	SE	Shadow economy (% of GDP) using the MIMIC method	Schneider F., (2022)
	SE_2	Shadow economy (% of GDP) using abnormal energy consumption	Achim M., et al., (2024)
Independent variable	HIC	Households level of internet (% of households)	Eurostat
	SIS	Secure Internet servers (per 1 million people)	World Development indicators
Control variable	UNEM	Unemployment rate (% of total labor force)	World Development indicators
	IF	Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole.	World Development indicators
	ERD	Expenditure on R&D (% of GDP)	Eurostat

Source: Authors' own research.

Based on various researches, we use some factors that influence the shadow economy as control variables according to the literature: unemployment rate (Baneliene & Melnikas, 2019; Canh & Dinh Thanh, 2020; T. P.-K. Tran et al., 2024; Zhanabekov, 2022), inflation (Baklouti & Boujelbene, 2019; Bhatti et al., 2024; Elgin & Iyidost, 2022; Goel & Saunoris, 2019; Luong et al., 2020) and R&D expenditures (Amanova, 2022; Nevzorova et al., 2018).

The econometric analysis is performed using panel data regression in Stata 15. First of all we applied the natural logarithm since all the variables are expressed in different units and we used the prefix "ln" for this purpose. We analyzed the data set by applying Levin-Lin-Chu (LLC) test to check stationarity and Wooldridge test for autocorrelation. The variables are stationary because they have constant mean and variance over time but there is autocorrelation which suggests that the past impacts the future and we chose to use the System Generalized Method of Moments (System GMM) for a dynamic panel. The System GMM method is recommended as it is more robust compared to GMM and improves the precision of the estimates, as it reduces the bias resulting from the correlation between endogenous variables and individual fixed effects (Bond et al., 2001). Second, we analyzed the two regression models where we gradually added one variable at a time in order to observe the influence of each one in the regression model and created lagged variables for SE, HIC and SIS. To further support the results we applied a robust test where we changed the dependent variable with the database developed by Achim (Achim et al., 2024) to observe if the ICT influences are similar. In all 4 situations we used Sargan test of overidentifying restrictions and Arellano-Bond test for zero autocorrelation in first-differenced errors. Finally, we

applied the nonlinear hypothesis test from which we concluded that in our study the long-run coefficients are more relevant than the regression coefficients and we formed a table to centralize them all and to facilitate comparability across different variables. The past influences the evolution of the shadow economy, which is why we have chosen to use its lagged values, reflecting its persistent effects on the future (Baklouti & Boujelbene, 2019; Ndoya et al., 2023).

Table no. 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_SE	270	2.806	.423	1.808	3.498
ln_SE 2	260	2.952	.503	2.067	3.859
ln_HIC	268	4.432	.119	3.984	4.597
ln_SIS	270	9.213	1.682	5.17	12.533
ln_UNEM	270	1.957	.484	.701	3.321
ln_IF	270	.519	1.09	-6.095	2.777
ln_ERD	269	.342	.571	-.968	1.253

Source: Authors' own research.

Table no.2 shows that most missing values are in SE_2 as there are no data for Lithuania, while the shadow economy is on average about 2.9 units in both approaches, high enough to raise questions about how it can be reduced. In the case of internet access, the average value is about 4.43 units out of the total number of households with internet access, and the average value of internet server security is 9.21 units per 1 million people; indicators showing that most EU countries rely on ICT services. The standard deviation of about 0.12 shows that there is a moderate dispersion in the level of digitalization, with not very significant differences between countries.

2. The model

The main purpose of this study is to analyze the influence of the digitalization process on the phenomenon of tax avoidance, which we further associate with the shadow economy according to the literature. The research aims to present the extent to which digitalization contributes to the reduction or facilitation of the shadow economy using ICT operations. The objective is to evaluate the efficiency of Internet access and the security of Internet servers in increasing the transparency of economic agents' operations and reducing undeclared activities, applying a macroeconomic level analysis. This study approaches the type of quantitative research, where the analyzed sample comprises the 27 member countries of the European Union, and the study period is 10 years and the time span is 2013-2022. Thus, our proposed research model is empirically represented in the two equations below:

$$SE_{it} = \alpha_0 SE_{it-1} + \alpha_1 SE_{it-2} + \beta_0 HIC_{it} + \beta_1 HIC_{it-1} + \sum_{k=1}^3 \delta_k VAR COTRL_{k,it} + \varepsilon_{it} \quad (1)$$

$$SE_{it} = \alpha_0 SE_{it-1} + \alpha_1 SE_{it-2} + \beta_0 SIS_{it} + \beta_1 SIS_{it-1} + \sum_{k=1}^3 \delta_k VAR COTRL_{k,it} + \varepsilon_{it} \quad (2)$$

We formed two regression models in which we changed only the independent variable to observe the impact of the two ICT operations separately and they were not included in the same regression model because they are both proxies for digitalization and measure the same thing. Where: SE is the dependent variable; HIC, SIS are the independent variables; VAR CONTRL are the control variables; i – country; t – year; k - index of control variable; α - slope coefficient for SE

lagged values; β - slope coefficient for ICT, δ - slope coefficient for control variables; ε - residual error.

Results and discussions

1. Main results

The results presented in figure no. 1 are interpreted according to the color intensity, where we associated a high intensity with an unfavorable situation, i.e. a high level of shadow economy and low level of Internet access, and otherwise a favorable situation where the intensity of the phenomenon is low. The results in figure no. 1 show that Lithuania, Latvia, Romania, Bulgaria, Greece and Croatia are in an unfavorable situation, and (Remeikienė et al., 2022) states that these countries are experiencing a slow progress of ICT services. Factors such as poverty or social exclusion show that the percentage of the population facing these problems is high in Romania (24.3%), Bulgaria (18.7%) and Greece (13.9%), which may influence the access to the Internet by households (Cuturela et al., 2023).

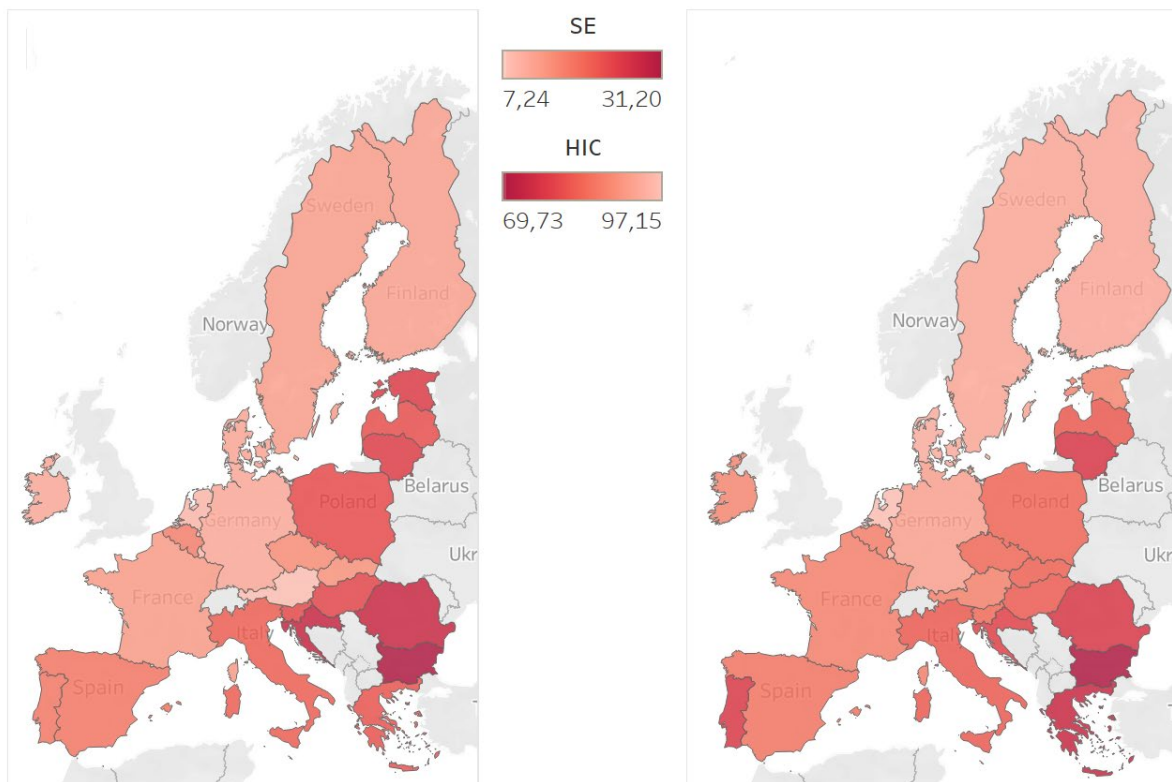


Figure no.1: Average of shadow economy and household internet access

Source: Authors' own research with Tableau Public.

The results (table no.3) following Sargan's test show that the lags of the variables are valid and we obtained a statistically positive relationship; comparing the initial results with the robust results. This suggests us that past informal activities in the past encourage behavioral intensification by increasing the shadow economy in the present by 0.58%. Zeiler states that the absence of detection and enforcement makes it easier for these activities to continue and even expand (Zeiler et al., 2019). The log of the SE variable has a positive coefficient in both situations, and the relationship is strong and significant when we analyzed SE in relation with HIC. If we look at the

case of the HIC variable and its lags we observe that it becomes more and more significant and increases the influence of internet access on the shadow economy as it is explained by the control variables.

Table no.3. The impact of internet access on the shadow economy

VARIABLES	(1) ln_SE	(2) ln_SE	(3) ln_SE	(4) ln_SE
L.ln_SE	0.790*** (0.00731)	0.689*** (0.0133)	0.682*** (0.0153)	0.587*** (0.0166)
L2.ln_SE	0.148*** (0.00977)	0.265*** (0.0132)	0.267*** (0.0171)	0.267*** (0.0260)
L.ln_HIC	-0.0626 (0.0455)	-0.298*** (0.0338)	-0.234*** (0.0535)	-0.333*** (0.0636)
ln_HIC	-0.0256 (0.0492)	-0.343*** (0.0686)	-0.361*** (0.101)	-0.441*** (0.0840)
ln_UNEM		0.218*** (0.00744)	0.236*** (0.0116)	0.249*** (0.0121)
ln_IF			0.00967*** (0.00231)	0.00864*** (0.00211)
ln_ERD				-0.153*** (0.0219)
Constant	-0.231*** (0.0389)	-3.141*** (0.187)	-2.965*** (0.298)	-3.463*** (0.427)
Observations	213	213	213	213
Number of countries	27	27	27	27
Sargan test	chi2(41)	26.12107	Prob > chi2	0.9658
Arellano-Bond test	Order 1 z	-3.430	Prob > z	0.001
	Order 2 z	0.819	Prob > z	0.412

Note: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' own research.

In table no. 3 the coefficients of L.ln_HIC shows that an increase 1% in past internet access leads to a decrease with 0.333% of shadow economy; while a 1% increase in HIC leads to a 0.441% decrease of SE. For the digitalization part, the variable ERD is discretely included, which recorded significant and positive results as expected but statistically negative, which means that it contributes to the reduction of the SE by 0.153% when it increases by 1%. The UNEM variable is highly statistically significant and increases as the explanatory variables are included, increasing the SE by 0.249%. As for inflation the coefficient is very small although it is very significant.

2. Robustness checks

We ran a robustness test to check whether the results obtained on the influence of ICT services on the size of the shadow economy remain constant. First we changed the proxy for ICT, then we replaced the dependent variable. The HIC variable was changed to SIS and the SE variable to SE_2 to test the influence of digitalization in a different way. The lags of the SIS variable show a positive coefficient sign, while the SIS variable has negative coefficients, hence we noticed that the past values do not influence the shadow economy in the same way, suggesting the existence of nonlinearity in this situation. Although highly statistically significant, the values of the coefficients for SIS are very small. A 1% increase in past L.SIS is associated with a 0.0593% increase in SE,

and 1% increase in SIS is associated with a 0.0195% decrease in SE, according to table no.4. The unemployment rate maintains its magnitude compared to other research where the sign of the coefficient is negative (Zhanabekov, 2022), but inflation also has less significant nuances and sufficiently small influences on SE (Luong et al., 2020).

Table no.4. The impact of server security on the shadow economy

VARIABLES	(1) ln_SE	(2) ln_SE	(3) ln_SE	(4) ln_SE
L.ln_SE	0.738*** (0.00626)	0.627*** (0.0255)	0.605*** (0.0240)	0.562*** (0.0256)
L2.ln_SE	0.195*** (0.00350)	0.362*** (0.0162)	0.373*** (0.0201)	0.344*** (0.0206)
L.ln_SIS	0.0330*** (0.00125)	0.0539*** (0.00307)	0.0541*** (0.00234)	0.0593*** (0.00324)
ln_SIS	-0.0342*** (0.00120)	-0.0136*** (0.00189)	-0.0158*** (0.00209)	-0.0195*** (0.00211)
ln_UNEM		0.286*** (0.0118)	0.298*** (0.0123)	0.314*** (0.0132)
ln_IF			0.00561* (0.00312)	0.00666*** (0.00254)
ln_ERD				-0.104*** (0.0240)
Constant	0.202*** (0.0146)	-0.884*** (0.0603)	-0.862*** (0.0619)	-0.663*** (0.0702)
Observations	216	216	216	215
Number of countries	27	27	27	27
Sargan test	chi2(41)	24.94031	Prob > chi2	0.9774
Arellano-Bond test	Order 1 z	-3.344	Prob > z	0.001
	Order 2 z	-0.932	Prob > z	0.351

Note: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' own research.

Table no.5. The impact of internet access on the new shadow economy

VARIABLES	(1) ln_SE_2	(2) ln_SE_2	(3) ln_SE_2	(4) ln_SE_2
L.ln_SE_2	0.790*** (0.0135)	0.792*** (0.00881)	0.796*** (0.0166)	0.789*** (0.0215)
L2.ln_SE_2	0.176*** (0.0111)	0.187*** (0.0118)	0.169*** (0.0182)	0.113*** (0.0255)
L.ln_HIC	-0.0498 (0.0556)	-0.0440 (0.0521)	-0.130 (0.0818)	0.0159 (0.0833)
ln_HIC	-0.293*** (0.0585)	-0.257*** (0.0584)	-0.174* (0.0933)	-0.255*** (0.0923)
ln_UNEM		0.0183** (0.00729)	0.0223*** (0.00350)	0.0237*** (0.00670)
ln_IF			0.00308** (0.00135)	0.00246** (0.00104)
ln_ERD				-0.0614***

VARIABLES	(1) ln_SE_2	(2) ln_SE_2	(3) ln_SE_2	(4) ln_SE_2
Constant	1.635*** (0.0663)	1.376*** (0.130)	1.420*** (0.0850)	(0.0145) 1.342*** (0.126)
Observations	205	205	205	205
Number of countries	26	26	26	26
Sargan test	chi2(41)	23.77107	Prob > chi2	0.9856
Arellano-Bond test	Order 1 z	-3.798	Prob > z	0.000
	Order 2 z	0.292	Prob > z	0.770

Note: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' own research.

Table no.6. The impact of server security on the new shadow economy

VARIABLES	(1) ln_SE_2	(2) ln_SE_2	(3) ln_SE_2	(4) ln_SE_2
L.ln_SE_2	0.862*** (0.0142)	0.857*** (0.0120)	0.844*** (0.0138)	0.842*** (0.0201)
L2.ln_SE_2	0.133*** (0.0120)	0.143*** (0.0121)	0.152*** (0.0144)	0.0826*** (0.0170)
L.ln_SIS	-0.0105*** (0.000911)	-0.00877*** (0.00177)	-0.0118*** (0.00241)	-0.00730*** (0.00209)
ln_SIS	-0.00471*** (0.00104)	-0.00460*** (0.00131)	-0.00296 (0.00235)	-0.00359** (0.00175)
ln_UNEM		0.0160** (0.00794)	0.0204* (0.0122)	0.0212** (0.00831)
ln_IF			0.00527*** (0.00152)	0.00336** (0.00139)
ln_ERD				-0.0605*** (0.0180)
Constant	0.163*** (0.0171)	0.104*** (0.0372)	0.115*** (0.0422)	0.318*** (0.0464)
Observations	208	208	208	207
Number of countries	26	26	26	26
Sargan test	chi2(41)	23.58508	Prob > chi2	0.9867
Arellano-Bond test	Order 1 z	-3.778	Prob > z	0.000
	Order 2 z	0.307	Prob > z	0.759

Note: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' own research.

After applying the regression model with the new dependent variable, we observed that ICT services have a similar impact on the shadow economy. This confirms that the obtained results are robust and are not significantly influenced by the choice of the specification of the dependent variable according to table no.5 and table no.6. The lag of the HIC variable does not remain as statistically significant and the coefficient is unstable. In the case of the simple HIC we observed a slight decrease in the coefficient and in the end when we added the last control variable it increased again.

Overall, we considered that there is a U-shape in the relationship with the HIC, which we explained as follows: access to boarding schools favors the shadow economy up to a certain level but then drops. The SIS impact has remained the same small, even if we changed the approach. Abu Alfoul, recommend that authorities need to adopt bold policies and support innovation in the ICT sector (Abu Alfoul et al., 2022). Where an essential observation is that the channel through which ICT affects the shadow economy may be financial development, control of corruption and level of education (Ndoya et al., 2023). We appreciate the results for R&D where an increase by 1% is associated with a decrease by 0.104% or 0.0614% or 0.0605% of SE, which validates the robustness test.

3. Alternative estimation: LRC

We applied a nonlinear hypothesis test to assess the relationship between internet access and the size of the shadow economy, assuming the existence of a U-shape in this relationship. We also applied the same treatment for the remaining variables in the context of the four situations presented above. The test results show that the value of Prob>chi2 is less than 0.05, which indicates that the Long-Run Coefficients (LRC) provide a more robust representation.

The nonlinear analysis emphasizes that the effect of digitalization on the shadow economy varies with the initial level of digitalization. These aspects highlight the need to use a model that incorporates long-run effects (Table no.7), as this can comprehensively capture the specificity of the relationship between ICT services and the shadow economy.

Table no. 7. Long-Run Coefficients for all cases

	SE			SE_2			
Lrc_HIC	-0.9207	***		-3.1060	***		
Lrc_SIS			-0.5620	***		-0.0434	*
Lrc_UNEM	0.5198	***	9.0490	**	0.2887	**	0.2563
Lrc_IF	0.0180	***	0.1919	***	0.0300	***	0.0406
Lrc_ERD	-0.3194	***	-2.9971	***	-0.7479	***	-0.7316

Source: Authors' own research.

Our results indicate that both HIC and SIS contribute significantly to the reduction of the shadow economy, digitalization being a valuable explanatory factor for the SE. We accept the hypothesis as we conclude that there is an inversely proportional relationship between the use of ICT services and the size of the shadow economy.

Discussions

The shadow economy is not an isolated phenomenon over time, but a process that depends on its past values. Thus, the use of lags in the analysis provides a more realistic perspective on the dynamics of the shadow economy, as shown in the literature (Baklouti & Boujelbene, 2019; Ndoya et al., 2023). We explain its persistence by the fact that economic agents operating informally develop networks and mechanisms to avoid regulation, which makes it difficult for them to return to the formal economy.

We observe how increasing internet access by 1% decreases the shadow economy by 0.255% (table no.5), when we used SE_2 for robustness checks. Expanding internet access has a positive impact on reducing informal activities, facilitating transparency and access to digital

resources (Adalbert Abraham Ghislain, 2022; Ajide & Dada, 2022; Boitan & Ștefoni, 2023). The effect of the SIS variable on the dependent variable is of low intensity but is highly statistically consistent. In an overall approach, we identify both coefficients with negative and positive sign for the two components of ICT services, which supports the idea that a minimum level of digital maturity is needed to turn the negative effect into a positive response. ICT services can offer advantages in fighting economic and financial crime with the help of digital platforms but can also bring new challenges to the authorities through the emergence of new types of tax avoidance; all of which have a U-shaped impact on the shadow economy (Lv et al., 2024; Nguyen et al., 2024).

Inflation does not have a significant effect on the shadow economy (Amzuică et al., 2023). Our results show an unfavorable situation in which high unemployment increases the shadow economy, but which is explained by the increase in non-performing loans leading to the expansion of the informal sector. Regulators should focus on increasing the security of banking systems by looking carefully at the ways in which the traditionally unbanked use digital financial technologies to access financial services (Verma et al., 2024). A percent of 1% increase in unemployment is associated with an increase in the shadow economy by 0.5198% or 0.2887% (table no.7) and we argue that the relationship indicates that during periods of high unemployment, people resort more frequently to informal economic activities, results confirmed by other researchers (Haruna & Alhassan, 2022; Sahnoun & Abdennadher, 2019; Yamen et al., 2023). We observe that higher investment in R&D stimulates innovation and leads to a decrease in hidden activities, as an increase in the percentage of GDP allocated to R&D spending will contribute to reducing the size of the shadow economy (Nevzorova et al., 2018) hence this spending has an inversely proportional impact on the shadow economy (Amanova, 2022).

Each country needs to ensure that government agencies have the necessary resources to access and analyze information (Alm, 2021), where with the help of digital finance and decreasing cash transactions, the share of the shadow economy in GDP can be reduced (Syed et al., 2021), as governments streamline their information collection and management by implementing digital technologies (Kitsios et al., 2023). New digitalization processes contribute beneficially to removing fiscal rigidity (Zhou et al., 2022) and increasing transparency by creating a more cooperative space between government and stakeholders (Sacchi et al., 2022). In practice, the measures become more effective when informal savings are not prevalent in the business environment, reducing the use of cash, without influencing each other as we have shown SE dependence on the past (Marmora & Mason, 2021).

Conversely, this digitization phenomenon can create the digital shadow economy, which is viewed as an activity carried out illegally in the internet space, relying on the online environment to generate illegal cash flows for the purpose of evading taxes (Gaspreniene et al., 2018). Thus, the spread of the internet can create new forms of criminality through the use of cryptocurrencies and other digital financial instruments (Nguyen et al., 2024). We also take into account the potential unintended consequences of digitization that may arise: the emergence of illegal markets, difficulties in the regulation and fiscal control of the online environment, problems in the protection and supervision of personal data. Therefore, states should consider the proposed investments as they are more vulnerable in times of budget deficits as the effect of rising government spending stimulates the expansion of the shadow economy (Vo et al., 2023). Even though our results are robust and show positive effects of digitalization.

In a final idea, our results are aligned in the literature with the group of researchers who have shown that digitalization reduces the shadow economy, i.e. economic and financial crime,

when we present long run coefficients (table no.7), but taking into account the existence of some instabilities (Achim et al., 2021; Verma et al., 2024).

Conclusion

This study is among the first in the literature to address the impact of ICT services on the shadow economy including the lag variant to capture the persistence of the relationship over time. The results reveal a nonlinear effect, suggesting that the influence of ICT is not uniform, but depends on previous levels of digitalization. At the same time, the estimates are more robust, confirming that the integration of lags provides a more accurate insight into the link between digitalization and the shadow economy. The research makes valuable contributions to the understanding of the affected areas through a graphical representation where we have identified that on average the EU countries in the South-East are deficient and we have looked at it from two points of view. The first is on the size of the informal economy, which suggests that these countries are facing economic instability because these hidden activities are prevalent and perpetuated, but they hinder development and reduce the living standards of the population. The second concerns household internet access, which is low for some countries, but where surprisingly we have identified roughly the same EU countries as for the shadow economy. The results from an econometric point of view indicate that the use of the internet and increasing the security of internet servers play an important role in reducing the size of the shadow economy. A stable economic environment, well-defined strategies and the adoption of technological innovations favor sustainable growth. The study contributes through robustness checks to the validation of the results, where we note that the influence of ICT on the shadow economy retains its magnitude. Few studies analyze the influence of ICT on the shadow economy in the European Union, we analyzed this influence using two different shadow economy databases to compare the results. The innovative contribution is the analysis also applies to internet security servers not only to internet access, where internet access also takes on a different aspect as it targets households.

The level of influence of R&D is low but significant, which is why we recommend that governments direct funds towards investments of this nature because the technological advances generated by R&D investments allow states to implement more effective systems to detect and reduce informal or illegal activities. We recommend encouraging the adoption of digital finance among taxpayers by reducing fees for mobile payments, and governments to limit the use of cash in commercial transactions. We believe that targeted measures to implement digitalization enable governments to implement ICT in an efficient and strategic way to detect informal economic activities and fraudulent transactions, reducing the shadow economy and improving economic transparency. Thus, the deployment of ICT services in the public and private sector facilitates electronic payments and process automation. The research is limited in terms of units observed, as it only covers EU countries, but which may be relevant by extending the sample to the rest of the countries in Europe that were not covered, but we keep in mind that these results are also influenced by other factors such as the economic, legislative and technological context of each country. Where the crisis caused by the pandemic also played an essential role, which may determine new research directions.

Acknowledgement

This article is part of the research project "The Synergistic Effect of Determinants of Sustainable Development in the ECO Region," funded by the Agence Universitaire de la Francophonie in

Central and Eastern Europe (AUF - ECO) as part of the call for projects "Support for Francophone Scientific Research in Central and Eastern Europe – RESCI-ECO - Call for Projects 2024" by AUF ECO.

References

- Abu Alfoul, M. N., Khatatbeh, I. N., & Jamaani, F. (2022). What Determines the Shadow Economy? An Extreme Bounds Analysis. *Sustainability*, 14(10), 5761. <https://doi.org/10.3390/su14105761>
- Achim, M. V., Borlea, S. N., & Văidean, V. L. (2021). Does technology matter for combating economic and financial crime? A panel data study. *Technological and Economic Development of Economy*, 27(1), 223–261. <https://doi.org/10.3846/tede.2021.13977>
- Achim, M. V., Postea, M. M., & Noja, G. G. (2024). New estimate of shadow economy based on the total energy consumption. Evidence from the European Union countries. *Energy Economics*, 130, 107335. <https://doi.org/10.1016/j.eneco.2024.107335>
- Adalbert Abraham Ghislain, M. B. (2022). Does the diffusion of information and communication technologies affect the shadow economy in Africa? *African Development Review*, 34(4), 513–526. <https://doi.org/10.1111/1467-8268.12676>
- Ajide, F. M., & Dada, J. T. (2022). The impact of ICT on shadow economy in West Africa. *International Social Science Journal*, 72(245), 749–767. <https://doi.org/10.1111/issj.12337>
- Alm, J. (2021). Tax evasion, technology, and inequality. *Economics of Governance*, 22(4), 321–343. <https://doi.org/10.1007/s10101-021-00247-w>
- Alstadsæter, A., Johannesen, N., Le Guern Herry, S., & Zucman, G. (2022). Tax evasion and tax avoidance. *Journal of Public Economics*, 206, 104587. <https://doi.org/10.1016/j.jpubeco.2021.104587>
- Amanova, M. (2022). Do R&D and digitalization affect shadow economy in Uzbekistan? *Proceedings of the 6th International Conference on Future Networks & Distributed Systems*, 258–264. <https://doi.org/10.1145/3584202.3584240>
- Amoh, J. K., & Ali-Nakyee, A. (2019). Does corruption cause tax evasion? Evidence from an emerging economy. *Journal of Money Laundering Control*, 22(2), 217–232. <https://doi.org/10.1108/JMLC-01-2018-0001>
- Amoh, J. K., Ofori-Boateng, K., Nsor-Ambala, R., & Bugri Anarfo, E. (2023). Tax efforts and tax evasion—economic development Nexus. Does institutional quality matter? *Cogent Economics & Finance*, 11(2), 2243174. <https://doi.org/10.1080/23322039.2023.2243174>
- Amzuică, B.-F., Mititelu, R.-A., & Nişulescu, I. (2023). Digitalization of Business – Implications on Tax Evasion Dimensions. *Proceedings of the International Conference on Business Excellence*, 17(1), 1888–1896. <https://doi.org/10.2478/picbe-2023-0166>
- Andrushchenko, V., Yershova-Babenko, I., Kozobrodova, D., Seliverstova, A., & Lysakova, I. (2022). Digitalization of society: Implications and perspectives in the context of the psychodimensionality of social reality / psychosynertics. *Revista Amazonia Investiga*, 11(56), 183–195. <https://doi.org/10.34069/AI/2022.56.08.19>
- Bagnall, J., Bounie, D., Huynh, K. P., Kosse, A., Schmidt, T., Schuh, S., & Stix, H. (2016). Consumer Cash Usage: A Cross-Country Comparison with Payment Diary Survey Data. *International Journal of Central Banking*. <https://www.ijcb.org/journal/ijcb16q4a1.pdf>
- Baklouti, N., & Boujelbene, Y. (2019). The Economic Growth–Inflation–Shadow Economy Trilogy: Developed Versus Developing Countries. *International Economic Journal*, 33(4), 679–695. <https://doi.org/10.1080/10168737.2019.1641540>

- Baliamoune, Mina N. (2002) : The new economy and developing countries: Assessing the role of ICT diffusion, WIDER Discussion Paper, No. 2002/77, ISBN 9291902799, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki, URL: <https://hdl.handle.net/10419/53060>
- Baneliene, R., & Melnikas, B. (2019). The Shadow Economy in the Eastern Partnership Countries: Modelling and Estimating in the Context of the Needs to Develop Economic Cooperation Between the European Union and Eastern Partnership Countries. *International Journal of Economic Sciences*, 8(1), 1–19. <https://doi.org/10.20472/ES.2019.8.1.001>
- Bhatti, M. I., Hamelin, N., & Saidov, T. (2024). What drives the hidden side of Uzbekistan's shadow economy? *Post-Communist Economies*, 36(3), 281–297. <https://doi.org/10.1080/14631377.2023.2287757>
- Boitan, I. A., & Ștefoni, S. E. (2023). Digitalization and the Shadow Economy: Impact Assessment and Policy Implications for EU Countries. *Eastern European Economics*, 61(2), 152–180. <https://doi.org/10.1080/00128775.2022.2102508>
- Bond, S. R., Hoeffler, A., & Temple, J. R. W. (2001). GMM Estimation of Empirical Growth Models. *SSRN*, 290522.
- Bozhenko, V., Boyko, A., Vondráček, M., & Karácsony, P. (2024). Shadow economy and financial stability from the perspective of finance digitalization. *Journal of International Studies*, 17(2), 191–205. <https://doi.org/10.14254/2071-8330.2024/17-2/10>
- Brici, I., & Achim, M. V. (2023). Does the Digitalization of Public Services Influence Economic and Financial Crime? *Studies in Business and Economics*, 18(2), 67–85. <https://doi.org/10.2478/sbe-2023-0025>
- Buehn, A., Lessmann, C., & Markwardt, G. (2013). Decentralization and the shadow economy: Oates meets Allingham–Sandmo. *Applied Economics*, 45(18), 2567–2578. <https://doi.org/10.1080/00036846.2012.671923>
- Buszko, A. T. (2018). Cultural Implications for the Shadow Economy. *Engineering Economics*, 29(1), 46–52. <https://doi.org/10.5755/j01.ee.29.1.18069>
- Canh, P. N., & Dinh Thanh, S. (2020). Exports and the shadow economy: Non-linear effects. *The Journal of International Trade & Economic Development*, 29(7), 865–890. <https://doi.org/10.1080/09638199.2020.1759676>
- Cuturela, A., Toma, S., & Simion, C. (2023). *Dimensions of social inclusion in Romania*. https://insse.ro/cms/sites/default/files/field/publicatii/dimensiuni_ale_incluziunii_sociale_in_romania_2022.pdf?utm_source=chatgpt.com
- Doan, N., Phuc Nguyen, C., & Quang Nguyen, B. (2025). How e-Government Affects the Shadow Economy: A Further Analysis. *International Economic Journal*, 1–41. <https://doi.org/10.1080/10168737.2025.2456156>
- Elgin, C. (2013). Internet usage and the shadow economy: Evidence from panel data. *Economic Systems*, 37(1), 111–121. <https://doi.org/10.1016/j.ecosys.2012.08.005>
- Elgin, C., & Iyidost, E. (2022). Velocity of money and shadow economy. *Applied Economics Letters*, 29(18), 1741–1745. <https://doi.org/10.1080/13504851.2021.1961117>
- European system of national and regional accounts in the European Union, (2013) Regulation No. 549/2013 of the European Parliament, URL: <https://eur-lex.europa.eu/eli/reg/2013/549/oj/eng> (accessed 12.11.24)
- Eurostat, Database, URL <https://ec.europa.eu/eurostat/data/database> (accessed 12.11.24).
- Galeeva, N. N., Rogacheva, A. M., Hanafieva, I. R., & Kadesnikova, O. V. (2022). The Tools to Prevent the Shadow Economic Processes During Their Digitalization. In E. G. Popkova

- (Ed.), *Business 4.0 as a Subject of the Digital Economy* (pp. 449–453). Springer International Publishing. https://doi.org/10.1007/978-3-030-90324-4_72
- Gasparėnienė, L., & Remeikienė, R. (2016, mai 12). Shadow economy estimation methods: Digital shadow economy assessment aspect. *9th International Scientific Conference "Business and Management 2016"*. Business and Management 2016, Vilnius Gediminas Technical University, Lithuania. <https://doi.org/10.3846/bm.2016.34>
- Gaspareniene, L., Remeikiene, R., & Ginevičius, R. (2018). Attitudes of European Consumers towards Digital Shadow Economy: Lithuanian and Spanish Cases. *Acta Polytechnica Hungarica*, 15(4), 121–142. <https://doi.org/10.12700/APH.15.4.2018.4.7>
- Goel, R. K., & Saunoris, J. W. (2019). Does variability in crimes affect other crimes? The case of international corruption and shadow economy. *Applied Economics*, 51(3), 239–258. <https://doi.org/10.1080/00036846.2018.1494378>
- Haruna, E. U., & Alhassan, U. (2022). Does digitalization limit the proliferation of the shadow economy in African countries? An in-depth panel analysis. *African Development Review*, 34(S1). <https://doi.org/10.1111/1467-8268.12653>
- Immordino, G., & Russo, F. F. (2018). Cashless payments and tax evasion. *European Journal of Political Economy*, 55, 36–43. <https://doi.org/10.1016/j.ejpoleco.2017.11.001>
- Kitsios, E., Jalles, J. T., & Verdier, G. (2023). Tax evasion from cross-border fraud: Does digitalization make a difference? *Applied Economics Letters*, 30(10), 1400–1406. <https://doi.org/10.1080/13504851.2022.2056566>
- Luong, T. T. H., Nguyen, T. M., & Nguyen, T. A. N. (2020). Rule of Law, Economic Growth and Shadow Economy in Transition Countries. *The Journal of Asian Finance, Economics and Business*, 7(4), 145–154. <https://doi.org/10.13106/JAFEB.2020.VOL7.NO4.145>
- Lv, J., Li, S., Zhu, M., & Huang, W. (2024). Can the digital economy development limit the size of the informal economy? A nonlinear analysis based on China's provincial panel data. *Economic Analysis and Policy*, 83, 896–921. <https://doi.org/10.1016/j.eap.2024.07.022>
- Mara, E. R. (2025). Quo Vadis Shadow Economy in A Digitalized World? Evidence from Panel Cointegration for EU Countries: *Journal of Innovation Economics & Management, Prépublication*(0), 1179–XL. <https://doi.org/10.3917/e.jie.pr2.0179>
- Marmora, P., & Mason, B. J. (2021). Does the shadow economy mitigate the effect of cashless payment technology on currency demand? Dynamic panel evidence. *Applied Economics*, 53(6), 703–718. <https://doi.org/10.1080/00036846.2020.1813246>
- Mazhar, U., & Méon, P.-G. (2017). Taxing the unobservable: The impact of the shadow economy on inflation and taxation. *World Development*, 90, 89–103. <https://doi.org/10.1016/j.worlddev.2016.08.019>
- Medina, L., & Schneider, F. (2018). Shadow economies around the world: What did we learn over the last 20 years? *International Monetary Fund*.
- Medina, L., & Schneider, F. G. (2019). Shedding Light on the Shadow Economy: A Global Database and the Interaction with the Official One. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3502028>
- Mohammadi Khyareh, M. (2019). A cointegration analysis of tax evasion, corruption and entrepreneurship in OECD countries. *Economic Research-Ekonomska Istraživanja*, 32(1), 3627–3646. <https://doi.org/10.1080/1331677X.2019.1674175>
- Ndoya, H., Okere, D., Belomo, M. L., & Atangana, M. (2023). Does ICTs decrease the spread of informal economy in Africa? *Telecommunications Policy*, 47(2), 102485. <https://doi.org/10.1016/j.telpol.2022.102485>

- Nevzorova, E. N., Kireenko, A. P., & Leontyeva, Y. V. (2018). If Development of Technologies can Win Shadow Economy. *2018 XIV International Scientific-Technical Conference on Actual Problems of Electronics Instrument Engineering (APEIE)*, 422–428. <https://doi.org/10.1109/APEIE.2018.8546303>
- Nguyen, C. P., Schinckus, C., Nguyen, Q. B., & Le Tran, D. T. (2024). Digitalization and informal economy: A global evidence of internet usage. *Journal of Industrial and Business Economics*, 51(1), 1–37. <https://doi.org/10.1007/s40812-023-00278-w>
- Nozim Muminov, Shoiria Olimjanova, Akmal Salimov, & Tatyana Kim. (2020). Digitalization AS An Important Factor Of Legalization Of The Shadow Economy. *International Journal on Economics, Finance and Sustainable Development*, 2(2), 16–19.
- Omar, N., Md Amin, W. L., & Abdul Raof, N. (2021). Addressing Offshore Tax Evasion Challenges in the Rising of Digitalization Economy. *Environment-Behaviour Proceedings Journal*, 6(18), 243–248. <https://doi.org/10.21834/ebpj.v6i18.3019>
- Put, S., (2020). The taxpayer's rights between proclamation and guarantee, in Eufire. European Financial Regulation, Ed. *Universităţii Alexandru Ioan Cuza, Iaşi*, p. 462. URL: https://eufire.uaic.ro/wp-content/uploads/2020/10/EUFIRE_2020.pdf
- Rahman, S. U., Faisal, F., Ali, A., Sulimany, H. G. H., & Bazhair, A. H. (2023). Do financial technology and financial development lessen shadow economy? Evidence from BRICST economies using heterogenous bootstrap panel causality. *The Quarterly Review of Economics and Finance*, 90, 201–210. <https://doi.org/10.1016/j.qref.2023.06.005>
- Regulation (eu) 2024/1624 of the European Parliament and of the council, (2024) . EUR-Lex. URL <https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX%3A32024R1624> (accessed 23.12.24).
- Remeikienė, R., Gasparėnienė, L., Bayar, Y., Ginevičius, R., & Ragaišytė, I. M. (2022). ICT development and shadow economy: Empirical evidence from the EU transition economies. *Economic Research-Ekonomska Istraživanja*, 35(1), 762–777. <https://doi.org/10.1080/1331677X.2021.1932545>
- Remeikiene, R., Gasparenienė, L., & Schneider, F. G. (2017). The definition of digital shadow economy. *Technological and Economic Development of Economy*, 24(2), 696–717. <https://doi.org/10.3846/20294913.2016.1266530>
- Sacchi, A., Santolini, R., & Schneider, F. (2022). On the effects of e-participation on shadow economy: A worldwide empirical analysis. *German Economic Review*, 23(3), 463–491. <https://doi.org/10.1515/ger-2021-0076>
- Sahnoun, M., & Abdennadher, C. (2019). *The nexus between unemployment rate and shadow economy: A comparative analysis of developed and developing countries using a simultaneous-equation model*. No. 2019-30.
- Schneider, F. (2022). New COVID-related results for estimating the shadow economy in the global economy in 2021 and 2022. *International Economics and Economic Policy*, 19(2), 299–313. <https://doi.org/10.1007/s10368-022-00537-6>
- Silalahi, P. (2022). Analysis of the effect of ICT, tax and corruption on shadow economy in G20 countries. *Jurnal Ekonomi Dan Kebijakan Pembangunan*, 11(2), 132–145.
- Silveira, J. J. D., Lima, G. T., & Torres, L. B. (2025). Persistence and Pervasiveness of Tax Evasion: An Evolutionary Analytical Framework. *International Journal of Economics and Finance*, 17(2), 87. <https://doi.org/10.5539/ijef.v17n2p87>
- Smith, G. S. (2015). Management models for international cybercrime. *Journal of Financial Crime*, 22(1), 104–125. <https://doi.org/10.1108/JFC-09-2013-0051>

- Syed, A. A., Ahmed, F., Kamal, M. A., & Trinidad Segovia, J. E. (2021). Assessing the Role of Digital Finance on Shadow Economy and Financial Instability: An Empirical Analysis of Selected South Asian Countries. *Mathematics*, 9(23), 3018. <https://doi.org/10.3390/math9233018>
- Sulistiyowati, L. N. ., & Effrisanti, Y. . (2022). The effect of digital finance behavior toward shadow economy in southeast asia countries. *International Conference On Economics Business Management And Accounting (ICOEMA)*, 1, 768-782. Retrieved from <https://conference.untag-sby.ac.id/index.php/icoema/article/view/2207>
- Tran, T. K. P. (2021). Unemployment and Shadow Economy in ASEAN Countries. *The Journal of Asian Finance, Economics and Business*, 8(11), 41–46. <https://doi.org/10.13106/JAFEB.2021.VOL8.NO11.0041>
- Tran, T. P.-K., Tran, N. P., Nguyen, P. V., & Vo, D. H. (2024). Government expenditure–shadow economy nexus: The role of fiscal deficit. *International Journal of Emerging Markets*, 19(2), 322–338. <https://doi.org/10.1108/IJOEM-12-2021-1934>
- Uyar, A., Benkraiem, R., Nimer, K., & Schneider, F. (2024). Education, Digitalization and Tax Evasion: International Evidence. *International Journal of Public Administration*, 47(1), 41–56. <https://doi.org/10.1080/01900692.2022.2082471>
- Veiga, L., & Rohman, I. K. (2017). e-Government and the Shadow Economy: Evidence from Across the Globe. In M. Janssen, K. Axelsson, O. Glassey, B. Klievink, R. Krimmer, I. Lindgren, P. Parycek, H. J. Scholl, & D. Trutnev (Ed.), *Electronic Government* (Vol. 10428, pp. 105–116). Springer International Publishing. https://doi.org/10.1007/978-3-319-64677-0_9
- Verma, A., Giri, A. K., & Debata, B. (2024). ICT Diffusion, Financial Instability, and Shadow Economy: Panel Evidence from SAARC Economies. *Journal of the Knowledge Economy*. <https://doi.org/10.1007/s13132-024-02420-y>
- Viren, M. (2015). Why so little revenues are obtained from a presumed large shadow economy? *Economics of Governance*, 16(2), 101–123. <https://doi.org/10.1007/s10101-015-0165-x>
- Vo, D. H., Tran, N. P., Tran, T. P.-K., Le, Q. T.-T., & Nguyen, P. V. (2023). Government expenditure, budget deficit and shadow economy. *Journal of Economic Policy Reform*, 26(4), 442–460. <https://doi.org/10.1080/17487870.2023.2268250>
- Wang, S., & Li, W. (2024). Effects of ICT and Energy Transition on Sustainable Fiscal Growth: Empirical Evidence from China. *Engineering Economics*, 35(2), 209–221. <https://doi.org/10.5755/j01.ee.35.2.33431>
- World Bank, World Development Indicators, URL <https://databank.worldbank.org/source/world-development-indicators> (accessed 12.11.24).
- Yamen, A., Coskun, A., & Mersni, H. (2023). Digitalization and tax evasion: The moderation effect of corruption. *Economic Research-Ekonomska Istraživanja*, 36(2), 2142634. <https://doi.org/10.1080/1331677X.2022.2142634>
- Yan, F., Chen, B., & Yang, Y. (2024). ICT, Financial Inclusion and the Informal Economy: Evidence from Selected Latin American and Caribbean Countries. *Emerging Markets Finance and Trade*, 60(5), 1002–1017. <https://doi.org/10.1080/1540496X.2023.2266110>
- Yu, C., & Li, Y. (2024). Digitalization of tax collection and enterprises' social security compliance. *International Tax and Public Finance*. <https://doi.org/10.1007/s10797-024-09867-4>
- Zeiler, I., Sallusti, F., Kamprad, A., & Bisogno, E. (2019). *Measuring illegal economic activities and illicit financial flows: Challenges and possible solutions*. 7th IMF Statistical Forum.

https://www.imf.org/en/News/Seminars/Conferences/2019/03/25/7th-statistical-forum?utm_source=chatgpt.com

Zhanabekov, S. (2022). Robust determinants of the shadow economy. *Bulletin of Economic Research*, 74(4), 1017–1052. <https://doi.org/10.1111/boer.12330>

Zhou, S., Zhou, P., & Ji, H. (2022). Can digital transformation alleviate corporate tax stickiness: The mediation effect of tax avoidance. *Technological Forecasting and Social Change*, 184, 122028. <https://doi.org/10.1016/j.techfore.2022.122028>

**PICBE |
2862**