

Rdhaounia, Narimen; El Weriemmi, Malek; Kouni, Mohamed

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The complex trilogy of shadow economy, inflation, and economic growth

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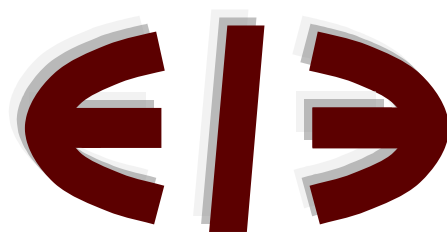
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Narimen Rdhaounia, Malek Elweriemmi and Mohamed Kouni

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EERI
Economics and Econometrics Research Institute
Avenue Louise
1050 Brussels
Belgium

Tel: +32 2271 9482
Fax: +32 2271 9480
www.eeri.eu

The Complex Trilogy of Shadow Economy, Inflation, and Economic Growth

Narimen Rdhaounia*
University of Sfax, Tunisia

Malek Elweriemmi
University of Gabes, Tunisia

Mohamed Kouni
University of Sousse, Tunisia

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 Classifications: E26, E31, O47, C31, C13

Contact Author's Email Address: Narimenrdhaounia18@gmail.com

I. Introduction

For several decades, the shadow economy has represented a significant yet often overlooked component of the economic fabric in developing countries, particularly in the Middle East and North Africa (MENA) region. This phenomenon is largely driven by weak institutional frameworks, inefficient public policies, and rigid formal markets, all of which push a substantial share of economic activity outside official channels. These dynamics raise major challenges in terms of governance, macroeconomic stability, and sustainable development.

Recent economic literature reveals complex and sometimes contradictory relationships between the shadow economy, inflation, and economic growth. On the one hand, some studies suggest that informality can serve as a buffer during times of economic or political crisis, helping to absorb shocks (Elgin & Oztunali, 2014; Medina & Schneider, 2019). On the other hand, a persistently large shadow economy tends to undermine public revenues, intensify inflationary pressures, and inhibit productivity gains ultimately hindering long-term growth (Loayza, 2016; Buehn & Schneider, 2022).

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

In this context, 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 aims to identify the structural

linkages among these variables within a macroeconomic setting marked by instability and duality between formal and informal sectors. This focus is motivated by the persistent expansion of the shadow economy in the region, which continues to undermine fiscal capacity, distort inflation dynamics, and hamper sustainable growth issues that remain insufficiently addressed in existing empirical literature

The structure of the article is as follows: The second section provides a review of the literature on the interconnections among the shadow economy, inflation, and growth. The third section outlines the methodological approach adopted in the study. The fourth section presents and discusses the key empirical findings. Finally, the fifth section offers robustness checks to assess the consistency and reliability of the results.

II. Literature Review

1. Economic growth and the shadow economy

The relationship between economic growth and the shadow economy has generated extensive debate in empirical literature, with studies offering both supportive and critical perspectives regarding the impact of informality on growth.

Positive Contributions of the Shadow Economy

Some empirical research suggests that the shadow economy may support economic growth, particularly in contexts where formal systems are inefficient or overly restrictive. Schneider (2011), using 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) demonstrated that over 66% of income generated in the informal sector is spent within the formal economy, creating a spillover effect that can stimulate formal sector activity and indirectly increase tax revenues.

These findings are echoed by Nabi and Drine (2009), who argue that informal activities can complement the formal economy by producing legal goods and services, thereby contributing to overall growth. Williams (2006) also highlights the potential of the shadow economy to increase competitiveness by absorbing excess labor and demand and providing employment for those excluded from the formal labor market.

In the case of Romania, Zaman and Goschin (2015) analyzed the relationship between informality and development from 1999 to 2012 using an OLS model. They found a moderately positive association between GDP and the size of the shadow economy, suggesting a parallel evolution of formal and informal sectors over the long run. Similarly, Asea (1996) posits that the shadow economy can play a role in market creation, fostering entrepreneurship, and driving institutional change conducive to capital accumulation.

Negative Impacts of Informality on Growth

Conversely, other studies underscore the adverse effects of informality on economic performance. Loayza (1997), focusing on Latin America, found that a growing shadow economy reduces the provision of public goods. Feige (1986) identified a negative relationship between informality and growth in 25 transition economies.

In a comparative analysis, Schneider (2005) concluded that in developing countries, a larger informal sector tends to shrink the size of the formal economy. Similarly, Davidescu, Strat, and Paul (2015) used Gutmann's method on quarterly Romanian data and found that the relationship between the shadow economy and the formal sector is U-shaped, meaning that while informality might help growth at first, it eventually becomes a limitation.

Baklouti and Boujelbene (2019) argue that an expanding informal sector erodes the tax base, reduces public investment, and undermines the efficiency of government services factors that collectively hinder long-term economic growth. Huynh (2020) further confirms that the shadow economy may act as a drag on GDP growth, emphasizing its constraining effect on the overall economy. Finally, Esaku (2021) notes the persistent challenge of defining the informal sector in a uniform and consistent manner, reflecting the diversity and complexity of shadow economic activities across countries.

2. Inflation and Economic Growth

We shall start with the adverse effects. Hansen (1999) noted in his study on dynamic panel models that inflation has a non-linear impact on economic growth. His findings indicate that exceeding the inflation threshold of 19.6% leads to a decline in economic growth with every subsequent inflation increase. Two criteria have been suggested for developed nations: 2.57% and 12.61%.

Yabu and Kessy (2015), to examine the relationship between economic growth and inflation in the three East African Community (EAC) member states, used a quadratic nonlinear model. Economic growth is negatively and significantly affected when the average inflation rate is higher than 8.46%, according to the results of the random effects model regression. The ideal inflation rates for Kenya, Tanzania, and Uganda are 6.77%, 8.41%, and 8.80%, respectively, according to the findings of the seemingly unrelated regression (SUR), which analyzes each nation independently. Similar to this, Moand Sikari Eita (2018) calculated the ideal effect of inflation on Swaziland's GDP. Findings from the ordinary least squares (OLS) approach reveal that GDP growth slows down by 1.02% when inflation rates rise beyond the ideal threshold of 12%. Furthermore, the two-stage least squares (2SLS) approach shows that inflation has a negative effect of about 18.5% after a specific point. There is a causal link between inflation and economic growth, as confirmed by the results of the Granger causality research.

On the other hand, Grimes (1991) studied the impact of inflation on economic growth using data from 21 countries for the period 1961-1987. His results indicate that in the short term, there is a positive correlation between inflation and economic growth, but this correlation becomes negative in the long term. Similarly, Ghosh and Phillips (1998) observed that inflation and economic growth are positively correlated at very low inflation rates (around 2% to 3% per year). However, this relationship reverses when inflation rates increase. Furthermore, they discovered that the relationship between inflation and growth is convex. This means that a rise in inflation from 10% to 20% causes a more pronounced decrease in the growth rate than that observed when inflation increases from 40% to 50%. Indeed, Levine and Zervos (1993) use cross-sectional data from 102 countries for the period 1960-1989. The authors identify two important relationships between inflation and growth: first, for countries operating at moderate inflation rates, rapid changes in inflation limit growth; and second, countries with high inflation systematically have lower growth compared to low-inflation regimes.

In keeping with previous studies, Kim and Willet (2000) state that it is possible to get inaccurate estimates of inflation thresholds by combining data from industrialized and developing nations. Khan and Senhadji (2001) expand on this idea by dividing their study into two subsamples, one for developed economies and one for emerging ones. They use a likelihood ratio test based on nonlinear least squares, where inflation thresholds are found by

minimizing the sum of squared residuals. Their findings point to distinct thresholds: 1% for developed countries and 11% for developing countries. Below these critical points, inflation tends to support economic growth, whereas exceeding these levels leads to adverse long-term growth effects.

Similarly, Burdekin and al. (2004) differentiate between the two groups of countries and uncover their threshold estimates. They report that in developed nations, inflation becomes increasingly detrimental, though not statistically significant, up to 8%, while for developing economies, price inflation maintains a positive and statistically significant effect on growth up to a threshold of 3%.

Finally, in his study, Ndoricimpa (2017) examines the non-linearities in the relationship between inflation and economic growth in Africa. The results of his work confirm the existence of such nonlinearities. More specifically, the results reveal that a threshold of 6.7% is identified for the entire sample, suggesting that the dynamics between inflation and economic growth change significantly once the inflation rate exceeds this threshold.

3. Shadow economy and inflation

Empirical research exploring the relationship between the shadow economy and inflation remains limited, though some notable studies have addressed this intersection. Cavalcanti and Villamil (2003) investigated how taxation interacts with the optimal inflation rate in economies characterized by structural distortions in labor markets, commodities, and currencies. Their findings indicate that in the presence of such distortions particularly the informal sector fiscal revenues tend to have a positive association with the inflation rate.

Nicolini (1998) examined tax evasion effects using a simplified monetary model, focusing on how fraud influences the share of tax revenues in government budgets and inflation levels. The study suggests that inflation may act as an indirect tool for taxing the shadow economy, as governments potentially raise inflation to offset 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, generating revenues through inflation. While this mechanism provides fiscal resources, it also leads to slower economic growth and higher inflation. Notably, their model does not differentiate the asymmetric effects of inflation

on formal and informal sectors. Inflation can, in fact, encourage a migration of economic activities from the formal to the informal sector.

Koreschkova (2006) used a general equilibrium monetary model featuring two production sectors formal and informal, with the latter's income untaxed. The government finances its deficit by optimizing tax and inflation rates. Calibrated initially for the United States and then extended to cross-country simulations, the study concludes that:

In economies with a significant shadow economy, inflation rates as high as 80% annually may be considered optimal and serve as a primary source of state financing.

In economies where the informal sector diminishes relative to other sectors, 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 highlight the role of central bank independence and exchange rate regimes, noting that countries with less autonomous monetary authorities exhibit a stronger link, while those with higher independence show a weaker connection. Their results imply that governments facing a growing informal sector may increasingly rely on inflationary finance instead of taxation, consistent with public finance theories of inflation.

More recently, Baklouti and Boujelbene (2019) provide evidence of varying dynamics across country groups: For OECD countries, prior to accounting for political stability, the relationship between inflation and the shadow economy is unidirectional from inflation to informality; inflation influences the shadow economy, but not vice versa. When political stability is introduced, the relationship reverses direction, indicating that the shadow economy does not significantly impact inflation. In MENA countries, however, the relationship is bidirectional, with inflation affecting the shadow economy and vice versa. The influence of the shadow economy on inflation diminishes once political stability is controlled for, suggesting that political stability moderates this feedback effect.

III. 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.

1. Data Presentation

This paper relies on 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 the 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 have selected some control variables that affect economic growth, inflation, and the shadow economy, which are, respectively, unemployment rate that informs us about the share of the active population that is without work (UR), Gross fixed capital formation (GFCF), expressed as a percentage of annual growth, is based on constant local currency. The latter includes land improvements, purchases of buildings, machinery, and equipment, as well as the construction of roads, railways, and other similar infrastructures, including offices, schools, hospitals, private

housing, and commercial and industrial buildings. Finally, the exchange rate (ER) is an index of the real effective exchange rate (2010 = 100). Indeed, the real effective exchange rate is the nominal effective exchange rate (a measure of the value of a currency relative to a weighted average of several foreign currencies) divided by a price deflator or a cost index.

2. Estimation method

We will apply a multivariate regression on panel data, since we have two varying parameters: i for the number of countries and t for time. Panel data offer various advantages over cross-sectional and time series data, allowing for a richer and more detailed analysis. This study uses a dynamic panel data methodology to estimate the regression on a set of countries, employing the 3SLS method 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 equations in a more robust manner. Moreover, the Three-Stage Least Squares are more efficient than the 2SLS and standard techniques, as they help guard against simultaneity bias. Armed with this knowledge, we have employed the three-stage least squares technique in this part of our work to estimate the relationship between the informality, inflation, and economic growth.

3. Model specification

To explore empirically the relationship between the shadow economy, inflation, and economic growth, it is essential to construct a model capable of accurately reflecting the interactions among these macroeconomic variables. In this context, an econometric model is proposed, comprising a system of three simultaneous equations, each capturing the dynamics

of one of the endogenous variables under study. The model specifically incorporates one equation for the shadow economy, another 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 from 1991 to 2017. The specification of this equation aligns with widely accepted formulations in the empirical literature and incorporates several key economic indicators commonly linked to informal economic activity. Specifically, four explanatory variables are included. Economic growth (GDP), which captures the overall expansion in 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 considered due to its impact on purchasing power and cost structures, which can drive 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. Ultimately, human capital (HC), reflecting the population's level of education and skills, plays a critical role in shaping the structure and efficiency of both formal and informal economic sectors.

The second endogenous variable is inflation (CPI). This variable reflects the fluctuations in the prices of goods and services consumed by households, thus indicating the general price level. This equation includes the following important variables: economic growth (GDP), which indicates the growth rate of the gross domestic product, expressed as an annual percentage. The shadow economy (SE), Calculated as a percentage of GDP, the presence of a significant shadow economy can affect fiscal and monetary policies, particularly influencing inflation. The money supply (MS) is included in this equation because it plays a central role in determining price levels, and its inclusion is supported by a rich theoretical foundation, such as the quantity theory of money. Tax revenues (TR) represent the income collected by the government through taxes and other fiscal levies. Variations in tax revenues can influence public spending and economic policies, potentially affecting inflation. Finally, human capital affects production costs, productivity, and the demand for goods and services; all of these factors have significant impacts on price levels.

The third endogenous variable is economic growth, measured as an annual percentage. The specification of the economic growth equation (GDP) also includes inflation and the shadow economy, as well as two other important variables: human capital (HC) and foreign direct

investment (FDI). Human capital is measured by the tertiary enrollment rate, which represents a high level associated with better innovation capacity and increased productivity, which can support a country's economic growth. Foreign direct investments indicate the capital invested by foreign companies or individuals in the capital of local businesses. These investments can have a significant impact on economic growth, as they bring technologies, capital, and skills that can stimulate economic development and promote growth.

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:

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

(1)

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

(2)

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

(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 condition 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.

While:

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

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

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

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

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

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

(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**

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

(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**

$$GDP_{it} = \gamma_0 CPI_{it} + \gamma_1 SE_{it} + \gamma_2 HC_{it} + \gamma_3 FDI_{it} + \lambda''_{it}$$

(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 presents and summarizes the descriptive statistics of the selected variables based on a sample of 405 observations (Obs). For the dependent variables, the results indicate that the average of the shadow economy is 24.54 with moderate variability, the standard deviation being 8.14. This value means that approximately a quarter of the total economic wealth is generated by informal activities, indicating that the shadow economy plays a significant role in the economies of the MENA region countries. Furthermore, inflation averages 5.68, which is relatively high and may reflect instabilities in monetary policies. Economic growth reaches an average of 4.26 with a standard deviation of 8.03. The maximum value is 86.82%, and the minimum value is -50.33%. These notable variations in GDP growth may be the result of economic crises or unpredictable economic policies.

Thus, according to the results presented in this table, the average human capital in the MENA region is reported as 25.62, with a notable standard deviation of 12.85. This value indicates a significant variability among countries. The extreme values, ranging from 4.47 to 72.96, demonstrate that while some countries exhibit very low levels of human capital, others show markedly high levels.

Furthermore, the results for the other variables included in the model show that tax revenues, self-employed workers, the unemployment rate, and foreign direct investments, as well as fixed capital formation, have average values of 13.07, 26.86, 9.47, 19.91, and 7.18, respectively. On the other hand, the average exchange rate and money supply in this region are 109.57 and 73.35, with extreme values ranging from 10% to 298.35% and from 23.77% to 260.61%, respectively.

Table 1: 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 performing regressions based on panel data, we conduct specification tests to ensure that the regression model is well suited to the data. To achieve this, we conduct the following tests: the residual normality test and the correlation test.

The normality of the residuals can be evaluated using several tests, such as the Shapiro-Wilk and Kolmogorov-Smirnov tests. In our study, we chose to use the Skewness test (the skewness coefficient) and the Kurtosis test (the kurtosis coefficient).

Table 3: Normality Test of Residuals

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

Note: * Statistically significant at 10%. ** Statistically significant at 5%. *** Statistically significant at 1%
As shown in Table 3, all the Prob>chi2 values are greater than 0.05. Given that these probabilities are greater than 5%, we accept the hypothesis of normality of the residuals. Therefore, we can conclude that the residuals follow a normal distribution, which allows us to proceed with the other tests.

Prior to estimating the final model, it is important to assess the presence of multicollinearity among the explanatory variables. Multicollinearity may compromise the reliability of the regression estimates by inflating the standard errors and making the coefficient estimates highly sensitive to small changes in the data (Bourbonnais, 2009).

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 below displays the correlation matrix, which illustrates the relationships between the variables in our models. It therefore allows testing for the existence of multicollinearity problems among the explanatory variables. In fact, a problem may exist when the correlation between the variables exceeds 0.8. We can therefore conclude that the problem of multicollinearity is completely absent because all the correlation coefficients are below the value of 0.7. Furthermore, we can verify this condition using another complementary test called the VIF (Variance Inflation Factor) test. Several previous studies have used this method to assess the presence or absence of multicollinearity issues. According to Marquardt (1970) and Gujarati (2012), a VIF must be less than 10 to indicate the absence of collinearity. As

shown in the table below, the VIF values for the three equations, shadow economy (SE), inflation (INF), and economic growth (GDP), range between 1.02 and 2.23, which is below the critical value. Moreover, their averages are 1.38, 1.49, and 1.55, which confirms the absence of multicollinearity issues among the model variables. We can therefore move on to the next analysis

Table 2: 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	1.0000
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

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

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

IV. Empirical Findings

Table 5 presents the estimation results obtained from our econometric model using the Three-Stage Least Squares (3SLS) method.

Table 3: 3SLS estimation

Variables	Spécification 1 SE	Spécification 2 CPI	Spécification 3 GDP
SE	---	1.140 (0.254)***	-0.078 (0.084)
CPI	0.493 (0.216)**	---	-0.486 (0.131)***
GDP	-0.755 (0.265)***	-0.153 (0.082)*	---
Self-Empl	0.345 (0.040)***	---	---
HC	-0.005 (0.075)	0.123 (0.098)	-0.041 (0.033)
MS	---	0.080 (0.001)***	---
TR	---	-0.532 (0.116)***	---
FDI	---	---	0.710 (0.204)***
Constant	15.013 (4.898)***	-15.804 (9.522)*	20.299 (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***

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

In the first specification of our global panel estimation, inflation exerts a positive and significant influence on the shadow economy, with a 5% threshold. This indicates that an increase of one percentage point in the CPI increases the size of the shadow economy by 0.493%. This result is supported by previous research, such as that of Mazhar and Méon

(2017), Koreshkova (2006), and Ergene (2015), which found a positive relationship between inflation and the shadow economy. We can explain this positive result by examining several aspects, such as inflation reducing consumers' purchasing power when prices rise, real wages decrease, and workers therefore seeking additional means to meet their needs, often by engaging in informal activities. More specifically, this result observed in the MENA region countries can be explained by economic theories that highlight the responses of economic agents to high transaction costs as well as the erosion of the value of liquidity.

In fact, regional observations indicate that inflation drives many economic actors towards informality to avoid the costs associated with the shadow economy. While economic growth has a negative and significant impact on the shadow economy at the 1% threshold, this means that a 1% increase in economic growth reduces the shadow economy by 0.755%. Similar works by Loayza (1997), Schneider and al. (2010), Davidescu, Strat, Paul (2015), and even Huynh (2020) support this result. Indeed, when the shadow economy increases, it tends to offer more job opportunities and ensure stable incomes, thereby reducing the need for informal activities. Not only can sustained economic growth lead to institutional and regulatory reforms, often aimed at creating a favorable economic environment and making the formal sector more attractive. Moreover, in the countries of the MENA region, where economies are marked by notable fluctuations due to dependence on natural resources, periods of economic growth can signal improvements in public services and the regulatory framework. Such developments can limit the incentives to operate informally.

On the other hand, the self-employed worker has a significant and positive impact on the shadow economy, at the threshold of 1%. This means that an increase in the number of self-employed workers will increase the shadow economy by 0.345%. The works of Williams and al. (2011), Brill (2011), Barbour and Llanes (2013), as well as Horodnic (2015), Williams, C and al (2016), validate this conclusion. This result can be explained by the fact that self-employed workers are often associated with sectors where labor market regulations are less stringent. Moreover, in many MENA countries, several barriers such as education and professional qualifications restrict access to the legal market and regulatory compliance requirements, so self-employed workers can bypass these barriers by turning to the shadow economy.

Finally, human capital has a negative impact with a coefficient of -0.005 on the shadow economy, but this impact is not significant since the probability reaches 0.930%, which is above the thresholds of 1%, 5%, and 10%. Economic theory shows that the variable of human

capital, measured by various indicators, such as the level of education, can influence the size of the shadow economy. In other words, higher human capital could theoretically limit the shadow economy by increasing productivity as well as employment opportunities in the formal sector. However, in our study, the coefficient of -0.005, although indicating a negative relationship, is not statistically significant. This shows that one cannot conclusively determine the influence of human capital on the shadow economy.

In the second specification, the table shows that economic growth has a negative impact on inflation at the 10% threshold. More specifically, a one percentage point increase in the economic growth rate results in an inflation decrease of approximately 0.15%. This result is in line with the conclusions of Yabu and Kessy (2015) as well as Haliru, 2021. An increase in economic growth helps to alleviate inflationary pressures. The evidence affirms that economically more advanced countries have the resources and mechanisms to manage macroeconomic challenges, such as inflation.

The shadow economy significantly and positively influences inflation at the 1% threshold. This means that a 1 percentage point increase in the shadow economy raises inflation by 1.140%. This result can be explained by the fact that the shadow economy, often characterized by undeclared transactions, can cause an increase in aggregate demand without any corresponding increase in supply, which puts upward pressure on prices. Moreover, high transaction costs and inefficiency in informality can lead to high prices for goods and services, thereby contributing to inflation. Empirical work, particularly by Rdhaounia and Kouni (2022) and Baklouti and Boujelbene (2019), supports this positive result.

For the money supply, according to the table estimation, a positive and significant impact at the 1% level is observed. An increase of one percentage point in the money supply leads to a 0.080% increase in inflation. This result is consistent with the famous Friedman theory (1968), namely the quantity theory of money. According to this theory, an increase in the money supply, without a proportional increase in production, leads to a rise in prices. This relationship is particularly important due to several factors. For instance, many countries in the MENA region heavily rely on oil exports, which can lead to economic volatility. Indeed, when oil prices are high, governments increase their public spending, financed by increased money creation, which leads to the phenomenon of inflation. Moreover, the countries in the MENA region often face political instability and conflicts, which disrupt markets and cause price increases.

However, the estimation table shows that human capital has a positive but non-significant impact on inflation, with a probability value of 0.209, which does not reach the conventional significance thresholds of 1%, 5%, or 10%. Thus, it can be concluded that the results are not statistically robust enough to confirm a definitive relationship.

Finally, there is a statistically significant negative relationship between tax revenues and inflation at the 1% significance level. When tax revenues increase by one point, inflation decreases by 0.532%. In other words, when the government increases its tax revenues, it seems to have a moderating effect on the phenomenon of inflation by reducing the pressure on prices. Research conducted by economists such as (Mazhar and Méon (2017) studied the impact of the informal sector on inflation and taxation, confirming these results. More specifically Their studies indicate that high tax revenues help stabilize inflation by providing the state with the necessary resources to finance expenditures without resorting to inflationary practices such as excessive money creation.

The third specification reveals that inflation significantly and negatively impacts economic growth at the 1% threshold. The evidence suggests that a 1% increase in the inflation rate decreases economic growth by approximately 0.486%. This result is consistent with the endogenous growth theory and shows that when there is taxation of human capital, inflation has a negative impact on economic growth (Lucas, 1988). More specifically, the endogenous growth theory, developed by economists such as Paul Romer and Robert Lucas, emphasizes the importance of internal factors, such as innovation, human capital, and government policy, in determining economic growth. According to this theory, inflation can have a negative effect on economic growth by affecting incentives for innovation and the accumulation of human capital. This relationship is consistent with empirical works such as Yabu and Kessy (2015) and Mosikari and Eita (2018).

Add to this the fact that the negative impact of inflation on economic growth is influenced by several important interrelated factors. One of the most critical is price stability, which fosters confidence among consumers and investors (Ramzan, 2021). When inflation becomes uncontrollable, it creates uncertainty in the market, discouraging investors from investing. This uncertainty also hampers investment and innovation, both of which are essential drivers of economic growth. Consumers worried about rising prices then hold back on spending, reducing total demand and economic growth. (Uddin, 2021)

On the other hand, foreign direct investment (FDI) has a positive and significant effect at the 1% level. An increase of 1% in FDI boosts economic growth by 0.710%. This evidence

suggests that FDI inflows into MENA countries can play an important role in stimulating economic activity, fostering innovation, and improving productivity. This positive correlation is supported by works such as those of Agrawal (2015) and Wang, X and al. (2022). Finally, regarding the impact of the shadow economy and human capital on economic growth, although the results show a negative effect, it is not statistically significant. Indeed, the probabilities are respectively 0.353% and 0.222%, which exceed the significance thresholds of 1%, 5%, and 10%. It would be appropriate to reflect on this variable, which appears to be non-significant across all models. It may be relevant to explore an alternative and broader indicator than human capital, which could provide significant results. This could serve as a starting point for our subsequent analysis.

In conclusion, the three-stage least squares (3SLS) estimator indicates that all models are statistically significant at the 1% level. The overall results highlight a bidirectional causal link between the shadow economy and inflation as well as economic growth and inflation, while a unidirectional link is observed between economic growth and shadow economy. These results confirm our hypotheses formulated at the beginning of the study

V. Robustness Checks

We verify the robustness of the empirical results by using several methods, such as adding control variables or employing econometric methods. In our work to validate the results of the global model, we use the generalized method of moments (GMM) as a technique to deepen the analysis.

Prior to presenting the results obtained using the GMM estimator developed by Arellano and Bond (1991), it is essential to verify that the necessary diagnostic tests have been satisfied. The validity of the instrumental variables is assessed through the Hansen test. The Arellano–Bond tests reveal the presence of second-order serial correlation in the first-differenced residuals, while no first-order autocorrelation is detected. In addition, the Durbin–Wu–Hausman test is applied to determine whether the impact of endogenous regressors is significant, thereby confirming the suitability of the GMM estimation approach. Table 6 presents the results of the previous regressions, disaggregated by MENA countries.

In the first specification focusing on the shadow economy (SE), the consumer price index (CPI) displays a positive coefficient of 0.082, statistically significant at the 10% level. This suggests a modest but meaningful positive relationship between inflation and the shadow

economy, indicating that rising inflation encourages individuals to engage in informal economic activities as a way to shield themselves from inflationary pressures. This finding aligns with the overall structure of our model. In contrast, the gross domestic product (GDP) shows a strong negative effect on the size of the shadow economy, with a coefficient of -0.157 significant at the 1% level, supporting the view that economic growth reduces informality by fostering formal sector integration. Furthermore, the variable representing self-employment exerts a positive and statistically significant influence at the 5% level, with a coefficient of 0.143 , reinforcing the idea that self-employed individuals are more likely to operate within the informal sector. On the other hand, human capital (HC) is associated with a negative coefficient (-0.023), although this effect is not statistically significant, as indicated by a p-value of 0.475 , which exceeds conventional significance thresholds (1%, 5%, and 10%). Overall, the results for inflation, economic growth, self-employment, and human capital are broadly consistent with the expectations of the theoretical model, supporting the robustness of the initial specification. Additionally, Table 1.6 reveals that the unemployment rate has a positive and statistically significant impact on the shadow economy, with a coefficient of 0.572 at the 5% significance level. This indicates that higher unemployment is associated with greater informal sector activity, as individuals often resort to shadow economic activities when they are excluded from the formal labor market. The informal sector's flexibility and low entry barriers offer a viable alternative for those facing economic hardship. These findings are consistent with previous studies, including those by Schneider (2011), Alexandru and Dobre (2013), Davidescu (2014), Burger and Fourie (2019), and Gaspareniene and Remeikiene (2021).

Table 1-4: 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

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

In the second specification, which focuses on inflation (CPI), the key variables from the overall model continue to yield consistent results. The shadow economy exerts a positive and statistically significant effect on inflation, with a coefficient of 0.941 significant at the 10% level, suggesting that the expansion of informal activities contributes to upward pressure on prices. GDP displays a negative and highly significant impact on inflation at the 1% threshold, indicating that economic growth tends to stabilize price levels. Similarly, tax revenues have a negative and statistically significant effect, reinforcing the idea that improved fiscal capacity can help control inflation. In contrast, the human capital variable remains statistically insignificant in this specification. Additionally, this model introduces the exchange rate as a control variable. The results show a negative and significant relationship, with a 1% increase in the exchange rate leading to a 0.033% decrease in inflation. This outcome supports the economic rationale that currency appreciation reduces inflationary pressures by lowering the cost of imported goods, thus easing production costs for domestic firms and consumer prices. These findings are in line with prior research conducted by Bailliu and Fujii (2005), Fatai, Koku, and Caushi (2016), Baklouti and Younes (2019), as well as Ha, Stocker, and Yilmazkuday (2020).

The third specification focuses on economic growth (GDP) and reveals a negative and statistically significant relationship between the shadow economy and growth, with Table 1.6 indicating that a 1% increase in the size of the informal sector leads to a 0.102% decline in GDP. This finding differs from that of the global model, where the negative effect of informality on growth was not statistically significant. Inflation also exerts a negative influence on economic growth, consistent with previous results. However, a notable

divergence is observed in the case of human capital, which now displays a negative and significant impact on growth. This may be explained by structural mismatches between education systems and labor market needs; for instance, an oversupply of graduates in low-demand fields can lead to elevated unemployment, limiting the economy's ability to harness its human resources effectively. Moreover, in some developing countries such as Tunisia and Algeria, a significant share of highly educated individuals migrate abroad in search of better opportunities, leading to a brain drain that undermines domestic growth potential. As for foreign direct investment (FDI), while it shows a positive coefficient, its effect on growth is not statistically significant, suggesting that without complementary institutional reforms and enhanced national capabilities, FDI alone may be insufficient to generate robust economic development. In contrast, gross fixed capital formation (GFCF) exerts a strong positive influence on growth, significant at the 1% level. This result highlights the essential role of physical capital accumulation in boosting productivity, expanding production capacity, and creating jobs. It also supports innovation and enhances competitiveness domestically and internationally, thereby contributing to long-term economic expansion. These findings align with several empirical studies, including those by Baklouti and Boujelbene (2019), Zhang et al. (2021), and Kchiri and Belghiti (2022).

VI. Conclusion

This article has explored 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, suggesting that these two phenomena are mutually reinforcing. The expansion of informal activities contributes to inflationary pressures through tax evasion and reduced public revenues, which may prompt governments to rely on monetary financing. Conversely, rising inflation fuels the shadow economy, as economic agents seek to escape the erosion of purchasing power through more flexible and often unregulated informal transactions.

Furthermore, the analysis uncovers a two-way relationship between inflation and economic growth, reflecting the dual role of inflation in MENA economies. While moderate inflation may encourage consumption and investment, persistent high inflation undermines growth by distorting price signals and diminishing real incomes. As for the relationship between the

shadow economy and economic growth, the evidence points to a unidirectional effect: economic expansion reduces the size of the informal sector by creating more formal employment opportunities and strengthening incentives for legal compliance. Nevertheless, a growing shadow economy remains a major constraint on development, as it undermines the tax base, limits public investment capacity, and deprives governments of critical resources needed for infrastructure, education, and healthcare.

To enhance the robustness of these results, 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 mitigates concerns related to endogeneity, thereby strengthening the reliability of our conclusions.

Policy Implications

These findings carry significant implications for policymakers in the MENA region. First, reducing the size of the shadow economy should be a central objective of economic reform, which requires not only stricter enforcement mechanisms but also the creation of inclusive, formal labor markets. Second, monetary and fiscal authorities must closely monitor inflationary dynamics, as inflation simultaneously weakens purchasing power and fuels informality. Third, investing in institutional quality, education, and innovation can help reduce informality and increase economic resilience. Finally, addressing structural constraints such as mismatches between education and labor market needs or weak public service delivery can foster stronger, more inclusive growth while limiting the appeal of the informal sector.

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