Research paper / Оригинальная статья
https://doi.org/10.51176/1997-9967-2025-3-6-18
МРНТИ 06.56.71
JEL: C23; E26; O17

Factors of Informal Economy Development in Central Asia and the Caucasus

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For citation: Tleppayev, A.M., Velesco, S., Khaustovich, N.A. & Sadykov, E.T. (2025). Factors of Informal Economy Development in Central Asia and the Caucasus. Economy: strategy and practice, 20(3), 6-18, https://doi.org/10.51176/1997-9967-2025-3-6-18

ABSTRACT

Informal economic activity poses significant challenges to fiscal capacity, regulatory efficiency, and inclusive development across the region. The purpose of this study is to identify and analyze the key factors influencing the level of the informal economy in Central Asia and the Caucasus. The empirical database is based on panel data for six countries (Kazakhstan, Kyrgyzstan, Tajikistan, Azerbaijan, Armenia, and Georgia) compiled from statistics from the World Bank and the IMF. A panel regression model with random effects was applied, taking into account the impact of macroeconomic and institutional variables. The results show that higher GDP per capita significantly reduces the size of the informal economy (coefficient –0.00026, $p < 0.001$), confirming the inverse relationship between income and the shadow sector. Financial development has a strong negative impact (–13.43, $p < 0.001$), highlighting the role of infrastructure and digital finance in formalization. Urbanization demonstrates a dual effect: in its early stages, it contributes to the growth of informal employment, but in mature urban systems, it reduces its level (–0.41, $p < 0.001$). Trade openness, on the contrary, positively correlates with the informal economy (+0.019, $p<0.001$), which indicates the risks of liberalization without accompanying digitalization of customs procedures. The findings confirm the need for targeted state measures to formalize the economy through digital tax infrastructure, expanded financial inclusion, and simplified business registration procedures. Future research may focus on examining tax distortions and wealth inequality as factors sustaining the informal sector.

KEYWORDS: Economy, Informal Economy, Economic Growth, Urbanization, Financial Development, Foreign Trade Turnover

CONFLICT OF INTEREST: the authors declare that there is no conflict of interest

FINANCIAL SUPPORT. The study was conducted within the framework of the targeted financing program of the Science Committee MSHE RK “Modernization of the distribution relations system and reduction of income inequality of the population of the Republic of Kazakhstan” IRN BR21882165.

article history:
Received 11 May 2025
Accepted 12 August 2025
Published 30 September 2025

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Факторы развития неформальной экономики в странах Центральной Азии и Кавказа

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Для цитирования: Тлеппаев А.М., Велеско С., Хаустович Н.А., Садыков Е.Т. (2025) Факторы развития неформальной экономики в странах Центральной Азии и Кавказа. Экономика: стратегия и практика, 20(3), 6-18, https://doi.org/10.51176/1997-9967-2025-3-6-18

АННОТАЦИЯ

Неформальная экономическая деятельность создает значительные трудности для фискальной устойчивости, эффективности регулирования и инклюзивного развития в регионе. Цель данного исследования – выявить и проанализировать ключевые факторы, влияющие на уровень неформальной экономики в странах Центральной Азии и Кавказа. Эмпирическая база основана на панельных данных по шести странам (Казахстан, Кыргызстан, Таджикистан, Азербайджан, Армения и Грузия), собранных из статистики Всемирного банка и МВФ. В качестве метода использована панельная регрессионная модель со случайными эффектами, учитывающая влияние макроэкономических и институциональных переменных. Результаты показали, что рост ВВП на душу населения статистически значимо сокращает размеры неформальной экономики (коэффициент – 0,00026, $p < 0,001$), подтверждая обратную зависимость между доходом и теневым сектором. Финансовое развитие оказывает сильное отрицательное влияние (–13,43, $p < 0,001$), подчеркивая роль инфраструктуры и цифровых финансов в формализации. Урбанизация проявляет двойственный эффект: на ранних стадиях способствует росту неформальной занятости, однако в зрелых городских системах снижает её уровень (–0,41, $p < 0,001$). Открытость торговли, напротив, положительно коррелирует с неформальной экономикой (+0,019, $p < 0,001$), что указывает на риски либерализации без сопутствующей цифровизации таможенных процедур. Полученные результаты подтверждают необходимость реализации целенаправленных государственных мер по формализации экономики через цифровую налоговую инфраструктуру, расширение финансовой доступности и упрощение процедур регистрации бизнеса. Будущие исследования могут быть направлены на изучение налоговых искажений и неравенства в распределении богатства как факторов, поддерживающих неформальный сектор.

КЛЮЧЕВЫЕ СЛОВА: экономика, неформальная экономика, экономический рост, урбанизация, финансовое развитие, внешнеторговый оборот

КОНФЛИКТ ИНТЕРЕСОВ: авторы заявляют об отсутствии конфликта интересов

ФИНАНСИРОВАНИЕ. Исследование проведено в рамках программы целевого финансирования Комитета науки МНВО РК «Модернизация системы распределительных отношений и снижение неравенства доходов населения Республики Казахстан» ИРН BR21882165.

История статьи:
Получено 11 мая 2025
Принято 12 августа 2025
Опубликовано 30 сентября 2025

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INTRODUCTION

The shadow economy (also "underground economy") is defined as unreported income from the production of legal goods and services that is deliberately concealed from public authorities to evade taxes, social contributions, regulations, or administrative procedures (Schneider & Enste, 2002). Within national accounts, the OECD (2002) grouped such hidden activities together with criminal transactions and household self-production under the broader concept of the non-observed economy (NOE). Later studies expanded and refined these distinctions. Schneider and Asllani (2022) emphasized the fiscal dimension of informal activity within European frameworks, while the World Bank (2022) adopted the broader term "informal economy", covering legal production and employment that are unregulated or unregistered, such as informal self-employment and small, unregistered firms, while excluding illegal activities and household own-use production.

The study adopts a narrow definition of informal output, understood as legal market activities that are neither registered nor taxed. Illicit trade and household self-production are excluded. The term shadow economy is used only when citing studies that employ this historical label, which typically focuses on taxevading but otherwise legal activities. Quantifying activity designed to remain hidden is inherently problematic. Estimates, therefore, rely on indirect methods - currencydemand equations, discrepancies in national accounts, or structural "multipleindicators multiplecauses" (hereinafter – MIMIC) models, each capturing different parts of the phenomenon and yielding a range rather than a single figure (Polese et al., 2022).

Despite measurement difficulties, a consistent picture emerges. An EY analysis of 131 countries finds that informal output averaged 11.8 % of world GDP in 2023, with a much higher country mean of ≈19 %, reflecting the weight of low-income economies; 119 countries have nonetheless reduced their informal share since 2000, by a median 6–7 p.p. of GDP. Regional contrasts are stark: North America and Western/Northern Europe record shares below 7 %, whereas East and Central Africa exceed 30 % (EY, 2025). The smallest proportion of shadow economy in terms of GDP is observed in the following countries: North America (5.0%), Western Europe (6.6%), Northern Europe (6.6%), Southern Europe (6.6%), and the Middle East (8.2%). The largest is in East Africa (41.6%), Central Africa (33.8%), and South Asia (27.2%).

The key reasons for the development of informality include the following factors. Institutional factors, such as the low efficiency of public administration, are a concern. Poor public services, weak political stability, and corruption reduce trust in institutions. An imperfect legal system and opaque laws, along with inequality before the law and weak law enforcement, create a ground for tax evasion.

Economic factors, such as high tax rates, encourage businesses and individuals to hide income. High unemployment forces people to work in the informal sector. Underdeveloped banking systems and electronic payments encourage the use of cash, which is more difficult to trace.

Social and demographic factors, such as low levels of education and skills, limit access to the formal sector and increase dependence on informal schemes. The high proportion of family workers and micro-enterprises leads to a lack of activity registration. Technological and structural factors include the prevalence of cash payments, which is more difficult to control and makes it easier to conceal income, as well as poor adoption of digital technologies, such as the lack of electronic payments, online business registration and digital tax systems. External shocks, such as economic crises, lead to a temporary increase in informal activity due to reduced revenues and increased regulation.

The costs are equally well documented: lost tax revenue, distorted competition, lower productivity, weaker social protection, and eroded public trust in state institutions. Unlocking the economic potential of informal businesses, therefore, requires a dual strategy - reducing the incentives to stay hidden while easing pathways to formality, primarily through digital payment ecosystems and risk-based tax administration.

This study contributes by analyzing the determinants of informal output in Central Asia and the South Caucasus with an updated panel (20002023) and an extended set of digitalgovernance indicators, thereby addressing the measurementdefinition gap highlighted above. Thus, the present study aims to empirically verify the impact of macroeconomic and institutional determinants on the level of informal economy in countries of Central Asia and the South Caucasus.

LITERATURE REVIEW

Since the early 1990s, the European Union has initiated several studies to investigate the activities of the shadow economy, such as those conducted by the European Foundation for the Improvement of Living and Working Conditions. Gutmann (1977) was among the first to characterize the shadow economy, describing it as a significant amount of

undeclared business and income ignored by official statistics. Building on this, Tanzi (1980) defined it more precisely as the portion of gross national product not accounted for or measured in official statistics, emphasizing the monetary component of hidden transactions and excluding barter and other non-monetary forms. Later, Schneider and Enste (2000) broadened the concept, defining the shadow economy as legal activities deliberately concealed from authorities to avoid taxes and regulations.

Empirical studies show an increase in the size and development of the global shadow economy (Feld & Schneider, 2011; Schneider et al., 2010; Williams & Schneider, 2016; Hassan & Schneider, 2016). Elgin et al. (2021) presented the first comprehensive database on the informal economy, combining model estimates (MIMIC, DGE) and direct survey data (employment, perception). The database covers more than 160 countries for the period 1990-2018, allowing cross-country and temporal comparisons. Polese et al. (2022) defined the informal economy as broader, including both legal and illegal activities outside the formal economy, such as unregistered businesses, informal employment, and unreported income.

There are numerous studies in the literature on the size of the shadow economy that is defined as all forms of unreported activities, including total undeclared wages and hidden business operations (Adair, 2021; Elgin, 2012; Elgin & Oztunali, 2012; Orsi et al., 2014; Quintano, Mazzocchi, 2013; Schneider et al., 2010; Schneider & Enste, 2000). According to Hussmanns (2004), the informal economy consists of two main components: the informal sector and informal employment. The informal sector includes the activities of unregistered enterprises, such as sole proprietors or small businesses, that are not subject to national regulations. Informal employment refers to all workers who do not have formal labor contracts, lack social security benefits, and do not pay taxes. To measure the scope of the informal economy, the ILO recommends using data from labor force surveys, which consider factors such as enterprise registration, the presence of written contracts, tax payments, and social security coverage.

Perry et al. (2007) distinguished between the informal economy and the shadow economy. The informal economy includes all unregulated economic activities, both legal and illegal, such as unregistered businesses and workers without formal contracts. The shadow economy refers explicitly to legal activities that are deliberately concealed to avoid taxes, regulations, or legal obligations. To measure these economies, the World Bank uses models like the Multiple Indicators Multiple Causes (MIMIC) and Dynamic General Equilibrium (DGE), along with direct measures from surveys on labor force, business registration, and social protection coverage.

Ginevicius et al. (2020) argued that national economic development can play an important role in reducing the shadow economy. They conclude that "the higher the level of national economic development, the smaller the size of the shadow economy". Many studies, notably by Feld and Schneider (2011), argued that the decision of citizens to work in the shadow economy is closely related to the growth and development of the formal economy. Economic growth encourages businesses and entrepreneurs to work in the formal sector because businesses make good profits and workers are well compensated. However, in the reverse situation, when the formal economy fails, people will seek the shadow economy to compensate for the reduction in income (Schneider et al., 2010). One of the main problems with the shadow economy pertains to the inefficient utilization of production factors and other economic and human resources. Should the shadow economy exhibit growth concerning the formal economy, this may result in the migration of entrepreneurs and workers from the formal economy to the informal sector. This migration may be driven by the desire to reduce expenditure on operations by avoiding taxes, regulations and other costs. The relationship between the formal and the informal economy is ambiguous.

Bitzenis et al. (2016) identified GDP growth as one of the drivers of the shadow economy. Similarly, Schneider and Williams (2013) showed that GDP growth is one of the main drivers of the shadow economy. On the one hand, some studies showed that the relationship between the formal economy and the shadow economy is negative (Dell'Anno & Solomon, 2008; Schneider & Enste, 2000). Since the growth of the official economy may cause workers and businesses to move from the shadow economy to the official economy to benefit from the growing economy, as a result, the shadow economy will degrade. On the contrary, Feld and Schneider (2011) indicated that the formal and shadow financial systems have a favorable relationship. They argue that during the expansionary stages of the market cycle, the informal sector also expands as it fulfils demands that are not satisfied by the formal financial system. In other words, when the formal economy grows, the shadow economy also grows alongside it. Studies show that when competition is reduced, shadow entrepreneurs are given the means to circumvent strict government regulations aimed at controlling the informal sector. Separate studies

demonstrate that the growth of the shadow economy has long-term positive effects on economic growth. In line with this, Williams (2006) found a favorable relationship between the shadow economy and economic growth. In the context of economies, the positive relationship between the formal economy and the shadow economy suggests that a country with higher economic growth in its formal economy may attract firms and enterprises from the shadow economy to the formal economy.

Structural reconfiguration of labor markets and accelerated digitalization keep informal output and employment central to policy debates in Central Asia and the South Caucasus, justifying refreshed determinant models incorporating institutional and technological variables. A regional panel for Kazakhstan (16 regions, 2013–2022) reports the informal (shadow) share falling to ~17.5% of GDP in 2023 with a projected further decline, highlighting income, unemployment and regional heterogeneity as core drivers, evidence reinforcing the inverse income, informality relationship and motivating inclusion of log GDP per capita and structural controls (Tleppayev et al., 2025). Adambekova et al. (2022) compared the volumes of capital export, GDP, the shadow economy and the role of the cash market in reducing the size of the shadow economy in Kazakhstan. Around one third of Kazakhstan's workforce remains informal; gaps between estimated wage mass and recorded pension contributions signal sizeable undeclared remuneration, supporting labormarket channels (social protection, contribution incentives) in formalization strategies (Beisembina et al., 2025).

Household panel evidence shows vulnerable employment depresses earnings, especially for women, underscoring informality's buffer role and the potential of gendersensitive financial inclusion to stabilize formal incomes (Karymshakov et al., 2023). Currency demand and employmentbased approaches yield dispersed informality estimates (≈20% vs. up to ~30%), emphasizing sensitivity to measurement choice and the need to clearly distinguish the informal output (% of official GDP) metric used here from alternative proxies (Khalatyan & Hakobyan, 2024). Mixed (pro and countercyclical) responses of informality to business cycles justify dynamic panel specifications with lagged dependent terms and endogeneity diagnostics in estimating persistence and adjustment speeds.

Recent scholarship shifts from static size estimation toward channel analysis (financial inclusion, institutional transparency, structural disparities, innovation incentives). A comprehensive multicountry panel simultaneously covering all six Central Asian and South Caucasus economies with integrated digital tax control and payment digitalization indicators is still absent - defining the principal research gap and the novelty of the proposed expanded, dynamic model.

Accordingly, the following hypothesis is formulated for empirical testing.

H1: A higher real GDP per capita is associated with a reduction in informal output.

Other factors include unemployment, regulations, taxes and social benefits, weak governance, inflation and level of financial sector development (Bittencourt et al., 2014; Bose et al., 2012; Dell'Anno & Solomon, 2008; Friedman et al., 2000; Schneider& Bajada, 2005). Esaku (2021) found that a reduction in income inequality in Uganda can diminish the size of the shadow economy. On the other hand, Safuan et al. (2021) noted that financial sector development and the size of the shadow economy have a non-linear relationship, which shows an inverted U-shaped curve. It was also shown that foreign direct investment reduces the shadow economy in Indonesia, and income growth expands the shadow economy, while the poverty index shows mixed results. Economic integration and trade openness are less ambiguous: the role of economic integration in economic growth has been well described in the literature since the 1950s (Shahbaz, 2012). Trade openness encourages specialization in sectors across countries (Were, 2015), promoting the need for formal licenses or patents that reduce informal activities in these sectors. Conversely, however, trade openness may actually stimulate the shadow economy as a result of illegal trade activity. If trade openness leads to a decrease in domestic producers and thus a decrease in labour demand (Vashisht, 2016). In this context, trade openness may lead to a higher informal economy, as well as the dual effect of digital customs control and risks of avoidance schemes; there is a need to consider institutional quality and e-invoicing regimes.

H2: Trade openness has an ambiguous effect: positive (formalization through supply chain standards) or negative (expansion of undeclared turnover channels) effects.

Urbanization: migration from rural to urban areas can lead to an increase in informality. Ndoya and Djeufack (2021) showed that there is an inverse U-shaped relationship between urbanization and the informal economy. In the initial phase, urbanization increases the informal economy in Africa and at a later stage, the effect of urbanization on the informal economy decreases with the interaction of governance quality.

In advanced digitalization, urbanization correlates with a reduction in informal output. Concentration of economic activity facilitates monitoring, e-invoicing implementation, platform cash solutions, and CBDC pilots. Bellon et al. (2022) noted that the reform's positive effects on tax collection were partially offset by issues in the VAT refund mechanism, suggesting that digital tools like e-invoicing should be complemented by other reforms to improve revenue mobilization.

H3: urbanization growth has a positive effect on the informal economy.

Financial development: the literature has noted the impact of financial development on the informal economy. Njangang et al. (2020) showed that financial development is an important determinant of the informal economy in 41 Sub-Saharan African (SSA) countries over the period 1991-2015. They found that financial development reduces the size of the informal economy and that there is a U-shaped relationship between financial development and the informal economy. Broad access to payment infrastructure, credit, and digital products reduces transaction costs of formalization.

H4: deepening financial development leads to a reduction in informal output.

METHODOLOGY

The objective of this study is to identify and empirically assess the determinants of the informal economy in the countries of Central Asia and the Caucasus. For this purpose, a panel data model is employed to estimate the impact of selected macroeconomic and structural variables on the size of the informal economy. The dataset covers six countries over a 20-year period (2001–2020), providing a balanced panel structure. The dependent variable is the share of the informal economy in GDP, while the explanatory variables capture economic growth, trade openness, financial development, and urbanization.

The share of the informal economy was taken as the dependent variable. The relationship is specified through a panel regression model, represented in formula (1):

$$OIE_{it} = \alpha + \beta_1 GDPpc_{it} + \beta_2 TRADE_{it} + \beta_3 FINDEV_{it} + \beta_4 URBAN_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where:

OIE*it* – denotes the output of the informal economy (% of GDP) for country *i* in year *t*;

GDP*pc* – GDP per capita;

TRADE – trade openness measured as the ratio of exports and imports to GDP;

FINDEV- represents the financial development index;

URBAN – the share of the urban population;

μ_i – captures unobserved country-specific effects;

ε_{it} – the idiosyncratic error term.

To construct the panel data model, information for Kazakhstan, Kyrgyzstan, Tajikistan, Azerbaijan, Armenia, and Georgia was collected from IMF and World Bank databases. The estimates of the informal economy were derived from the World Bank dataset based on the Multiple Indicators Multiple Causes (MIMIC) approach, which is widely applied in the literature to assess informal activity. Since the informal economy is a latent (hidden) variable that cannot be directly observed, the MIMIC model enables its evaluation by linking observable indicators with underlying causal factors. Table 1 presents the variables employed in the model specification and their coding for the empirical analysis.

Table 1. Description of the selected variables for the model construction

Variable	Description	Unit / Scale	Source
OIE	Output of informal economy estimated by the MIMIC model	% of GDP	World Bank
GDPCAPITA	Gross domestic product per capita	Constant 2015 US$	World Bank WDI
TRADE	Trade openness (sum of exports and imports of goods and services relative to GDP)	% of GDP	World Bank WDI
FINDEV	Index of financial development (depth, access, efficiency of financial institutions & markets)	Index (0–1)	IMF database
URBAN	Share of population residing in urban areas	% of total population	World Bank WDI

Note: compiled by authors

Panel data combine both cross-sectional and time-series dimensions, which makes them particularly valuable in empirical economic research. A key advantage of panel datasets is the larger number of observations relative to pure time-series or cross-sectional data. This increases the degrees of freedom, reduces collinearity among explanatory variables, and improves the efficiency of econometric estimation. Furthermore, panel data provide opportunities to capture heterogeneity across countries or entities, and allow for dynamic adjustments that cannot be adequately identified using only time-series or cross-sectional techniques.

In applied econometrics, three principal models are commonly employed to analyze panel datasets: the pooled ordinary least squares (pooled OLS), the fixed-effects (FE) model, and the random-effects (RE) model. The pooled OLS estimator treats the data as if they were a single large cross-section, ignoring the panel structure. While simple, this approach assumes homogeneity across countries and does not account for unobserved heterogeneity, which can bias estimates.

The fixed-effects model addresses this limitation by introducing entity-specific intercepts. It controls for unobserved, time-invariant heterogeneity that may correlate with the explanatory variables. In the context of this study, the FE specification would, for instance, allow each country in the sample (Kazakhstan, Kyrgyzstan, Tajikistan, Azerbaijan, Armenia, and Georgia) to have its own baseline level of informality, reflecting institutional or cultural characteristics that remain relatively stable over time.

The random-effects model, by contrast, assumes that unobserved country-specific effects are randomly distributed and uncorrelated with the explanatory variables. This specification is more efficient than FE if the assumption holds, since it exploits both within-country (over time) and between-country (cross-sectional) variation. However, if the unobserved effects are correlated with the regressors, RE estimates become inconsistent, while FE remains consistent.

To formally choose between fixed and random effects, a Hausman test should be used, with the null hypothesis that the random effects model is preferred to the fixed effects model.

RESULTS

In Armenia, the MIMIC base shows a decline from 48.4% in 1993 to 42.2% in 2019, but a slight increase to 43.6% in 2020. In Azerbaijan, the peak was in 2000 (60.6%), followed by a gradual decline. Georgia has the highest level of informality, but also shows a slow decline. Kazakhstan and Kyrgyzstan show a steady decline. All countries except Tajikistan (according to DGE) show a decline in informality. Leading the decline: Georgia (-6.6 p.p.), despite its still high level (61.8% in 2020). Kazakhstan (-5.0 p.p.) - the most stable positive dynamic. Thus, it is shown in more detail in Figure 1.

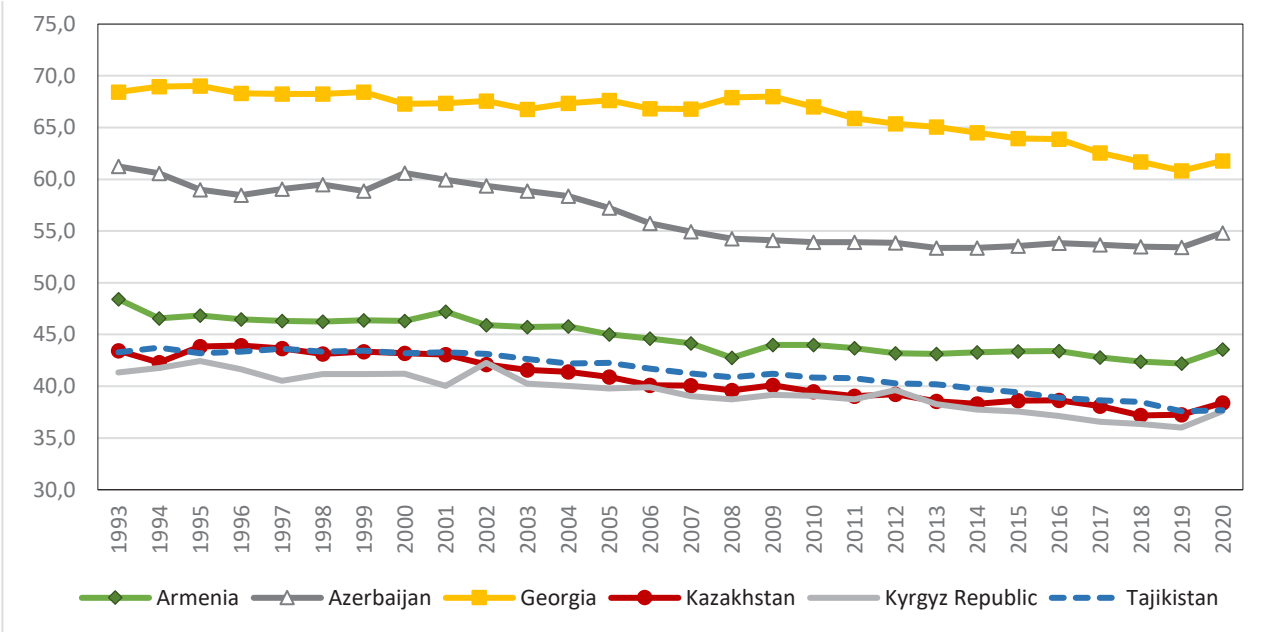

Figure 1. Dynamics of informal economy level by countries for 1993-2020

Note: compiled by the authors based on data World Bank (2022)

For a more comprehensive understanding of the dynamics of the informal economy in the countries of Central Asia and the Caucasus, a preliminary descriptive analysis was conducted. The results indicate that in 2020 the share of the informal economy increased in Armenia (+1.4 p.p.), Azerbaijan (+1.3 p.p.), and Georgia (+1.0 p.p.), reflecting the impact of the COVID-19 pandemic. At the same time, the long-term decline in informality observed in Armenia, Azerbaijan, and Kyrgyzstan can be associated with tax administration reforms, digitalization processes, and deeper integration into the global economy (Table 2).

Table 2. Key trends in Central Asia and Caucasus countries for 1993-2020

Country	Dynamic	Peak values	Minimum values	Change (1993–2020)	Specific periods
Armenia	Decline with fluctuations	47,2% (2001)	42,2% (2019)	-4,8 p.p	Growth in 2020 (+1,4 p.p.)
Azerbaijan	Decline after the growth	60,6% (2000)	53,4% (2019)	-6,4 p.p	Peak in 2000, then gradual decline
Georgia	Slow decline	69,0% (1994–1995)	60,8% (2019)	-6,6 p.p	The highest level in the region
Kazakhstan	Stable decline	43,9% (1996)	37,2% (2018)	-5,0 p.p.	Greatest progress since 2005
Kyrgyzstan	Fluctuations with decline	42,4% (1995)	36,0% (2019)	-3,7 p.p	Slight growth in 2012 (+0,9)
Tajikistan	Decline	43,7% (1994)	37,6% (2019)	-5,6 p.p	Downward trend

Note: compiled by authors

The informal economy shows similar cycles to the formal economy. In developing countries, recessions are deeper and recoveries stronger than in developed countries. Unlike the formal sector, employment in the informal economy is weakly cyclical (acyclical). This is due to wage flexibility and changes in labor intensity.

To construct a panel data model, we first have to choose between a fixed effects model and a random effects model. According to the results of the Hausman test, the $\chi 2$ statistic is 4.8 and the probability (p-value) is 0.313, indicating that there is no reason to reject the null hypothesis. This means that the random effects (RE) model is preferred because the individual effects (between-group differences) are not correlated with the regressors. The random effects model is consistent and efficient. The random effects model differs from the fixed effects model and general models in that it does not use the method of least squares, but the principle of maximum likelihood. Thus, in the model we are interested in the behavior of the population as a whole, i.e. the conclusion is made regarding the characteristics of the general population and it is possible to generalize the conclusion beyond the sample used in the model.

Table 3 reports the results of the Hausman specification test, which is used to decide between fixed and random effects.

Table 3. Hausman test results according to the Eviews program

Test Summary		**Chi-Sq. Statistic**	**Chi-Sq. d.f.**	**Prob.**
Cross-section random		4.758597	4	0.3130
Cross-section random effects test comparisons				
Variable	Fixed	Random	Var (Diff.)	Prob.
GDPCAPITA	-0.000259	-0.000260	0.000000	0.1177
FINDEV	-12.706691	-13.434175	0.146770	0.0576
URBAN	-0.460658	-0.410109	0.000708	0.0574
TRADE	0.018684	0.018915	0.000000	0.0545
*The null hypothesis states that the random effects model is consistent and efficient. Since Prob. = 0.313 > 0.05, the null cannot be rejected, suggesting that the random effects estimator is preferred.				

Note: compiled by authors basing on Eviews

The low p-values for the financial development, urbanization and trade openness variables indicate possible differences between the fixed and random effects models. However, the overall Hausman test statistic ($\chi^2 = 4.76$, $p = 0.313$) indicates that these differences are not statistically significant at the 5% level. Therefore, the null hypothesis of consistency of the random-effects estimator cannot be rejected. Random effects model RE is efficient: exploits both within-group and between-group variation, provides estimates with lower variance, allows estimation of time-constant variables (e.g. gender, country), suitable for data with rare observations or a small number of periods.

Given that the Hausman test supports the use of the random-effects specification, the next step is to estimate the model using the RE estimator. Table 4 reports the results of the random-effects regression, which evaluates the impact of GDP per capita, financial development, urbanization, and trade openness on the share of the informal economy in GDP.

Table 4. Model of random effects for panel data

Variable	Coefficient	Std. Error	t-Statistic	Prob.	
GDPCAPITA	-0.000260	5.86E-05	-4.437587	0.0000	
FINDEV	-13.43418	2.816384	-4.770009	0.0000	
URBAN	-0.410109	0.112586	-3.642645	0.0004	
TRADE	0.018915	0.004729	4.000035	0.0001	
C (constant)	68.76178	7.874635	8.732059	0.0000	
Effects Specification					
			S.D.	Rho	
Cross-section random			14.40685	0.9957	
Idiosyncratic random			0.944401	0.0043	
Weighted Statistics					
R-squared	0.694610	Mean dependent var		0.708142	
Adjusted R-squared	0.683403	S.D. dependent var		1.684258	
S.E. of regression	0.947681	Sum squared resid		97.89287	
F-statistic	61.98010	Durbin-Watson stat		0.549159	
Prob(F-statistic)	0.000000				
Unweighted Statistics					
R-squared	-0.942512	Mean dependent var		47.09329	
Sum squared resid	22049.72	Durbin-Watson stat		0.002438	

Note: compiled by authors basing on Eviews

All the estimates obtained have a t-statistic value greater than the critical modulus. Consequently, the hypothesis that these coefficients are equal to zero is rejected with a probability of error equal to 0.05, and the coefficients obtained are significant. We can therefore conclude that these variables influence the informal economy indicator. According to the model calculations, the presented factors have an impact on the size of the informal economy and are presented in Table 5.

Table 5. Assessment of the influence of the highlighted factors on the level of the informal economy

Factor growth by 1-unit causes	Change in the output of informal economy per unit
GDPpercapita	- 0,0003
Findev	-13.43
Urban	-0,41
Trade	0,019

Note: compiled by authors

Between-group (cross-section) effects: 14.406 dominate, Rho = 0.9957. 99.57% of the total variance is explained by differences between groups (countries/regions). This confirms the appropriateness of the choice of the random effects model. Based on the analysis of the informal economy in the countries of Central Asia and the Caucasus, we can derive the following key economic conclusions:

1) economic growth tends to decrease the size of the informal economy in both the short and long terms. The informal sector contracts when the formal economy expands. However, in times of economic downturns, the informal economy increases as a coping mechanism for businesses and individuals;

2) there is a significant inverse relationship between financial development and the size of the informal economy. As financial infrastructure improves and access to financial services expands, the scope of informal activity declines. At the same time, the relationship may be non-linear, which suggests the need for further research on the nuanced impact of financial sector development on informality;

3) urbanization initially boosts informal employment, but as cities grow and governance improves, the effect of urbanization on informality diminishes. Moreover, digitalization in urban areas, such as the introduction of electronic payment systems, can further facilitate the formalization of businesses;

4) trade openness has a dual effect. On the one hand, it may stimulate the informal economy through illegal trade flows and undeclared transactions. On the other hand, it can support formalization by reducing trade barriers, strengthening institutional frameworks, and fostering deeper economic integration.

The recommendations should focus on targeted policy measures derived from the study's findings.

First, strengthening financial infrastructure is essential. Expanding access to financial services, for instance through subsidies for opening bank accounts and the promotion of electronic Know Your Customer (e-KYC) procedures for micro-entrepreneurs, can enhance financial inclusion. At the same time, the development of digital payment systems, including central bank digital currencies (CBDCs), reduces reliance on cash and limits opportunities for concealing informal activity.

Second, simplification of registration and taxation procedures for small and medium-sized enterprises should be prioritized. The introduction of user-friendly digital instruments for tax filing and e-invoicing can lower entry barriers into the formal sector, while digital platforms for employment monitoring would enable more effective oversight of informal labor relations.

Third, trade openness requires parallel investments in digital customs infrastructure. The implementation of risk-based customs analytics supported by artificial intelligence can strengthen transparency in cross-border operations, ensuring that trade liberalization contributes to formalization rather than to the expansion of informal channels.

Finally, urbanization processes call for the development of smart infrastructure that facilitates the automatic registration and reporting of business activities. Examples include the use of smart cash registers and geo-portals for monitoring informal employment, which together can support the transition of enterprises and workers into the formal economy.

CONCLUSION

This study analyzed the factors influencing the informal economy in the countries of Central Asia and the Caucasus, emphasizing the importance of institutional reforms, digitalization, and trade openness in reducing informality. Our findings suggest that economic growth, urbanization, and financial development significantly impact the size of the informal economy. Additionally, trade openness, though beneficial for formalization, can also create avenues for informality if not accompanied by digital reforms.

The informal economy remains a global problem, but its reduction is possible through a combination of measures incorporating institutional reinforcement, technological innovation, and international coordination. Success depends on taking into account the economic, social and cultural peculiarities of each country.

The growth of the formal economy leads to the degradation of the informal sector. However, during economic crises or downturns in the formal economy, the informal industry expands. Financial development has a tangible impact on the informal economy, reducing its size under improved financial infrastructure and available access to financial services. However, there is a complex non-linear relationship between the level of financial development and the informal economy, which requires further in-depth analysis. Financial inclusion reduces the transaction costs of formalization, facilitates access to credit, and reduces incentives to operate in the shadow. Urbanization and population growth in cities can both stimulate and limit the development of the informal economy. In the initial stages, urbanization promotes the growth of informal jobs. Still, in later stages, as living standards and

governance improve, the impact of urbanization on the informality of the economy becomes minimal. Late-stage urbanization, digital payment systems, and real-time infrastructure (e-invoicing, tax administration platforms) may contribute to formalization through enhanced monitoring and network effects of compliance. Trade openness is twofold: it stimulates modernization and higher standards, but it may also expand channels for undeclared turnover without corresponding digital customs infrastructure. Digitalisation of payment systems (CBDC, digital wallets) reduces cash turnover and increases transaction traceability.

In order to reduce the informal economy, it is necessary to increase the transparency of the tax system, to combat corruption, to simplify registration, to support small businesses, to introduce electronic cash registers and electronic accounts, and to analyze big data to detect irregularities. It is recommended that future research focus on the analysis of how changes in tax rates, tax exemptions and subsidies can encourage the reduction or augmentation of the informal sector size. The analysis of policies aimed at reducing tax pressure will facilitate the identification of the best practices to minimise the informal economy.

A significant area of research is the impact of an improved legal and institutional framework on the reduction of the informal economy. The effectiveness of tax authorities and law enforcement, as well as the fight against corruption, should be important topics for further research.

Under the active introduction of digital payment systems, digital tenge and other financial technologies, and given the accumulation of data, it will be possible to analyze how these changes may influence the transition of part of the informal sector to the formal sector.

Although the study has already identified significant correlations between the informal economy and various economic and social factors, further development of the analysis models will facilitate the elaboration of more precise recommendations for policymakers and governments in the context of combating the informal economy and minimizing its negative consequences.

AUTHOR CONTRIBUTIONS

Conceptualization and theory: ES; research design: AT, NK and SV; data collection: AT and ES; analysis and interpretation: AT, SV, NK and ES; writing draft preparation: AT, NK and SV; supervision: ES; correction of article: AT; proofread and final approval of article: AT, NK and SV. All authors have read and agreed to the published version of the manuscript.

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