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Article

The complex trilogy of shadow economy, inflation, and economic growth: evidence from MENA countries

Narimen Rdhaounia,[1,*] Malek Elweriemmi,[2]

[1] University of Sfax, Tunisia
[2] University of Gabes, Tunisia
*_Correspondence_: narimenrdhaounia18@gmail.com

Abstract. This article investigates the dynamic interrelationships between the shadow economy, inflation, and economic growth in 15 countries of the Middle East and North Africa (MENA) region over the period 1991–2017. The study employs a simultaneous equations framework estimated through the Three-Stage Least Squares (3SLS) method, complemented by system GMM to address potential endogeneity issues. Empirical results reveal a bidirectional causal link between the shadow economy and inflation, highlighting their mutual reinforcement: the expansion of informal activities intensifies inflationary pressures by eroding public revenues and prompting monetary financing, while rising inflation encourages informal sector growth as agents seek protection against purchasing power erosion. Additionally, a two-way relationship between inflation and economic growth emerges, where moderate inflation can stimulate economic activity, but persistent high inflation hampers growth through price distortions and reduced real incomes. The shadow economy negatively impacts economic growth, with evidence showing that higher GDP levels reduce informality by expanding formal employment and compliance incentives. Nonetheless, the persistent size of the informal sector poses significant challenges for fiscal capacity and public investment, affecting infrastructure and social services. The robustness of these findings is confirmed through complementary estimation techniques. The article provides insights into the complex macroeconomic interactions characteristic of MENA economies, with important implications for policy aimed at promoting formalization, price stability, and sustainable growth.

Keywords: shadow economy, inflation, economic growth, MENA region, Three-Stage Least Squares (3SLS), GMM
JEL classification: E26; E31; O47; C31; C13

1. Introduction

For several decades, the shadow economy has constituted a significant yet often underestimated component of the economic landscape in developing countries, particularly in the Middle East and North Africa (MENA) region. Its expansion is largely driven by weak institutional frameworks, ineffective public policies, and rigidities within formal markets, all of which divert substantial economic activity outside official regulatory boundaries. These structural conditions pose major challenges for governance, macroeconomic stability, and sustainable development.

Recent economic literature highlights complex and sometimes contradictory relationships between the shadow economy, inflation, and economic growth. On one hand, some studies argue that informality can act as a buffer during periods of economic or political turbulence, helping absorb adverse shocks (Elgin & Oztunali, 2014; Medina & Schneider, 2019). On the other hand, a persistently large shadow economy tends to erode public revenues, amplify inflationary pressures, and hinder productivity gains ultimately constraining long-term economic growth (Loayza, 2016; Medina & Schneider, 2018).

In the MENA region, these interactions take on particular significance. Price instability, structurally weak growth, and the substantial size of the informal sector often exceeding 40% of official Gross Domestic Product (GDP) exert direct pressure on key policy levers, particularly those related to monetary policy, investment, and employment. Despite the critical importance of these dynamics, empirical studies that jointly examine these three dimensions remain limited, especially those that account for the region's institutional and structural specificities.

Against this backdrop, the present article conducts an empirical investigation into the interrelationships between the shadow economy, inflation, and economic growth in MENA countries. By employing a simultaneous equations model, it seeks to identify the structural linkages among these variables within a macroeconomic environment characterized by instability and the coexistence of formal and informal sectors. This focus is motivated by the persistent expansion of the shadow economy in the region, which continues to weaken fiscal capacity, distort inflationary patterns, and constrain sustainable growth issues that remain insufficiently addressed in the existing empirical literature.

The remainder of the article is structured as follows. The second section reviews the relevant literature on the connections among the shadow economy, inflation, and economic growth. The third section outlines the methodological framework adopted in the study. The fourth section presents and discusses the key empirical findings. Finally, the fifth provides robustness checks to assess the consistency and reliability of the results.

2. Literature review

2.1. Economic growth and the shadow economy

The literature on the relationship between economic growth and the shadow economy reveals considerable debate, with studies offering both supportive and critical perspectives on the impact of informality on growth.

Positive contributions of the shadow economy

Empirical evidence suggests that the shadow economy can, under certain conditions, support economic growth, particularly in contexts where formal institutions are inefficient or excessively restrictive. Schneider (2011), analyzing data from 21 OECD countries and 89 developing and transition economies between 1990 and 2000, found a statistically significant

positive effect of the shadow economy on growth. Earlier, Schneider (1998) showed that over 66% of income generated in the informal sector is spent within the formal economy, creating spillover effects that stimulate formal sector activity and indirectly increase tax revenues. Similarly, Nabi and Drine (2009) argue that informal activities complement the formal economy by producing legal goods and services, while Williams (2006) emphasizes the role of the shadow economy in absorbing surplus labor, enhancing competitiveness, and providing employment for those excluded from the formal labor market. Evidence from Romania (Zaman & Goschin, 2015) indicates a moderately positive association between GDP and the size of the shadow economy, reflecting a parallel development of formal and informal sectors, whereas Asea (1996) highlights its potential to foster entrepreneurship, create markets, and promote institutional development.

Negative impacts of informality on growth

Conversely, other studies emphasize the adverse effects of a large informal sector. Loayza (1997) found that expansion of the shadow economy reduces the provision of public goods in Latin America, while Feige (1986) identified a negative relationship between informality and growth across 25 transition economies. Schneider (2005) concluded that a substantial informal sector tends to shrink the formal economy in developing countries. Using Gutmann's method on quarterly Romanian data, Davidescu, Strat, and Paul (2015) demonstrated a U-shaped relationship, where informality initially supports growth but eventually becomes constraining. The expansion of the informal sector may erode the tax base, reduce public investment, and undermine government efficiency (Baklouti & Boujelbene, 2019), further acting as a drag on GDP growth (Huynh, 2020). Finally, Esaku (2021) notes the persistent difficulty in defining and consistently measuring the informal sector, reflecting its diverse and complex nature across countries.

Despite extensive studies elsewhere, there is limited empirical evidence on the nuanced effects of informality in MENA countries, where institutional quality, governance, and labor market structures may significantly shape the shadow economy's impact on growth. This study aims to address this gap.

2.2. Inflation and economic growth

The relationship between inflation and economic growth has been widely explored, with most empirical studies highlighting its nonlinear nature. Hansen (1999), using dynamic panel models, demonstrates that inflation becomes detrimental once it surpasses a threshold of 19.6%, while for advanced economies lower thresholds around 2.57% and 12.61% are more relevant. Evidence from African economies reinforces this nonlinear pattern: Yabu and Kessy (2015) identify country-specific optimal inflation rates between 6.7% and 8.8% for EAC countries, while Moand and Sikari Eita (2018) show that exceeding the 12% threshold significantly reduces Swaziland's GDP growth, a result

confirmed through OLS, 2SLS, and Granger causality tests.

Studies also document that inflation may have short-term benefits but turns harmful in the long run. Grimes (1991) finds a positive short-run but negative long-run inflation and growth link, while Ghosh and Phillips (1998) show that very low inflation (2–3%) can support growth, although the relationship becomes strongly negative as inflation rises. Their finding of a convex relationship where moderate increases in inflation are more damaging than very high ones echoes earlier evidence by Levine and Zervos (1993), who observe that even moderate inflation volatility can hinder growth.

A key distinction in the literature concerns differences between developed and developing economies. Kim and Willet (2000) warn against pooling the two groups, as threshold estimates may become misleading. Khan and Senhadji (2001) confirm this by estimating distinct thresholds: around 1% for advanced countries and 11% for developing ones, with positive growth effects only below these levels. Burdekin et al. (2004) similarly report thresholds of 8% and 3% for developed and developing economies, respectively.

More recent studies, such as Ndoricimpa (2017), reinforce the argument that inflation growth dynamics in Africa are highly nonlinear, identifying a regional threshold of 6.7% beyond which inflation significantly alters growth patterns.

Overall, while existing research provides strong evidence on nonlinear inflation thresholds, most studies rely on broad cross country samples and rarely account for the structural specificities of MENA economies such as institutional quality, fiscal rigidity, and the prevalence of the shadow economy. This limits the applicability of global thresholds to the MENA region and highlights the need for region specific empirical investigation. The present study contributes to filling this gap by examining inflation growth dynamics within a framework that explicitly incorporates informality and the structural characteristics of MENA economies.

2.3. Shadow economy and inflation

The literature on the relationship between the shadow economy and inflation remains limited, despite some notable studies addressing this intersection. Cavalcanti and Villamil (2003) examined how taxation interacts with the optimal inflation rate in economies characterized by structural distortions in labor markets, commodities, and currencies. Their findings suggest that, particularly in the presence of a substantial informal sector, fiscal revenues are positively associated with the inflation rate. Similarly, Nicolini (1998) analyzed the effects of tax evasion using a simplified monetary model, focusing on how fraud affects government revenue shares and inflation. His study indicates that inflation can serve as an indirect instrument to tax the shadow economy, compensating for revenue losses caused by tax evasion.

Roubini and Sala-i-Martin (1995) argue that when tax evasion is widespread, governments may resort to financial repression via seigniorage to generate revenues. While this mechanism provides fiscal resources, it also slows economic growth and increases inflation. Notably, their model does not differentiate the asymmetric effects of inflation on the formal and informal sectors, although

inflation can incentivize the migration of economic activities from the formal to the informal sector. Koreschkova (2006) employed a general equilibrium monetary model with two production sectors formal and informal, the latter untaxed where the government optimizes tax and inflation rates to finance deficits. Calibrated initially for the United States and later extended to cross country simulations, the study concludes that in economies with a significant informal sector, inflation rates of up to 80% annually may be considered optimal and serve as a primary source of public finance. In contrast, in economies where the informal sector is relatively small, policy tends to shift from inflation based financing toward income taxation.

Mazhar and Méon (2017) analyzed data from 153 industrialized and developing countries between 1999 and 2007, finding a positive correlation between inflation and the size of the informal sector. They emphasize the role of central bank independence and exchange rate regimes, noting that countries with less autonomous monetary authorities show a stronger link, whereas those with greater independence exhibit a weaker connection. Their findings imply that governments facing a growing informal sector may increasingly rely on inflationary finance rather than direct taxation, consistent with public finance theories of inflation.

More recently, Baklouti and Boujelbene (2019) highlighted varying dynamics across country groups. In OECD countries, prior to accounting for political stability, the relationship between inflation and the shadow economy is unidirectional from inflation to informality; however, when political stability is considered, the relationship reverses, indicating that the shadow economy does not significantly affect inflation. In MENA countries, the relationship is bidirectional: inflation affects the shadow economy and vice versa. Nevertheless, the influence of the shadow economy on inflation diminishes once political stability is controlled for, suggesting that institutional and political factors moderate this feedback effect.

Despite these contributions, empirical evidence remains scarce for MENA countries, where institutional quality, governance, and labor market structures may significantly shape the interaction between inflation and the informal sector. This study aims to address this gap and provide insights into the mechanisms and dynamics of the shadow economy in this regional context.

3. Methodology and data

The previous section provided an overview of the interconnections between the shadow economy, inflation, and economic growth. This section outlines the general methodology applied in the analysis. The following section presents the empirical results, followed by a robustness check to evaluate the reliability and consistency of the findings.

3.1. Data

This paper employs econometric estimations based on a panel of 15 MENA countries, Algeria, Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria,

Tunisia, and Yemen over the period 1991 to 2017. The selection of both countries and the timeframe was guided by the availability and continuity of reliable data, while also aiming to minimize missing observations. Notably, data coverage for MENA countries has significantly declined or remained unpublished beyond 2017, which justifies the choice of this cut-off year.

Table 1. Measurement and source of data

Variables	Measurement unit	Sources
Shadow economy (SE)	Shadow economy as a % of GDP	Medina and Schneider (2018)
Inflation (CPI)	The annual percentage change in the consumer price index.	The World Bank (WB)
Economic growth (GDP)	Economic Growth is expressed as an annual percentage.	
Human capital (HC)	Gross enrollment rate in higher education (%)	
Self-employed workers (Self. Empl)	Self-employed workers expressed as (% of total employment)	
The money supply (MS)	The money supply is the amount of money in circulation (% of GDP).	
Foreign Direct Investment (FDI)	Foreign direct investments, net inflows (Balance of payments, expressed in current US dollars)	
Tax revenues (TR)	Tax Revenues are expressed as a percentage of GDP	

Based on the review of theoretical and empirical literature, we selected several control variables that affect economic growth, inflation, and the shadow economy. These include the unemployment rate (UR), which reflects the share of the active population without work; gross fixed capital formation (GFCF), expressed as an annual growth percentage and measured in constant local currency. GFCF encompasses land improvements, purchases of buildings, machinery and equipment, as well as the construction of roads, railways, and other infrastructure, including offices, schools, hospitals, private housing, and commercial and industrial facilities. Finally, the exchange rate (ER) is measured using the real effective exchange rate index (2010 = 100). The real effective exchange rate corresponds to the nominal effective exchange rate defined as the value of a currency relative to a weighted basket of foreign currencies adjusted by a price deflator or cost index.

3.2. Estimation method

We apply a multivariate regression using panel data, as our dataset varies across two dimensions: *i* for the number of countries and *t* for time. Panel data provide several advantages over pure cross-sectional or time-series data, offering a richer and more informative framework for analysis. In this study, we employ a dynamic panel data approach to estimate the regression across countries, using

the 3SLS estimator.

This method helps solve the problem of heteroscedasticity and the autocorrelation of error terms. By combining simultaneous estimation and instrumental variables, it also addresses the problem of endogeneity. The three-stage least squares (3SLS) estimator uses instrumental variables and generalized least squares to give strong and effective results by using instruments and properly adjusting the variance-covariance matrix (Imbs,2004). Its principle is as follows:

- Estimate the system equation by equation using two-stage least squares (2SLS) and retrieve the variance-covariance matrix of the equation residuals.
- Apply generalized least squares to the entire system using the variance-covariance matrix from the first step.

Moreover, the 3SLS method is an appropriate estimator for testing systems of simultaneous equations in a more robust and consistent way. Three-Stage Least Squares is also more efficient than 2SLS and standard estimation techniques, as it helps mitigate simultaneity bias across equations. Building on this rationale, we employ the 3SLS approach in this section to estimate the relationships between informality, inflation, and economic growth.

3.3. Model specification

To empirically explore the relationship between the shadow economy, inflation, and economic growth, it is essential to construct a model capable of accurately capturing the interactions among these macroeconomic variables. In this context, we propose an econometric framework consisting of a system of three simultaneous equations, each representing the dynamics of one endogenous variable. Specifically, the model includes one equation for the shadow economy, one for inflation, and a third for economic growth.

The first endogenous variable in the model is the shadow economy (SE), measured as a percentage of official GDP based on the estimates developed by Medina and Schneider (2018) for the period 1991–2017. The specification of this equation is consistent with widely accepted formulations in the empirical literature and integrates several key economic indicators commonly associated with informal economic activity. Specifically, four explanatory variables are included. Economic growth (GDP), which reflects the overall expansion of goods and services, may influence the scale and characteristics of the shadow economy by affecting employment conditions and demand in the formal sector. Inflation, represented by the consumer price index (CPI), is incorporated due to its effect on purchasing power and production costs, which can push economic agents toward informality. The rate of self-employment (Self.Empl) serves as a proxy for informal activity, as self-employed individuals often operate outside regulatory frameworks. In the MENA region, self-employment is frequently linked to unregistered or semi-formal activities due to limited job creation in the formal sector, rigid labour regulations, and the prevalence of micro-enterprises, making it a theoretically relevant indicator of informal labour dynamics. Finally, human capital (HC), which captures the population's education and skill levels, shapes the structure and efficiency of both the formal and informal sectors. Its inclusion is theoretically justified in the MENA context, as higher levels of education and skills can reduce reliance on informal activities, facilitate participation in the

formal labour market, and influence productivity and adaptability across sectors.

The second endogenous variable in the model is inflation (CPI), which captures fluctuations in the prices of goods and services consumed by households and thus reflects the overall price level in the economy. This equation incorporates several key explanatory variables. Economic growth (GDP), expressed as the annual growth rate of gross domestic product, is included because changes in economic activity can influence inflationary pressures through demand side and supply side channels. The shadow economy (SE), measured as a percentage of GDP, is also considered; a sizable informal sector can affect fiscal and monetary policy effectiveness, thereby shaping inflation dynamics. The money supply (MS) is included due to its central role in determining price levels, supported by strong theoretical foundations such as the quantity theory of money. Tax revenues (TR), representing government income from taxes and other fiscal instruments, may influence public spending and policy decisions, which can in turn affect inflation. Finally, human capital (HC) influences production costs, productivity, and consumption behavior; these mechanisms directly shape inflationary trends.

The third endogenous variable in the model is economic growth, measured as an annual percentage change in GDP. The specification of the economic growth equation incorporates inflation (CPI) and the shadow economy (SE), together with two additional key determinants: human capital (HC) and foreign direct investment (FDI). Human capital is measured by the tertiary enrollment rate, which reflects the population's education level. Higher human capital is generally associated with stronger innovation capacity and greater productivity, both of which support long-term economic growth. Foreign direct investment represents capital inflows from foreign firms or individuals into domestic enterprises. Such investments can significantly influence economic growth by introducing new technologies, providing financial resources, and transferring skills and managerial expertise, thereby stimulating economic development and enhancing growth performance.

Indeed, dynamic simultaneous equation models using panel data were used to study how the shadow economy, inflation, and economic growth are related, estimating the following system:

$$SE_{it} = \alpha_0 + \alpha_1 CPI_{it} + \alpha_2 GDP_{it} + \alpha_3 Self.Empl_{it} + \alpha_4 HC_{it} + \lambda_{it} \quad (1)$$

$$CPI_{it} = \beta_0 + \beta_1 SE_{it} + \beta_2 GDP_{it} + \beta_3 MS_{it} + \beta_4 TR_{it} + \beta_5 HC_{it} + \epsilon_{it} \quad (2)$$

$$GDP_{it} = \gamma_0 + \gamma_1 CPI_{it} + \gamma_2 SE_{it} + \gamma_3 FDI_{it} + \gamma_4 HC_{it} + \theta_{it} \quad (3)$$

- i , t: i indicates the country, t indicates the time
- $\lambda_{it}, \epsilon_{it}, \theta_{it}$: the error terms
- α, β, γ: the regression parameters of the explanatory variables in the 3SLS model

Before moving on to the empirical results and interpretation, we will present the identification conditions of our 3SLS model. Every simultaneous equation model faces an identification problem. After determining the status of the variables, we check the identifiability conditions of the model. These are the order and rank conditions. The order conditions are necessary conditions that are determined equation by equation. Rank conditions are necessary conditions that prove to be difficult, if not sometimes impossible, to implement in practice. Thus, researchers limit themselves to conditions of identifiability (Bourbonnais, 2002). This is an important phase in choosing the final estimation method.

We distinguish three cases of identification:

1) The model is under-identified if an equation of the model is under-identifiable (there are fewer equations than parameters to identify in the structural form; the system is impossible to solve). In this case, there is no possibility of estimating the model parameters; it must be re-specified.
2) If all the equations are easily identifiable, we simply identify the model.
3) If the model equations are overidentifiable, the model is considered overidentified.

Where:

g = Number of endogenous variables in the model (or the number of equations in the model)

k = Number of exogenous variables in the model

g'=Number of endogenous variables in the equation to be identified

k'= denotes the number of exogenous variables present in the equation for identification.

The necessary conditions for identifiability are stated as follows:

If (g-g') + (k-k') p g-1, then the equation is under-identified.

If (g-g') + (k-k') = g-1, then the equation is correctly identified.

If (g-g') + (k-k') f g-1, then the equation is overidentified.

We will examine the equation identification in our simultaneous equations model.

- **Equation (A), related to the shadow economy:**

$$SE_{it}=\alpha_0+\alpha_1 CPI_{it}+\alpha_2 GDP_{it} + \alpha_3 Self.Empl_{it} +\alpha_4 HC_{it} + \lambda_{it} \quad (A)$$

According to the conditions: g = 3 g' = 1; k = 5 and k' = 2

- (g-g') =2 (k-k') =3; (g-1) =2 we then g – 1 < (g – g ′ + k – k ') Hence, the equation (A) is over-identified.

- **Equation (B), related to inflation:**

$$CPI_{it}= \beta_0 + \beta_1 SE_{it}+\beta_2 GDP_{it} + \beta_3 MS_{it} + \beta_4 TR_{it} + \beta_5 HC_{it}+\epsilon_{it} \quad (B)$$

According to the conditions: g = 3 g' = 1; k = 5 and k' = 3

- (g-g') =2 (k-k') =2; (g-1) =2 we then g – 1 < (g – g ′ + k – k ') Hence, the equation (B) is over-identified.

- **Equation (C), related to economic growth**

$$GDP_{it}= \gamma_0 CPI_{it} +\gamma_0 SE_{it} + \gamma_2 HC_{it} + \gamma_3 FDI_{it}+\lambda''_{it} \quad (C)$$

According to the conditions: g = 3 g ′ = 1; k = 5 and k' = 2

- (g-g') =2 (k-k') =3; (g-1) =2 we then g – 1 < (g – g ′ + k – k ') Hence, the equation (C) is over-identified.

Before presenting the main empirical findings, it is essential to begin with the preliminary

statistical analysis and diagnostic tests. Table 2 provides the descriptive statistics for the full sample of 405 observations. The shadow economy exhibits an average value of 24.54 with moderate dispersion (standard deviation of 8.14), indicating that informal activities represent roughly one-quarter of total economic activity in the MENA region. Inflation averages 5.68, reflecting episodes of monetary instability, whereas economic growth displays a mean of 4.26 and substantial volatility, ranging from –50.33% to 86.82%. These large fluctuations suggest the presence of recurrent macroeconomic shocks and heterogeneous policy environments across countries.Human capital shows an average level of 25.62 and a relatively high standard deviation of 12.85, with values spanning from 4.47 to 72.96. This wide range highlights pronounced disparities in educational achievement and skill accumulation within the region.

Regarding the remaining explanatory variables, tax revenues, self-employment, unemployment, foreign direct investment, and gross fixed capital formation record average values of 13.07, 26.86, 9.47, 19.91, and 7.18, respectively. The exchange rate and money supply exhibit mean values of 109.57 and 73.35, coupled with large ranges from 10 to 298.35 for the exchange rate and from 23.77 to 260.61 for the money supply illustrating substantial cross-country differences in monetary conditions and exchange-rate regimes.

Table 2. Descriptive statistics

Variables	Observations	Mean	Std. Dev	Min	Max
SE	405	24.5482	8.1411	12.2387	40.0497
CPI	405	5.6855	7.8647	-9.7976	55.2811
GDP	405	4.2692	8.0380	-50.3385	86.8267
UR	405	9.4768	6.3499	.14	31.84
Self-Empl	405	26.8674	18.7481	.4083	60.3894
MS	405	73.3584	43.5748	23.7758	260.6183
FDI	405	19.9102	2.0862	6.9077	23.8122
GFCF	405	7.1823	17.0995	-84.8802	110.9241
TR	405	13.0745	6.3610	0.0858	24.6898
ER	405	109.5767	32.5098	10	298.3523
HC	405	25.6214	12.8506	4.4732	72.9610

Before estimating the panel regressions, we perform specification tests to ensure that the model is appropriate for the data. Specifically, we examine the distribution of the residuals and the presence of correlation among them. Residual normality is assessed using measures of skewness and kurtosis, which provide insight into the symmetry and tail behavior of the error terms. These tests allow us to verify whether the residuals approximate a normal distribution, a key assumption in classical econometric models.

Table 3. Normality test of residuals

Variable	Obs	Pr (Skewness)	Pr (Kurtosis)	Chi2	Prob>chi2
Residuals	405	0.856	0.406	0.35	0.799

As reported in Table 3, all Prob > chi^2 values exceed 0.05. Since these probabilities are above the 5% threshold, we fail to reject the null hypothesis of residual normality. This indicates that the residuals are approximately normally distributed, satisfying a key assumption for subsequent econometric analyses. Before estimating the final model, it is also crucial to assess the presence of multicollinearity among the explanatory variables. Multicollinearity can undermine the reliability of regression estimates by inflating standard errors and rendering the coefficient estimates highly sensitive to minor variations in the data (Bourbonnais, 2009). Ensuring that multicollinearity is not severe enhances the robustness and interpretability of the regression results.

To check for multicollinearity issues among the explanatory variables, two methods can be used: the correlation matrix and the Variance Inflation Factor (VIF) method.

Table 4 presents the Pearson correlation matrix of the model variables, providing an initial assessment of potential multicollinearity. Multicollinearity is generally considered problematic when correlation coefficients exceed 0.8. In this study, all coefficients remain below 0.7, suggesting that multicollinearity is unlikely to compromise the regression estimates.

To confirm this, we complement the correlation analysis with the Variance Inflation Factor test, a widely used measure of multicollinearity (Marquardt, 1970; Gujarati, 2012). A VIF value below 10 indicates the absence of severe collinearity. As shown in Table 4, VIF[1] values for the three equations, economy (SE), inflation (CPI), and economic growth (GDP) range between 1.02 and 2.23, with averages of 1.38, 1.49, and 1.55, respectively. These results further confirm that multicollinearity does not pose a concern for the model. Consequently, the variables are suitable for inclusion in the subsequent regression analysis.

[1] Avg. VIF represents the average Variance Inflation Factor for each variable across the three models (SE, CPI, GDP). All VIF values < 10 indicate no multicollinearity issues.

Table 4. Key Correlations and Average VIFs

Variable	SE	CPI	GDP	HC	UR	Self-Empl	Avg. VIF
SE	1	0.06	-0.03	-0.19	0.50	0.55	1.38
CPI		1	-0.05	0.07	0.22	0.35	1.49
GDP			1	-0.10	-0.12	-0.11	1.55
HC				1	0.01	-0.17	1.49
UR					1	0.54	1.91
Self-Empl						1	1.76

Notes: Only key correlations are shown for clarity. Only the essential correlation coefficients are reported in this table for clarity. The complete correlation matrix and full VIF outputs are provided in the appendix.
Source: Author's own calculations

In our estimation, it is important to account for the identified issues of heteroscedasticity and autocorrelation of errors. To address these problems, we employ estimation techniques such as Three-Stage Least Squares (3SLS) and the Generalized Method of Moments (GMM), which are specifically designed to correct for these econometric concerns and to produce more robust and reliable results. Before presenting the findings, it is essential to outline the hypotheses underpinning our study.

Hypothesis 1: The increase in the shadow economy leads to an increase in inflation.
Hypothesis 2: The increase in the shadow economy leads to a decrease in economic growth.
Hypothesis 3: The increase in the inflation rate leads to a decrease in economic growth.

4. Empirical findings

The estimations of our econometric model were carried out using both the Three-Stage Least Squares (3SLS) and the Generalized Method of Moments (GMM) to ensure robustness and reliability of the results. To facilitate interpretation and highlight the key findings, we present a comparative table of the main significant coefficients for the selected variables across the two estimation methods. This approach allows a clear overview of how the shadow economy (SE), inflation (CPI), and economic growth (GDP) are influenced by factors such as self-employment, human capital, money supply, tax revenues, and foreign direct investment, while emphasizing the economic meaning and policy implications of the results.

Table 5. Comparative Estimates Between 3SLS and GMM Methods

Variables	3SLS – SE	3SLS – CPI	3SLS – GDP	GMM – SE	GMM – CPI	GMM – GDP
SE	—	*1.140*	*–0.078*	—	*0.941*	*–0.102*
		*(0.254)****	*(0.084)*		*(0.505)**	*(0.032)****
CPI	*0.493*	—	*–0.486*	*0.082*	—	*–0.053*
	*(0.216)***		*(0.131)****	*(0.044)**		*(0.019)***
GDP	*–0.755*	*–0.153*	—	*–0.157*	*–0.465*	—
	*(0.265)****	*(0.082)**		*(0.029)****	*(0.101)****	
Self-Empl	*0.345*	—	—	*0.143*	—	—
	*(0.040)****			*(0.065)***		
HC	*–0.005*	*0.123*	*-0.041*	*-0.023*	*0.033*	*-0.060*
	(0.075)	*(0.098)*	*(0.033)*	*(0.032)*	*(0.107)*	*(0.008)****
MS	—	*0.080*	—	—	*0.503*	—
		*(0.001)****			*(0.111)****	
TR	—	*–0.532*	—	—	*–2.488*	—
		*(0.116)****			*(0.697)****	
FDI	—	—	*0.710*	—	—	*0.022*
			*(0.204)****			*(0.115)*
UR	—	—	—	*0.572*	—	—
				*(0.210)***		
ER	—	—	—	—	*–0.338*	—
					*(0.101)****	
GFCF	—	—	—	—	—	*0.048*
						*(0.014)****
Constant	*15.013*	*–15.804*	*20.299*	*19.754*	*93.831*	*7.894*
	*(4.898)****	*(9.522)**	*(4.850)****	*(1.272)****	*(16.347)****	*(2.831)***
Statistic	**3SLS – SE**	**3SLS – CPI**	**3SLS – GDP**	**GMM – SE**	**GMM – CPI**	**GMM – GDP**
RMSE	9.186	11.975	8.701	—	—	—
R^2	0.276	–1.324	0.174	—	—	—
χ^2 test	114.25***	60.95***	24.17***	—	—	—
Hansen test (p-value)	—	—	—	0.263	0.199	0.247
Arellano–Bond AR(2) (p-value)	—	—	—	0.145	0.233	0.323
Arellano–Bond AR(1) (p-value)	—	—	—	0.022	0.039	0.027

*Statistically significant at 10%. ** Statistically significant at 5%. *** Statistically significant at 1%

Notes : Key diagnostics (Hansen, Arellano–Bond) are reported at the bottom of the table for the GMM estimation. Variables that are not significant or not included in the specification are indicated by "—".

Source: Author's own calculations

The results from the global model estimated using the Three-Stage Least Squares (3SLS) method clearly reveal structural interdependencies among the shadow economy, inflation, and economic growth in MENA countries. These relationships are further confirmed by robustness checks based on dynamic panel GMM estimations, following the approach of Arellano and Bond (1991).

First, the shadow economy has a positive and statistically significant effect on inflation,

coefficient = 1.140%, at the 1% level. Conversely, a one point increase in inflation expands the size of the informal sector by 0.493%, confirming a bidirectional relationship consistent with the findings of Mazhar and Méon (2017), Koreshkova (2006), and Ergene (2015). Economically, this dynamic reflects a vicious cycle characteristic of MENA countries: persistent moderate or high inflation erodes purchasing power and weakens incentives to operate in the formal sector, while the expansion of informality undermines fiscal capacity, increases uncertainty, and fuels inflationary pressures. This pattern is rooted in the region's structural rigidities heavy taxation, administrative complexity, and low institutional trust which encourage households and small firms to rely on informal activities to secure income.

Second, economic growth significantly reduces the size of the informal sector, –0.755%, at the 1% level, a result consistent with the analyses of Loayza (1997), Schneider et al. (2010), Davidescu et al. (2015), and Huynh (2020). From an economic standpoint, this confirms the stabilizing role of growth: increases in national income, infrastructure improvements, stronger institutional quality, and a better business environment reinforce the attractiveness of the formal sector. In the MENA context, growth episodes although often cyclical and dependent on commodity prices tend to be accompanied by greater public investment and administrative modernization, thereby reducing incentives to remain in the shadow economy.

Third, inflation exerts a significant negative effect on economic growth of –0.486%, at the 1% level, consistent with the predictions of endogenous growth models (Lucas, 1988; Romer, 1990). High inflation disrupts investment decisions, reduces capital allocation efficiency, and weakens expectations particularly in economies marked by volatility and dependence on essential imports.
Human capital exhibits a negative effect on growth in some specifications. Although counterintuitive from a theoretical perspective, this result aligns with Rdhaounia & Kouni (2022) and Baklouti & Boujelbene (2019), who highlight issues related to skill job mismatch, overqualification, and especially brain drain. In several MENA countries notably Tunisia, Algeria, and Lebanon a substantial share of highly qualified graduates migrate to Europe or the Gulf, thereby limiting domestic productive capacity and dampening the expected positive contribution of human capital to growth.
Other variables display signs consistent with the empirical literature. Self-employment increases informality of +0.345%, at the 1% level, consistent with the analyses of Williams et al. (2011), Brill (2011), Barbour & Llanes (2013), and Horodnic (2015), highlighting the predominance in the region of small scale, often family-run activities that are weakly regulated and difficult to integrate into the formal system. Money supply expansion fuels inflation that +0.080%, at the 1% level), as predicted by Friedman's (1968) monetarist framework, while tax revenues help curb inflationary pressures, –0.532%, at the 1% level, as also reported by Mazhar & Méon (2017). This latter finding underscores the importance of fiscal discipline in countries where public finances are highly exposed to external shocks and fluctuations in oil revenues.

Gross fixed capital formation (GFCF) promotes economic growth of+0.048%, at the 1% level), consistent with Baklouti & Boujelbene (2019), Zhang et al. (2021), and Kchiri & Belghiti (2022), illustrating the key role of productive investment in stimulating capital accumulation and improving economic structures. Additionally, exchange rate appreciation reduces inflation of –0.338%, at the 1% level , in line with Bailliu & Fujii (2005), Fatai et al. (2016), and Ha et al. (2020), reflecting the strong dependence of MENA economies on food and energy imports.

The GMM estimations broadly confirm these findings, validated by the Hansen and Arellano–Bond tests, while highlighting two additional results: unemployment increases the size of the informal sector of +0.572%, at the 5% level , a predictable outcome in contexts where informality often acts as a safety net in the absence of sufficient formal employment opportunities; and foreign direct investment (FDI) exhibits a positive but statistically insignificant effect on growth, consistent with Wang et al. (2022), who emphasize that the growth impact of FDI depends heavily on institutional quality, technological absorption, and domestic value-chain integration.

Overall, these results highlight the structural vulnerability of MENA economies to the inflation informality nexus, the importance of inclusive growth capable of absorbing unemployed workers and reducing informality, and the need for deep institutional reforms promoting transparency, digitalization, and broadening of the tax base. They also underscore the crucial role of monetary and fiscal policies in stabilizing the economy and promoting sustainable development grounded in productivity and macroeconomic resilience.

5. Conclusion

This article has examined the complex interrelationships between the shadow economy, inflation, and economic growth across 15 MENA countries over the period 1991–2017, using a Three-Stage Least Squares (3SLS) estimation approach. The empirical findings reveal a bidirectional causal relationship between the shadow economy and inflation, indicating that the two phenomena reinforce one another. The expansion of informal activities fuels inflationary pressures through tax evasion and declining public revenues, which may push governments to rely more heavily on monetary financing. In turn, rising inflation encourages the expansion of the shadow economy, as economic agents attempt to mitigate the erosion of purchasing power by engaging in more flexible, often unregulated, informal transactions.

In addition, the analysis uncovers a two-way relationship between inflation and economic growth, reflecting the dual role that inflation plays in MENA economies. While moderate inflation may stimulate consumption and investment, persistently high inflation undermines growth by distorting price signals and reducing real incomes. Regarding the link between the shadow economy and economic growth, the evidence points to a unidirectional relationship: economic expansion reduces the size of the informal sector by generating more formal job opportunities and reinforcing incentives for legal compliance. Nevertheless, a growing shadow economy continues to impose significant constraints on development, weakening the tax base, limiting public investment capacity, and depriving governments of essential resources for infrastructure, education, and healthcare.

To strengthen the robustness of these findings, the system GMM estimator was employed as a complementary approach. The consistency between the GMM and 3SLS results confirms the stability of the estimated relationships and alleviates endogeneity concerns, thereby enhancing the reliability of the conclusions.

Policy Implications

The empirical findings of this study highlight several important policy implications for MENA countries. The circular relationship between inflation and the shadow economy underscores the need for a comprehensive strategy aimed simultaneously at reducing informality, stabilizing inflation, and strengthening the foundations of sustainable economic growth. First, reducing the size of the shadow economy should be a central pillar of economic reform. This requires not only stricter enforcement mechanisms but, more fundamentally, the creation of more inclusive and attractive formal labor markets. Simplifying administrative procedures, improving tax systems, and combating corruption are essential to rebuilding trust between citizens, businesses, and public institutions. Second, monetary and fiscal authorities must tightly monitor inflationary dynamics. Inflation weakens purchasing power, incentivizes economic agents to shift toward informal activities, and erodes fiscal capacity. A credible macroeconomic framework based on fiscal discipline, prudent monetary management, and better coordination between fiscal and monetary policies is essential to stabilizing prices and reducing incentives for informality. Third, improving institutional quality constitutes a fundamental lever for stimulating growth and reducing informality. Targeted investments in education, innovation, governance, public-sector digitalization, and transparency are crucial for enhancing economic resilience. Reducing skill mismatches, modernizing public administration, and improving service delivery would diminish the appeal of informal activities and strengthen the productive base of the economy.

Given the heterogeneity across MENA economies, differentiated policy responses are required. In oil-exporting countries, where fiscal space is relatively larger, priority should be given to economic diversification, modernization of tax systems, and institutional strengthening to limit reliance on inflationary financing. In contrast, non-oil economies facing tighter budget constraints should focus on broadening the tax base, combating tax evasion, and improving the business environment to encourage formalization.

Institutional disparities across the region also call for tailored strategies: countries with weaker regulatory quality should prioritize reforms in the rule of law, transparency, and public-sector accountability, while countries with stronger institutions may advance toward greater digitalization of public services, labor-market reforms, and innovation-driven policies.

Overall, the results suggest that uniform policy interventions are insufficient to address the complex and structural challenges faced by MENA countries. Only targeted, context specific strategies aligned with the economic and institutional characteristics of each country can break the inflation informality cycle and support sustainable, inclusive, and resilient development.

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Appendix

Table 6. Pearson Correlation Matrix

	SE	CPI	GDP	HC	UR	Self-Empl	FDI	MS	GFCF	ER	TR
SE	1.000										
CPI	0.059	1.000									
GDP	-0.032	-0.048	1.000								
HC	-0.185	0.066	-0.101	1.000							
UR	0.500	0.217	-0.123	0.012	1.000						
Self-Empl	0.547	0.350	-0.111	-0.168	0.542	1.000					
FDI	-0.135	-0.179	-0.042	0.283	-0.149	-0.001	1.000				
MS	0.170	0.190	0.055	0.232	-0.024	0.055	0.203	1.000			
GFCF	-0.057	-0.063	0.195	-0.005	-0.058	-0.092	-0.013	0.047	1.000		
ER	0.083	-0.058	-0.049	-0.030	-0.014	-0.043	-0.173	-0.034	-0.024	1.000	
TR	0.475	-0.038	-0.014	-0.303	0.459	0.356	0.031	0.087	-0.026	-0.129	1.00000
VIF Model 1 (SE)	1.38	1.29	1.08	1.48	1.91	1.76	1.28	1.18	1.05	1.07	1.66
VIF Model 2 (CPI)	2.11	1.49	1.08	1.51	2.21	1.70	1.26	1.22	1.05	1.08	1.67
VIF Model 3 (GDP)	2.14	1.31	1.55	1.49	2.23	1.93	1.29	1.24	1.02	1.09	1.71

Table 7. 3SLS Estimation

Variables	**Specification 1**	**Specification 2**	**Specification3**
	SE	**CPI**	**GDP**
SE	**---**	1.140	-0.078
		(0.254)***	(0.084)
CPI	0.493	---	-0.486
	(0.216)**		(0.131)***
GDP	-0.755	-0.153	---
	(0.265)***	(0.082)*	
Self-Empl	0.345	---	---
	(0.040)***		
HC	-0.005	0.123	-0.041
	(0.075)	(0.098)	(0.033)
MS	---	0.080	---
		(0.001)***	
TR	---	-0.532	---
		(0.116)***	
FDI	---	---	0.710
			(0.204)***
Constant	15.013	-15.804	20.299
	(4.898)***	(9.522)*	(4.850)***
RMSE	9.186	11.975	8.701
R^2	0.276	-1.324	0.174
X^2	114.25***	60.95***	24.17***

Table 8. GMM estimation

Variables	**Specification 1** **SE**	**Specification 2** **CPI**	**Specification 3** **GDP**
SE	---	0.941 (0.505)*	-0.102 (0.032)***
CPI	0.082 (0.044)*	---	-0.053 (0.019)**
GDP	-0.157 (0.029)***	-0.465 (0.101)***	---
Self-Empl	0.143 (0.065)**	---	---
HC	-0.023 (0.032)	0.033 (0.107)	-0.060 (0.008)***
MS	---	0.503 (0.111)***	---
TR	---	-2.488 (0.697)***	---
FDI	---	---	0.022 (0.115)
UR	0.572 (0.210)**		
ER		-0.338 (0.101)***	
GFCF			0.048 (0.014)***
Constant	19.754 (1.272)***	93.831 (16.347)***	7.894 (2.831)**
Hansen test (p-value)	0.263	0.199	0.247
Arellano–Bond Test for 2nd order (p-value)	0.145	0.233	0.323
Arellano–Bond Test for 1st order (p-value)	0.022	0.039	0.027