DIGITALIZATION AND SHADOW-ECONOMY REDUCTION IN UZBEKISTAN: THE ROLE OF ELECTRONIC PAYMENTS, E-GOVERNMENT, AND TAX ADMINISTRATION

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ABSTRACT

Digitalization serves as a key driver of transparency and efficiency in public administration and economic activities. It also provides governments with new tools to monitor economic activity and strengthen fiscal governance. This study examines how improvement in digital economy and its tools jointly influence the size of shadow economy and hidden activities in Uzbekistan. Using official secondary data, the research considers three indicators: the United Nations E-Government Development Index, the value of point-of-sale transactions, and tax revenue as a share of GDP. These indicators reflect different dimensions of digital development and the government's capacity to support a more transparent and formal economy. Descriptive statistics, Pearson correlation analysis, and Ordinary Least Squares regression are employed to examine the relationships between digital development and the shadow economy, while tax revenue is considered to provide additional fiscal context. The findings indicate that digitalization indicators increased considerably, whereas the shadow economy share fluctuated throughout the study period. The estimated relationships between the individual digitalization indicators and the shadow economy are negative. These findings suggest that technological progress alone may not be sufficient to ensure a sustained reduction in informal economic activity. The study highlights the importance of strengthening digital tax administration, improving transaction transparency, and enhancing tax compliance to support economic formalization

and economic security in Uzbekistan. Overall, the research contributes to understanding the relationship between digital development and shadow economy within Uzbekistan's evolving economic environment.

Key words: digitalization; shadow economy; e-government; electronic payments; tax revenue; POS transactions; economic security; Uzbekistan.

INTRODUCTION

The shadow economy remains a problem for economic growth especially in developing countries. The shadow economy includes activities that are not fully reported to government authorities and may involve income, informal jobs and tax evasion. A large shadow economy can cut government tax revenue, economic transparency and make competition unfair for businesses. Therefore, cutting economic activity is key to strengthening economic security and supporting sustainable development [1].

Digitalization offers ways to tackle the shadow economy. Electronic payments, e-government services and digital tax administration can make economic transactions clearer. Help government authorities keep track of activity more easily. Electronic payments leave records of each transaction. E-government services cut the need for face-to-face meetings between citizens, businesses and officials. Digital tax systems, such as invoices and online cash registers help tax authorities gather data faster and spot potential tax evasion. Research by Nose and Mengistu (2023) shows that digital technologies can boost tax collection and compliance [2]. However, their success depends on proper laws, strong administration and good digital infrastructure.

Uzbekistan is an example for studying the link between digitalization and cutting the shadow economy. In years Uzbekistan has broadened digital public services and brought new technology into tax administration. Electronic invoices and cash receipts are now processed digitally and automated reporting systems play a role in tax administration. These changes show how digital tools are increasingly used to improve tax reporting and watch business activity.

Nevertheless, having digital systems does not automatically turn every economic activity into a formal one. Despite this progress many challenges stay. Some businesses

may keep underreporting income or work outside registration. Also, low digital skills, access to technology and the cost of compliance can stop some economic actors from using digital services fully. Therefore, it is important to look at not how digital technologies grow but also how they truly help cut informal economic activity. This study aims to see how digitalization can help shrink the shadow economy, in Uzbekistan focusing on three areas: payments, e-government and tax administration. The study looks at how these tools can make transparency boost tax compliance and back formal economic activity. It also pinpoints the challenges that may reduce their effectiveness and gives ideas for making digital technology work better against the shadow economy.

LITERATURE REVIEW

Digitalization is widely expected to limit the shadow economy by increasing transparency and lowering compliance costs. Rohman and Veiga (2017) find that higher e-government development significantly reduces the shadow economy across 128 countries [3]. In tax administration, Nose and Mengistu (2023) conclude that digital tools can improve collection, but gains depend on legal and administrative reforms, connectivity and staff capacity. Digitalization may influence the shadow economy through several interconnected mechanisms, including the wider use of electronic payments, improved access to public services, and more efficient tax administration. At the same time, the effectiveness of digitalization may vary depending on the level of technological development, public access to digital services, and the extent to which businesses and individuals use formal payment systems. Topcu (2025) finds that digital payments reduce the size of the informal economy across 22 countries, with stronger effects in developing countries and where technology use is widespread [4]. However, most evidence comes from cross-country panels, and, to our knowledge, few studies examine Uzbekistan using official statistics. This study addresses that gap for 2010-2024.

METHODOLOGY

This study examines the relationship between digitalization and the shadow economy in Uzbekistan using official secondary data for 2010-2024. The UN E-Government

Development Index (EGDI) is published only every two years, so all variables are matched to the EGDI survey years [5].

The dependent variable is the share of the shadow economy in GDP, comes from the National Statistics Committee of Uzbekistan's SIAT database [6]. The explanatory variables are the United Nations E-Government Development Index (EGDI) and the annual value of point-of-sale (POS) transactions, obtained from the Central Bank of Uzbekistan [7]. Tax revenue as a percentage of GDP is considered as a supplementary contextual indicator using the World Bank's World Development Indicators [8].

Descriptive statistics and Pearson correlation coefficients are used to summarize the variables and examine their relationships. Ordinary Least Squares (OLS) regression is then applied to estimate the associations between the shadow economy and the digitalization indicator. Logarithmic transformations are used for the variables to facilitate elasticity interpretation.

In Stata several diagnostic tests are run to check the OLS model. The Breusch-Pagan/Cook-Weisberg test and the White test look at heteroskedasticity. The Cameron-Trivedi information-matrix test gives model diagnostics. The Shapiro-Wilk and skewness-kurtosis tests assess the normality of the residuals. Variance inflation factors, VIF check for multicollinearity. All tests use a 5% significance level.

Because the sample has eight observations statistical power is low. Five residual degrees of freedom remain in the combined regression. Therefore, the results are seen as links, not proof of causality.

Years	Shadow economy (% of GDP)	UN E-Government Development Index value	POS transactions (bln soums)	Tax revenue (% of GDP)
	Y	X1	X2	X3
2010	7,6	0,44975	5 700	-
2012	7,3	0,50991	12 658	11,809808

2014	8,1	0,46951	22 758	11,927428
2016	7,7	0,54335	53 050	11,822584
2018	6,9	0,6207	63 712	12,152344
2020	6,5	0,6665	81 000	12,698003
2022	7,4	0,7265	177 671	11,455917
2024	7,9	0,7999	303 158	-

Table 1. Database

RESULTS & DISCUSSION

This section examines the relationship between digitalization and the shadow economy in Uzbekistan. The dependent variable (Y) is the share of the shadow economy in GDP, while the independent variables are the UN E-Government Development Index (X1) and the annual value of point-of-sale (POS) transactions (X2). Descriptive statistics, correlation analysis, and OLS regression are used to analyze the relationships between these variables. Tax revenue as a percentage of GDP (X3) is also examined as a supplementary indicator.

Variable	Obs	Mean	Std. dev.	Min	Max
Y	8	7.425	.5257647	6.5	8.1
X1	8	.598265	.1263312	.44975	.7999
X2	8	89963.38	102029.2	5700	303158
X3	6	11.97768	.4186575	11.45592	12.698

Table 2. Descriptive Statistics

The table presents the descriptive statistics for the variables used in the study. The shadow economy (Y) averaged 7.43%, while the EGDI (X1) and POS transaction value (X2) increased over the study period. Tax revenue (X3) has only six observations and is analyzed separately. Overall, the descriptive statistics show that digitalization indicators increased substantially over the period, while the shadow-economy indicator did not decline continuously. These patterns provide a useful starting point for the correlation and regression analyses, but they do not establish a causal relationship.

	lnY	lnX1	lnX2
lnY	1.0000		
lnX1	-0.2695	1.0000	
lnX2	-0.1029	0.9480	1.0000

Table 3. Correlation matrix

Table presents pairwise Pearson correlations of the log-transformed variables. Both explanatory variables have a weak negative correlation with the hidden economy share, and neither is statistically significant (lnX1: r =−0.27, p = 0.519; lnX2: r = −0.10, p = 0.809). The strongest relationship is between the two explanatory variables themselves: lnX1 and lnX2 are almost perfectly correlated (r = 0.948, p < 0.001). Digital government development and POS transaction growth moved together closely over the period, which matters for the regression results below.

Source	SS	df	MS	Number of obs	=	8
				F(1, 6)	=	0.47
Model	.002660728	1	.002660728	Prob > F	=	0.5185
Residual	.033959634	6	.005659939	R-squared	=	0.0727
				Adj R-squared	=	-0.0819
Total	.036620362	7	.00523148	Root MSE	=	.07523

lnY	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnX1	-.0930839	.1357626	-0.69	0.519	-.425283	.2391153
_cons	1.952982	.0770962	25.33	0.000	1.764335	2.14163

Table 4a. OLS Regression Results: Shadow Economy and E-Government Development

Model 1 examines the relationship between e-government development and the shadow economy. The coefficient of lnX1 is negative (−0.0931), so higher e-government development is associated with a smaller shadow economy share. This matches the expectation that digital public services lower compliance costs and administrative burdens and make informal activity harder to sustain. In elasticity terms, a 1% rise in the EGDI corresponds to a 0.09% fall in the shadow economy share. The estimate is imprecise (p = 0.519) and the model explains 7.3% of the variation (R^2 = 0.0727). With only eight observations, the result is best read as an indication of direction, not a firm estimate of the effect size.

Source	SS	df	MS	Number of obs	=	8
				F(1, 6)	=	0.06
Model	.000387417	1	.000387417	Prob > F	=	0.8085
Residual	.036232946	6	.006038824	R-squared	=	0.0106
				Adj R-squared	=	-0.1543
Total	.036620362	7	.00523148	Root MSE	=	.07771

lnY	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnX2	-.0056022	.0221178	-0.25	0.809	-.0597225	.0485182
_cons	2.062876	.2395681	8.61	0.000	1.476674	2.649078

Table 4b. OLS Regression Results: Shadow Economy and Electronic Payments

Model 2 explores the connection between the shadow economy and the value of point-of-sale (POS) transactions. The coefficient for lnX2 is slightly negative at −0.0056. This is in line with evidence that card payments leave a transaction trail and make evasion harder [9]. A 1% rise in POS transaction value corresponds to a 0.006% fall in the shadow economy share ($p = 0.809$, $R^2 = 0.0106$). On its own, electronic payment volume therefore tracks little of the movement in the shadow economy over the period. This makes sense because POS values reflect economic activity, consumption growth and price shifts - factors that aren't directly tied to formalization.

Source	SS	df	MS	Number of obs	=	8
				F(2, 5)	=	1.09
Model	.011085776	2	.005542888	Prob > F	=	0.4060
Residual	.025534586	5	.005106917	R-squared	=	0.3027
				Adj R-squared	=	0.0238
Total	.036620362	7	.00523148	Root MSE	=	.07146

lnY	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnX1	-.5863963	.4051464	-1.45	0.207	-1.627858	.4550658
lnX2	.0820749	.0639004	1.28	0.255	-.0821863	.2463361
_cons	.8069178	.8952825	0.90	0.409	-1.494479	3.108315

Table 4c. OLS Regression Results: Combined Model

Model 3 brings both digitalization measures together. The coefficient for lnX1 is −0.5864 meaning a 1% increase in the EGDI leads to a 0.59% drop in the shadow economy share assuming POS transactions stay constant. This is the effect found in the analysis and it keeps the negative sign seen in Model 1. The coefficient for lnX2 is positive at 0.0821. However, neither of these coefficients is statistically significant ($p = 0.207$ and $p = 0.255$). The model's F-test ($p = 0.4060$) also fails to reject the null indicating the model as a whole is not significant. The R^2 rises to 0.3027. The adjusted R^2 is only 0.0238, which shows the sample has very little statistical power. The shift in coefficient values between Models 1

and 2 and Model 3 is mainly due to the correlation (0.948), between lnX1 and lnX2. As a result, these estimates are only indicative. They do suggest, though that government and electronic payments grew together during the period studied.

Test name	Threshold value	Result(p-value/ statistic)	Decision
Breusch-Pagan/Cook-Weisberg (heteroskedasticity)	$p > 0.05 \rightarrow$ constant variance	0.2165	Fail to reject H_0
White's test (heteroskedasticity)	$p > 0.05 \rightarrow$ constant variance	0.4239	Fail to reject H_0
Cameron & Trivedi IM-test (total)	$p > 0.05 \rightarrow$ valid assumptions	0.5469	Fail to reject H_0
Shapiro–Wilk on residuals (normality)	$p > 0.05 \rightarrow$ normal distribution	0.8559	Fail to reject H_0
VIF (multicollinearity)	$VIF < 10 \rightarrow$no serious multicollinearity	9.87	Close to the threshold of 10

Table 5. Diagnostic Tests

Table 5 reports the diagnostic tests for the combined model. The Breusch-Pagan/Cook-Weisberg test ($p = 0.217$) and White's test ($p = 0.424$) show no evidence of heteroskedasticity, so the null hypothesis of constant error variance is not rejected. The Cameron-Trivedi IM-test ($p = 0.547$) shows no sign of misspecification. The Shapiro-Wilk test on the residuals ($p = 0.856$) is consistent with normality. The variance inflation factor is 9.87 for both explanatory variables, just below the conventional threshold of 10.

The tests indicate that the combined model meets the main OLS assumptions on error variance, specification and residual normality. The reported standard errors and confidence intervals can therefore be interpreted with confidence. The VIF of 9.87 is close to the threshold. This VIF matches the correlation of 0.948 between lnX1 and lnX2. This overlap explains why the coefficients change between Models 1-3 and why the model's estimates

are imprecise: when two regressors move together so closely the combined model has difficulty separating their individual contributions. The EGDI and POS transaction value both rose steadily over 2010-2024 so this is a feature of the data and not a flaw, in the specification.

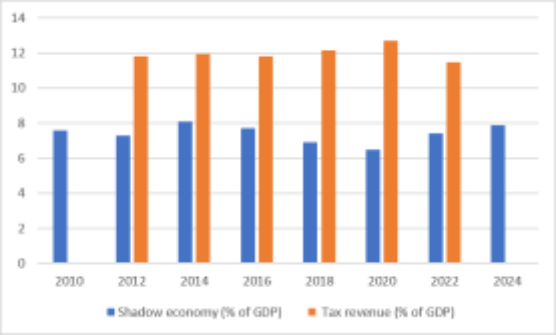


Figure 1: Trends in the Shadow Economy and Tax Revenue in Uzbekistan, 2010–2024

The bar graph illustrates changes in the shadow economy and tax revenue as percentages of GDP in Uzbekistan. The share of the shadow economy declined from 7.6% in 2010 to 6.5% in 2020, before rising to 7.9% in 2024. Tax revenue remained relatively stable between approximately 11.5% and 12.7% of GDP during 2012-2022, reaching its highest level in 2020. These trends provide a comparative overview of the development of both indicators over time. Tax revenue complements the analysis by adding a fiscal dimension to the examination of the shadow economy in Uzbekistan.

CONCLUSION AND POLICY RECOMMENDATIONS

This study examined whether digitalization is associated with a smaller shadow economy in Uzbekistan in 2010-2024. The e-government index rose from 0.45 to 0.80 and POS transactions grew about 53-fold, yet the shadow economy share fell from 7.6% to 6.5% by 2020 and then rose to 7.9% in 2024. Both indicators show the negative sign in separate regressions (−0.093 and −0.006) but neither is statistically significant and the correlation between them is strong (0.948). The results do not say that digitalization tools are ineffective. They suggest that expanding digital tools is not enough on its own.

From a policy perspective Uzbekistan should keep developing tax administration, electronic invoicing and online cash-register systems to improve transaction transparency

and tax compliance. Public authorities should also simplify reporting procedures improve digital literacy and make sure that small businesses can access electronic services.

Furthermore, digital reforms should come with enforcement and measures that encourage businesses to operate formally. The effectiveness of these policies should be evaluated using indicators of tax compliance and informal economic activity.

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