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Article abstract

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Demystifying Rising Income Inequality Influence on Shadow Economy: Empirical Evidence from Nigeria

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We investigate whether rising income disparity contributes to the proliferation of shadow economic activities in Nigeria. The study uses data from 1991 to 2018 and adopts the Auto-regressive Distributed Lags (ARDL) cointegration approach to study the effects of income inequality on the shadow economy in both the short- and the long-run. Our results show that the Nigerian shadow economy responds positively to increases in income inequality, especially in the short run. We also find that the large income disparity in Nigeria drives the poor into informal economic activity, primarily for survival, and that unemployment partly contributes to informality. Our findings suggest that unemployment may be both a result and a cause of rising income disparity in Nigeria, leading to an expansion of the shadow economy. These findings indicate that regulating the proliferation of shadow economic activities in Nigeria will necessitate, among other things, the implementation of measures to reduce income gaps, such as stronger institutional frameworks and the expansion of financial intermediation services such as credit supply to the informal sectors.

Keywords: Income inequality; shadow economy; taxation; government spending; income distribution

JEL Classifications: E26, H26, O17, H20, I30

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1 Introduction

Rising income inequality between the "haves and have-nots" hinders development, particularly in Emerging Markets and Developing Economies (EMDEs). In Nigeria, the situation is quite dire considering the extent of wealth disparity along ethnic and geopolitical divides, with more wealth concentrated in the Southern part of the country (majority Yoruba and Igbo ethnic groups). In contrast, the Hausa-Fulani ethnic group, located in Northern Nigeria, is predominantly poor. According to Oxfam International (2017), the North-Western region of Nigeria has 71.4% multidimensional poverty, thus making it the largest in the country. This is higher than the North-East and the North-Central regions with 69.1% and 60.7%, respectively. Hence, the northern regions exhibit higher multidimensional poverty when compared to the 49.8% in the South-West, 55.5% in the South-South, and 59.5% in the South-East. Furthermore, Northern Nigeria coincidentally has the highest level of economic informality in the country (NBS, 2021).

On the other hand, the International Labour Organization (ILO) describes the shadow economy as having more low-income workers than the official economy, employing more than 60% of those aged 15 and above (ILO, 2018a). Due to lower pay and high demand for lower-quality products in developing countries, the daily livelihoods of the poor largely depend on shadow economy activities, which continue to provide safer havens for less-educated or unskilled workers. For example, in 2019, approximately 60.1% of workers worldwide work in the informal economy (ILO, 2021), which accounts for approximately one-third of Gross Domestic Product (GDP) in EMDEs while accounting for about 62% of GDP in Sub-Saharan Africa (ILO, 2018b). Data from the ILO also show that about 70% of employees in EMDEs and 90% of employees in Sub-Saharan Africa are employed in the informal economy (ILO, 2018b). Furthermore, between 1991 and 2018, the percentage of the informal economy in Nigeria has averaged about 57.1% of GDP, as indicated in Medina and Schneider (2019). This puts Nigeria's shadow economy to GDP above that of Mauritius (22.4%) but lower than that of Zimbabwe (60.6%), the smallest and largest shares of the informal economy in Africa, respectively. Consequently, the shadow economy that remains unregulated, untaxed, and excluded from official statistics is detrimental to socioeconomic transformation and long-term growth. This is because shadow activities weaken the government's capacity to mobilize tax revenues while also reducing access to social welfare programmes and distorting macroeconomic policy[1]. Thus, it is not unexpected that high levels of shadow economic activities may facilitate disproportionate income distribution and led to a dramatic breakdown in government efforts to generate tax revenues.

[1] See, among others Tanzi (1999), Schneider and Enste (2000), Capasso and Jappelli (2013), Berdiev and Saunoris (2019).

Recently the association between the shadow economy and income inequality has received considerable attention from academics. However, empirical studies have so far documented mixed associations between the two concepts (Rosser et al., 2000; Elveren & Zgür, 2016; Yap et al., 2018; Berdiev & Saunoris, 2019; Esaku, 2021a). For instance, Elgin and Elveren (2021) show a negative association between economic informality and income inequality in richer economies while presenting a positive relationship in poorer nations. Dell'Anno and Solomon (2014) further explore the shadow economy-income inequality nexus by testing the implications of their theoretical model and found unclear evidence of causality. However, Esaku (2021a) submits that inequality positively influences the shadow economy in developing countries, specifically in the context of Uganda. This lack of consensus calls for further study in a different context to advance our understanding of the dynamics of the relationship between unequal income distribution and the shadow economy. Furthermore, prior studies have either grouped all emerging and developed economies together or focused on one or a few countries. Hence, policy suggestions from these studies may not be generally applicable due to differences in the economic structures of nations. Therefore, we aim to extend the literature by focusing on the Nigerian context.

In this paper, we assess the extent to which the shadow economy responds to changes in income inequality in Nigeria. To the best of our knowledge, this is the first attempt to study the relationship between income inequality and the shadow economy due to the proliferation of hidden market activities in Nigeria using Medina and Schneider's estimated data (2019). To achieve our objective, we use the Autoregressive Distributed Lags (ARDL) technique and time-series data between 1991 and 2018 to establish both the long- and short-run impacts of income inequality on the size of the shadow economy in Nigeria. Our findings indicate that increases in income inequality push the Nigerian shadow economy up in both the long- and short-run, other things being equal. This finding highlights the need for curbing expanding income inequality in order to mitigate increases in the size of the shadow economy in Nigeria. Moreover, we also find strong evidence that the high unemployment rate and jobless growth in Nigeria partly increase the likelihood of the unemployed joining the informal economy for survival purposes. Lastly, our findings are robust to a different long-run estimation technique and model stability tests.

The novelty of this paper is threefold. Firstly, by using the most recent data on the shadow economy, it expands the literature by shedding further light on how rising income disparity leads to the proliferation of hidden economic activity in the context of Nigeria. The second contribution of this paper is that it gives reliable insights into specific policy recommendations that would assist in redistributing incomes through pro-poor intervention programmes that aim to limit the spread of informality. Finally, we argue that unemployment may be both a consequence of and a reason for rising income disparity in Nigeria, leading to an increase in shadow economic activities.

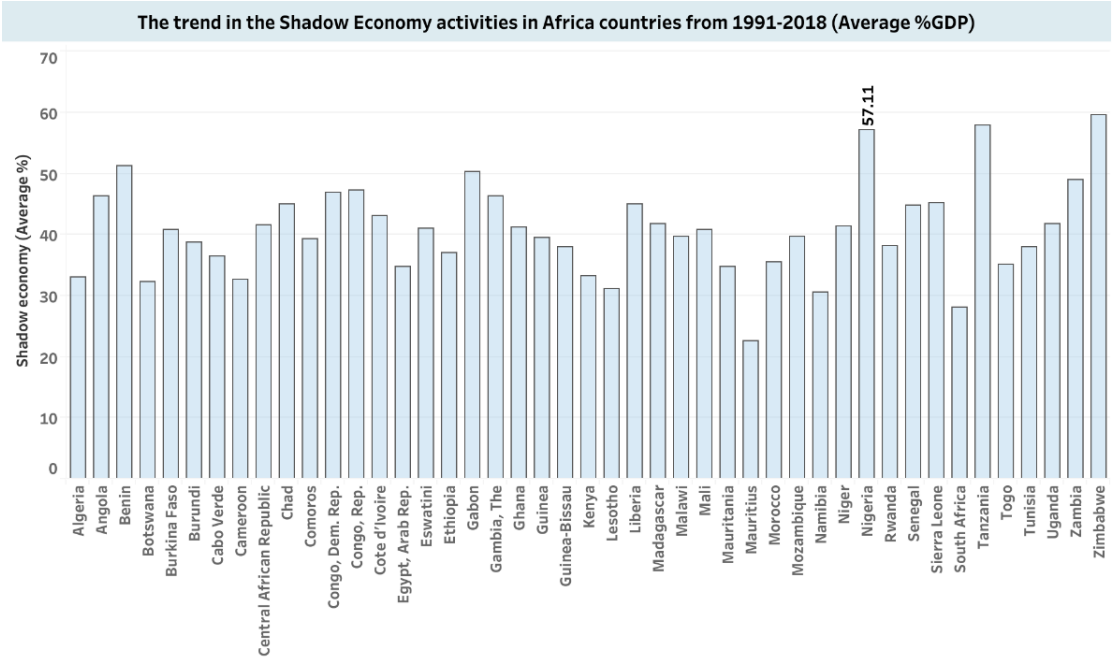
Following this section, part 2 presents both theoretical and empirical literature on income inequality and the shadow economy. Section 3 discusses the data and summary statistics.

Section 4 describes the methodology and econometric estimating strategy of this paper. Section 5 contains the findings of this analysis. Section 6 concludes the study based on the findings from the preceding sections.

1.1 Some stylized facts

There are four facts about the Nigerian shadow economy that are pertinent to this paper. First, Nigeria has a substantial shadow economy, accounting for an average of 57.1% of GDP from 1991 to 2018, making it the third-largest in Africa (see, Figure 1). Zimbabwe had the largest shadow economy in Africa, accounting for 60.6% of GDP, while Mauritius had the smallest, accounting for 22.4% of GDP[2]. Second, income disparity is more significant in Northern Nigeria than in the South. Oxfam International (2017) reports 71.4% in the North-West, followed by 69.1% in the North-East and 60.7% in the North-Central, compared to 49.8% in the South-West, 55.5% in the South-South, and 59.5% in the South-East. Moreover, 40% of the total population of 184 million, or 83 million people, live below the poverty line based on the country's benchmark of $381.75 a year (NBS, 2020). Third, to keep afloat, most small-scale businesses in Nigeria borrow money from family and friends (NBS, 2021).

Figure 1: Average size of the shadow economy in Africa (1991-2018)



Source: Authors' calculation based on Medina and Schneider (2019) dataset

[2] See Medina and Schneider (2019)

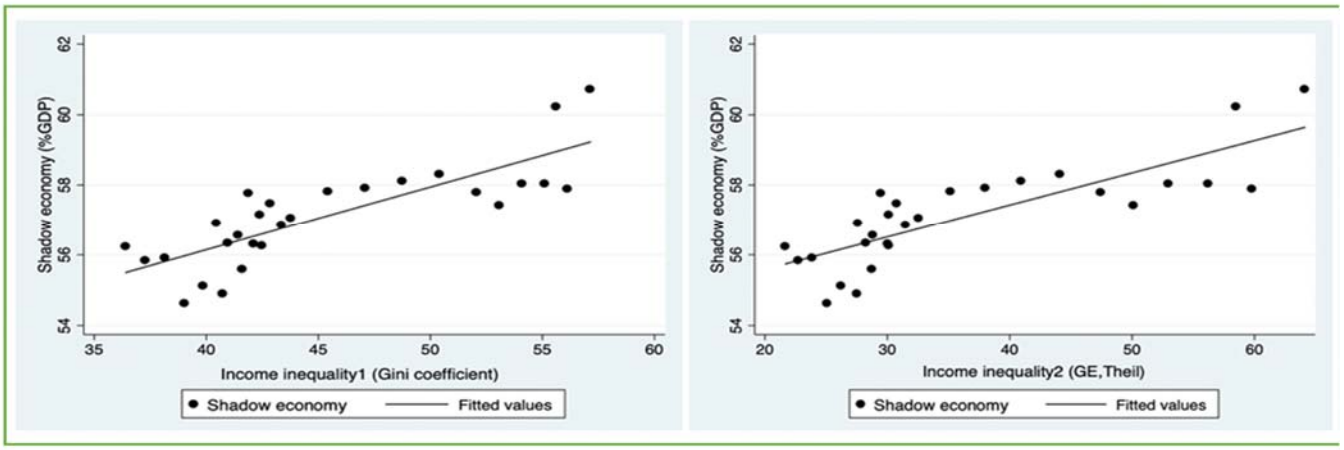
Finally, many individuals and businesses avoid paying taxes as a result of a lack of basic service delivery[3]. This is due to the government's wasteful spending of tax revenues on projects and programmes that bring little value to the economy.

Figure 2 depicts the relationship that exists between key explanatory variables (the Gini and Theil indexes) and the shadow economy. The positive slope implies that income inequality increases the share of the shadow economy. Whether the explanatory variable is assessed using the Gini index or the Theil index, the positive slopes are the same. Nigerian society remains generally uneven, with a widening income disparity exacerbated along ethnic lines, and with rich individual households concentrated in the country's south.[4]

2 Review of literature and hypothesis development

The rising disparity in economic opportunities between the "haves" and "have-nots" has stimulated the interest of development economists. Our paper draws on the seminal work of (Schneider, 2005), who defines the shadow economy as "economic activities and the income derived from them that circumvent or otherwise government regulations, taxation, or observation" (p.599). Numerous authors have documented empirical studies on income inequality and the informal sector in 16 transition economies (Rosser et al., 2000), inequality and the shadow economy in 154 countries (Yap et al., 2018), inequality and the informal economy in Turkey (Elveren & Özgür, 2016), income inequality and the shadow economy in

Figure 2: Shadow economy Vs. income inequality



Source: Authors' calculation

[3] See McCulloch et al. (2021)

[4] See Archibong (2018), Madu (2006), and Mustapha (2006).

114 developed and developing economies (Berdiev & Saunoris, 2019), income inequality and the shadow economy in both the long and short-run in Uganda (Esaku, 2021a), and informality and income inequality in 125 countries (Elgin & Elveren, 2021). The underground economy, black market economy, subterranean economy, parallel economy, hidden economy, or unofficial economy are various terms used to describe the shadow economy.

According to Medina and Schneider (2019), the average size of the shadow economy in 158 countries between 1993 and 2018 was 33.4% of GDP: in Africa, it accounts for roughly 40.3% of GDP (with Zimbabwe accounting for about 60% of GDP and Mauritius accounting for 23% of GDP); in Asia-Pacific, it accounts for nearly 30% (with Azerbaijan accounting for 57% of GDP and Japan accounting for 11% of GDP); and in Europe, it accounts for roughly 25%. However, estimating the size of the shadow economy can be problematic since no one wants to be recognized, making it difficult to collect reliable official statistics. Model-based estimates (output informality), labour force survey-based estimates (employment informality), and firm/opinion survey-based estimates are some of the widely estimated methodologies (perceived informality). In this view, the shadow economy is closely related to macroeconomic indicators of underdevelopment since individuals and households escape taxes that could otherwise be used to provide social welfare services such as healthcare delivery, infrastructure, and education.

Poor people's livelihoods in many Emerging Markets and Developing Economies (EMDEs) are based on shadow economy activities. For example, in 2019, approximately 60.1% of workers worldwide work in the informal economy (ILO, 2021), which accounts for approximately one-third of GDP and approximately 70% of total employment in EMDEs, and approximately 90% of total employment and 62% of GDP in sub-Saharan Africa (ILO, 2018b). Many researchers have focused on the effects of the shadow economy on economic outcomes, such as tax burden and social security (Dell'Anno & Davidescu, 2019), labour market regulations (Ulyssea, 2010), tax evasion (Tanzi, 1999), tax morale (Oviedo et al., 2009; Torgler & Schneider, 2009), corruption and institutions ((Buehn & Schneider, 2012; Dreher & Schneider, 2010), and financial sector development (Canh & Thanh, 2020; Capasso & Jappelli, 2013), but few have looked at how income inequality impacts the shadow economy (Berdiev & Saunoris, 2019; Bhattacharya, 2011; Chong & Gradstein, 2007; Elveren & Özgür, 2016; Esaku, 2021b, 2021a; Hatipoglu & Ozbek, 2011; Rosser et al., 2000). This paper examines key theoretical and empirical studies on the relationship between income inequality and the shadow economy.

Every society has income inequality throughout the income distribution, and technological advancements in the formal sector have come to play a significant role in raising nations out of poverty (Chong & Gradstein, 2007). The choice of technology, whether high-level or low-level, is important. When inequality rises, people with a steady source of income are more inclined to invest in "rent-seeking" to get access to sophisticated technology in the official sector than

those without a steady source of income. It is these people who are more likely to migrate to the shadow economy. In this view, strong institutions are important in allowing income to be dispersed equitably, and when institutions are weak, increased inequality leads to a larger shadow economy (Mishra & Ray, 2010). The authors identify three ways in which inequality may affect informality and corruption: too many wealth-constrained individuals, barriers to entry for productive or wealth-constrained enterprises, and high demand for informal sector items owing to distributional issues.

Political stability in a country can influence whether economic agents work in the formal or informal sector (Hatipoglu & Ozbek, 2011). This is because civil instability benefits the wealthy while reducing transfers and increasing informality as a result of poor redistribution. Poor workers with low skill levels find it easier to operate in developing economies where informality is prevalent than in a wealthier formal sector. Wage disparities in income redistribution might cause both low and high skilled employees to migrate from rural to urban areas (Bhattacharya, 2011). The prevalence of a wage disparity between the formal and informal sectors, according to the author, influences the level of income inequality. Despite contributing significantly to national output, especially in developing countries, the informal sector tends to serve as a "buffer zone" for low-skilled workers.

In a few related studies, the causal relationship and feedback between income inequality and the shadow economy are unclear. Dell'Anno and Solomon (2014) find that institutional quality and ICT are positively associated with a higher level of income inequality in their theoretical model; however, when the model is tested, the informal sector's effect on income inequality is unclear; the currency approach to measuring informal activities produces negative results, while the electricity approach produces positive results when regressed. Surprisingly, they also show that the MIMIC technique has a significant positive influence on income inequality. Furthermore, their findings support the majority of the empirical literature's contention that the MIMIC approach is the most commonly used by researchers. The relationship between the shadow economy and income inequality may be either positive or negative, depending on a country's degree of economic development (Gutierrez-Romero, 2007). This bidirectional relationship between income inequality and the informal sector is also found in the studies of Rosser et al. (2000) and Berdiev and Saunoris (2019), with the proliferating informal sector creating more inequality as a result of declining tax revenues and weakening social safety nets, and growing inequality causing informal activities as social cohesion and truth deteriorate. Yap et al. (2018) find that income inequality is strongly and nonlinearly connected with the shadow economy, meaning that a decrease in the shadow economy may lower or raise the degree of income inequality. The authors also establish an inverted-U shaped link in developing countries with a shadow economy threshold of 65% and an inverted-N shaped relationship in developed countries.

Elveren and Özgür (2016), for example, show that in Turkey, international trade competition that lowers labour costs stifles wages for unskilled workers, resulting in increased income gap and increasing demand for lower-quality commodities produced in the informal sector. In Uganda, Esaku (2021a) suggests that higher income disparity has a significant impact on the share of the shadow economy in both the long and short run. This can happen in an economy where the income disparity between the "haves and have-nots" is increasing, and the latter will continue to engage in the shadow economy. Because of the predominance of low wages, the informal economy in most developing economies maintains fewer educated or low-skilled workers. Also, because of the prevalence of low-wage jobs, the informal economy draws less educated or low-skilled workers in most emerging economies. Unlike previous findings, Elgin and Elveren (2021) find a negative relationship between informality and income disparity in richer economies and a positive one in poorer ones. They did, however, suggest that increasing female labor-force participation is linked to lower income disparity.

A large informal sector can increase inequality by reducing tax revenues that finance government transfer programs. However, causation may not run in the reverse direction (Rosser et al., 2000). Considering the growing tendency of shadow market operations in Africa, one critical question is whether rising income inequality contributes to the proliferation of hidden economic activity. This paper seeks to contribute to this body of knowledge by examining the consequences of income inequality on the shadow economy.

Stemming from the above literature, we set the following hypotheses:

H1. There is a link between the widening income inequality and the proliferation of the shadow economy in Nigeria.
H2. The rising income inequality effect on the shadow economy is higher in the short-run than the long-run.

3 Data and summary statistics

To explore the income inequality-shadow economy nexus in Nigeria, we curate annual time series data from multiple sources spanning 28 years (1991 to 2018). Our dependent variable is the annual percentage of the shadow economy to GDP sourced from Medina and Schneider (2019) and designated herein as *shadow*. The data is compiled using an indirect measure of informality, namely the multiple indicator-multiple cause (MIMIC) approach. This measurement technique offers more consistent annual data over time compared to other direct measures such as labour force and household surveys (Elgin et al., 2021). Our primary explanatory variable is the Gini index, designated *gini* and sourced from the Standardized World Income Inequality Database (WIID) developed by The United Nations University, World Institute for Development Economics Research (UNU-WIDER, 2021). The Gini inequality index is the most widely used and cited in the literature and shows the deviation from

equality in income distribution in a country. Hence, a higher gini value indicates a higher unequal distribution of income. To ensure our estimations are robust and reliable for informed conclusions, we use the Theil index as an alternative measure of inequality sourced from WIID. Both indices are commonly adopted in studying income inequality in empirical studies. Furthermore, the Gini index is a relatively simple and efficient representation of income distribution, while the Theil index is superior in its decomposability quality (Charles-Coll, 2011; Liao, 2016).

In addition, we include various control variables that characterize the Nigerian economy, public sector, and institutional strength that have the tendencies of affecting changes in the shadow economy. They include unemployment rate (unemp), government expenditure (govexpen) measured in percentage of GDP, bureaucratic quality (buqua) measuring the strength of bureaucratic processes and their autonomic nature from political pressure, the log of corruption perception (corr), GDP growth rate (gdpgr) measured as the annual changes in economic growth, and a measure of financial development in its log form (findev) indicating the extent of access to formal financial institutions. Furthermore, we use data from the World Development Indicators for the unemployment rate, government expenditure, and GDP growth rate (World Bank, 2021) and the access to financial institution index proxy for financial development is sourced from the International Monetary Fund (IMF) (IMF, 2021). Lastly, corruption perception was sourced from Transparency International, while bureaucratic quality was obtained from the International Country Risk Guide (ICRG, 2021).

The above description of the data is formally presented as summary statistics in Table 1 and the correlation matrix in Table 2. Accordingly, Table 1 shows the mean value shadow economy to be 57.10% of GDP during the period studied. This portrays a relatively large presence of economic informality in Nigeria. Furthermore, gini and theil have average values of 45.35 and 38.72, respectively. The difference in values is a representation of the differences in computing both indices. Other mean values include 4.27% for unemp, 4.35% for govexpen, 1.16 for buqua, -2.97 for corr, 4.37% for gdpgr and -2.60 for findev.

Table 1: Summary Statistics

	Shadow	Gini	Theil	Unemp	Govexpen	Buqua	Corr	Gdpgr	Findev
Mean	57.10	45.35	38.72	4.27	4.35	1.16	-2.97	4.37	-2.60
Median	57.09	42.67	32.77	3.82	4.47	1.00	-2.91	4.82	-2.87
Std. Dev.	1.40	6.35	12.61	1.33	3.04	0.49	0.191	3.86	0.43
Max.	60.70	57.15	63.24	8.45	9.44	2.00	-2.74	15.32	-1.99
Min.	54.62	36.40	23.12	3.59	0.91	0.00	-3.75	-2.04	-3.12
Obs.	28	28	28	28	28	28	28	28	28

Table 2: Correlation Matrix

	Shadow	Gini	Theil	Unemp	Govexpen	Buqua	Corr	Gdpgr	Findev
Shadow	1.000								
Gini	0.816	1.000							
Theil	0.809	0.998	1.000						
Unemp	-0.328	-0.467	-0.418	1.000					
Govexpen	-0.509	-0.646	-0.652	0.074	1.000				
Buqua	0.434	0.635	0.657	-0.129	-0.321	1.000			
Corr	-0.044	-0.067	-0.092	-0.153	0.157	-0.239	1.000		
Gdpgr	-0.192	-0.384	-0.422	-0.345	0.287	-0.343	0.158	1.000	
Findev	-0.665	-0.694	-0.676	0.450	0.808	-0.317	0.132	0.070	1.000

The correlation matrix presented in Table 2 suggests high positive correlations between our measures of income inequality and the shadow economy in Nigeria. While this provides a preliminary look at the income inequality-shadow economy nexus, a further empirical examination is needed to reach a convincing conclusion and identify the causal link among the variables.

4 Methodology

4.1 Model specification

To test the two hypotheses earlier developed, we begin by specifying the functional link among the shadow economy and the independent variables discussed in the preceding section. Thus, we specify the relationships for different measures of income inequality as follows:

$$\text{Shadow} = f(\text{gini}, \text{govexpen}, \text{unemp}, \text{gdpgr}, \text{corr}, \text{buqua}, \text{findev}) \quad (1)$$

$$\text{Shadow} = f(\text{theil}, \text{govexpen}, \text{unemp}, \text{gdpgr}, \text{corr}, \text{buqua}, \text{findev}) \quad (2)$$

where all variables are as previously defined. Also, see Table A1 for a description of the variables and the sources. Furthermore, the explanatory variables included in both models were drawn following arguments from extant literature on the shadow economy. For instance, Esaku (2021a) show that economic growth has an inverse relationship with the shadow economy while government expenditure increases shadow economy tendencies in Uganda. Hence, both variables are included to capture the growth in Nigeria's economy and the extent of government participation in the economy through spending. Furthermore, the unemployment rate is included following the extant literature. For instance, Mauleón and Sardà (2017) and Adriana

(2014) show that high unemployment rates lead to a high shadow economy. We account for financial development by including an index for accessing formal financial institution services as studies have shown that financial development leads to reduced shadow activities (Elbahnasawy et al., 2016). Additionally, we include corruption perception index following the evidence that corruption and shadow economy are positively reinforcing (Vo et al., 2015). Moreover, higher levels of corruption undermine institutional quality and consequently expand the shadow economy. Lastly, institutional quality is one way of curbing shadow economic activities (Ruge, 2010). Hence, we include bureaucratic quality as our measure of strong institutions devoid of political influence. The next section will discuss our econometric specifications and techniques of analysis

4.2 Econometric estimation strategy

The study adopts the Autoregressive Distributed Lags (ARDL) technique of Pesaran and Shin (1999) and Pesaran et al. (2001) to investigate both the short- and long-run impacts of income inequality on the shadow economy in Nigeria. The ARDL technique is more reliable and efficient in the presence of small sample sizes and handles variables of different orders of integration compared to other cointegration techniques (Nkoro & Uko, 2016). Moreover, it also accounts for endogeneity issue and uses a bounds test of joint significance to assess the existence of cointegration among variables (Awad & Youssof, 2016). While the ARDL process does not require pretesting for stationarity, it becomes analytically weak in the presence of an I(2) series. Hence, pretesting helps avoid futile efforts (Nkoro & Uko, 2016).

The general form of ARDL specification is given as below:

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \sum_{i=0}^{q} \beta_i \Delta x_{t-i} + \delta_i y_{t-i} + \beta_i x_{t-i} + \varepsilon_{it}; t = 1,2,3 \qquad (3)$$

where y is the dependent variable; γ_0, the intercept; x, a vector of independent variables. The superscripts p and q are the lag operators of the dependent and independent variables, respectively. β and δ are unknown coefficients; Δ the difference operator; and ε_{it} is the residual.

Accordingly, we express equation (1) in the ARDL form as follows:

$$\begin{aligned}\Delta shadow_t = \gamma_0 + \sum_{i=1}^{p} \alpha_1 \Delta\, shadow_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta gini_{t-i} + \sum_{i=1}^{q} \alpha_3\, \Delta govexpen_{t-i} + \\ \sum_{i=1}^{q} \alpha_4\, \Delta unemp_{t-i} + \sum_{i=1}^{q} \alpha_5\, \Delta gdpgr_{t-i} + \sum_{i=1}^{q} \alpha_6\, \Delta corr_{t-i} + \\ \sum_{i=1}^{q} \alpha_7\, \Delta buqua_{t-i} + \sum_{i=1}^{q} \alpha_8\, \Delta findev_{t-i} + \beta_1 shadow_{t-i} + \beta_2 gini_{t-i} + \\ \beta_3 govexp_{t-i} + \beta_4 unemp_{t-i} + \beta_5 gdpgr_{t-i} + \beta_5 corr_{t-i} + \beta_5 buqua_{t-i} + \\ \beta_5 findev_{t-i} + \varepsilon_{it} \qquad (4)\end{aligned}$$

where α_1,...,.α_8 and $\beta_1.,.,.\beta_8$ are parameters for short and long-runs, respectively.

Transforming equation (2) into the ARDL form only requires substituting theil for gini in equation (4) above.

The ARDL approach begins by assessing the existence of cointegration among the variables through an F-test of joint significance. Here, the null hypothesis is that cointegration is absent ($H_o: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$) while the alternative hypothesis is that cointegration exists ($H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq 0$). The reported F-statistic will be compared with the critical values of Narayan (2005) which are specified for small sample datasets. We also compare them with the critical values of Kripfganz and Schneider (2018) for robustness. The null hypothesis is then rejected when the reported F-statistic for both models is above the upper bound critical values, and we can conclude there is cointegration in either model. On the other hand, F-statistic values below the lower bound critical values will signify that there is no cointegration in either model. Furthermore, the long-run coefficients are reported at this stage.

When cointegration and the long-run coefficients are established, the next step involves estimating short-run coefficients and the Error Correction Model (ECM) using a reparameterized form of equation (4) as follows:

$$\Delta shadow_t = \gamma_0 + \sum_{i=1}^{p} \alpha_1 \Delta\, shadow_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta gini_{t-i} + \sum_{i=1}^{q} \alpha_3\, \Delta govexpen_{t-i} + \sum_{i=1}^{q} \alpha_4\, \Delta unemp_{t-i} + \sum_{i=1}^{q} \alpha_5\, \Delta gdpgr_{t-i} + \sum_{i=1}^{q} \alpha_6\, \Delta corr_{t-i} + \sum_{i=1}^{q} \alpha_7\, \Delta buqua_{t-i} + \sum_{i=1}^{q} \alpha_8\, \Delta findev_{t-i} + \beta ECT_{t-i} + \varepsilon_{it} \quad (5)$$

where all variables retain their previous definitions and β stands for the error correction term coefficient, which captures how rapidly any distortions from long-run equilibrium per period are adjusted. The coefficient should be negative and significant to be valid.

5 Estimation Results and Discussions

5.1 Stationarity tests

In line with Nkoro and Uko (2016), we begin by pretesting the stationarity of our variables to identify variables that are stationary beyond the first order I(1) and before performing the ARDL estimation. For this purpose, we employ the widely used Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests of stationarity and present the results in Table 3. The results of the stationarity tests show no variable to be stationary at second order (I(2)). Since all variables are either I(0) or I(1), we can proceed to perform the cointegration test using the ARDL bounds testing technique.

Table 3: Augmented Dickey-Fuller and Philip-Perron Stationarity Tests

	Levels[I(0)]				First Difference [I(1)]			
	Intercept		Intercept and Trend		Intercept		Intercept and Trend	
	ADF	PPerron	ADF	PPerron	ADF	PPerron	ADF	PPerron
Shadow	-3.196***	-2.406	-3.676**	-2.942	-4.213 ***	-6.125***	-4.033***	-6.427 ***
Gini	-2.696***	-0.821	-2.816	-1.177	-1.755**	-3.343**	-1.746	-3.583**
Unemp	0.658	1.301	0.245	0.354	-2.477***	-3.942***	-3.146*	-4.580***
Buqua	-2.834*	-2.230	-2.912	-2.196	-4.894***	-3.829 ***	-5.039***	-3.828**
Gdpgr	-1.742	-2.608*	-1.612	-2.451	-3.786***	-7.072***	-3.975***	-6.985***
Findev	-0.515	-0.748	-2.586	-1.784	-3.156**	-4.182***	-3.092	-4.137 ***
Govexpen	-1.173	-1.291	-1.472	-1.398	-3.619**	-4.724***	-3.565**	-4.625***
Corr	-3.452***	-4.084***	-3.373*	-4.078***				
GE1	-3.623***	-1.128	-2.721	-1.004	-1.609	-3.724***	-1.677	-4.348
Findev	-0.456	-1.03	-2.492	-1.951	-3.455***	-5.300***	-3.373*	-5.216***

Statistical significance is denoted by ***, 1%; **, 5%; and *, 10%

5.2 Cointegration Evidence

Sequel to the stationarity test results, we then show the outcomes of our cointegration tests for different measures of income inequality in Table 4.

Table 4: Cointegration Results

Panel (a): Models to be estimated		
Models	Dependent Variable	Explanatory Variables
1	Shadow	gini govexpen unemp gdpgr corr buqua findev
2	Shadow	theil govexpen unemp gdpgr corr buqua findev
Panel (b): ARDL Bounds Test Result		
	ARDL	F-statistic
Model 1	(1,1,0,0,0,1,1,1)	5.852
Model 2	(1,1,0,0,0,1,1,1)	5.532
Panel (c): Critical Values		
	Narayan (2005)	Kripfganz and Schneider (2018)
	Lower Bounds	Upper Bounds	Lower Bounds	Upper Bounds
10%	2.384	3.728	2.483	3.934
5%	2.875	4.445	3.062	4.764
1%	4.104	6.151	4.567	6.904

Panel (a) in Table 4 shows the models used for the cointegration test. In panel (b), the optimum lags for each variable in both models are presented alongside the ARDL bounds test F-statistic values. Notably, both models, under different measures of income inequality, have F-statistic values above the upper bound critical values of both Narayan (2005) and Kripfganz and Schneider (2018) at the 5% level of significance. For reference, the upper bound critical value for Pesaran et al. (2001) is 3.5. We, therefore, find evidence for rejecting the null hypothesis of no cointegration and establishing the existence of cointegration in both models. Hence, we can extend our assessment to the long- and short-run alongside the ECM for both models.

5.3 Long Run Estimates for the Income inequality-shadow economy Nexus

We show the outcomes of the ARDL long-run estimation for both models in Table 5. Specifically, the results highlight the long-run relationships between the different measures of inequality and the Nigerian shadow economy in columns 1 and 2 for the Gini and Theil indexes, respectively. Furthermore, we check the robustness of this relationship using an alternative long-run estimation technique such as the Feasible Modified Ordinary Least Squares (FMOLS) technique and present the results in columns 3 and 4 of Table 5. Accordingly, both columns 1 and 2 show the existence of a significantly positive long-run relationship between the extent of income inequality and the size of the shadow economy in Nigeria. These results confirm our first hypothesis. Specifically, they show that a unit change in the gini coefficient and theil index raises the Nigerian shadow economy's size by 0.259 and 0.132 units, respectively, at 1% significance level. This finding agrees with earlier submissions in the literature on the positive nexus between income inequality and the shadow economy (Chong & Gradstein, 2007; Mishra & Ray, 2010; Hatipoglu & Ozbek, 2011; Esaku, 2021a).

Moreover, a positive inequality-shadow economy nexus is intuitive given the extent of inequality in Nigeria and the high tendency of the poor to explore the shadow economy. For instance, an Oxfam (2017) report contextualize income inequality in Nigeria, showing that the top five richest Nigerians accounted for more money ($29.9 billion) in 2016 than what is required ($24 billion) to lift all indigent Nigerians out of poverty. Hence, despite being the largest economy in Africa, Nigeria hosts about 12.1% of the world's extreme poor (World poverty clock, 2021), while almost 41% of its population live in poverty. Furthermore, empirical evidence lends credence to a positive poverty-income inequality nexus in Nigeria (Ogbeide & Agu, 2015). Therefore, for people to survive, engaging in the shadow economy becomes almost irresistible. Igudia et al. (2016) also point out that amongst other factors, "the need to survive" often influences shadow economic practices in Nigeria. Consequently, about 81.3% of Nigeria's labour force, representing informal employment, is employed by microenterprises (Dell'Anno & Adu, 2020). An obvious take from this is that expanding income gap in Nigeria is bound to push more income-disadvantaged individuals and households

Table 5: Long Run Estimates

	ARDL	ARDL	FMOLS	FMOLS
	(1)	(2)	(3)	(4)
variables	Gini	Theil	Gini	Theil
Income inequality	0.259***	0.132***	0.309***	0.154***
	(0.039)	(0.021)	(0.033)	(0.017)
Government expenditure	0.118	0.156*	0.309***	0.318***
	(0.080)	(0.084)	(0.064)	(0.067)
Unemployment	0.558***	0.522***	0.704***	0.647***
	(0.119)	(0.126)	(0.120)	(0.121)
GDP growth	0.073**	0.074*	0.125***	0.131***
	(0.033)	(0.038)	(0.032)	(0.034)
Corruption	0.550	0.747	0.361	0.525
	(0.748)	(0.808)	(0.494)	(0.515)
Bureaucratic quality	-1.184***	-1.276***	-0.829***	-0.902***
	(0.295)	(0.331)	(0.256)	(0.273)
Financial development	-1.714***	-2.005***	-2.179***	-2.310***
	(0.475)	(0.514)	(0.456)	(0.477)
Constant	40.942***	47.422***	34.486***	42.95***
	(3.588)	(2.973)	(2.805)	(2.357)
Number of observations	27	27		
R-squared	0.955	0.950	0.833	0.826
Adj. R-squared	0.916	0.907	0.772	0.761
F-statistic	24.908	22.281		
Probability of F-stat	0.000	0.000		

Statistical significance is denoted by ***, 1%; **, 5%; and *, 10%; standard errors are in parentheses

into the shadow economy either as self-employed or informal employees, thereby exerting any negative effect associated with expanding shadow economy such as low tax revenue, inefficient resource allocation, and reduced effectiveness of macroeconomic policies (Dell'Anno & Adu, 2020; Mazhar & Meon, 2017).

Furthermore, Table 5 also shows that both unemployment and economic growth positively influence the Nigerian shadow economy in both models estimated.

For instance, model 1 shows that a unit increase in the unemployment rate raises the shadow economy by 0.558% while changing economic growth by 1% expands the shadow economy by 0.073%. The former suggests that increasing unemployment levels in Nigeria increases the likelihood of joining the informal economy. This relationship agrees with the findings of

Mauleón and Sardà (2017) for Greece and Spain, Adriana (2014) for Romania and Ogbuabor and Malaolu (2013) for Nigeria. On the coefficient of economic growth, our finding contradicts that of Esaku (2021a) but partly agrees with (Elbahnasawy et al., 2016). Other studies (Nguyen & Duong, 2021; Zaman & Goschin, 2015) also reported a positive association between shadow economy and economic growth. In the Nigerian context, a positive relationship between economic growth and the shadow economy is not surprising. The Nigerian economy experienced concurrent increases in both economic growth and unemployment, as was common with other African economies between 2002 and 2014 (Dada, 2018). This rise in growth with no job creation (jobless growth) is likely to force the unemployed into the informal economy as a safety net, thereby expanding the shadow economy.

Furthermore, the extant literature provides evidence that better institutional quality and financial development could potentially curtail the expansion of the shadow economy (Esaku, 2021a; Elbahnasawy et al., 2016; Ruge, 2010). Accordingly, our results agree with this claim in that we find both bureaucratic quality and access to financial institutions to inversely affect the level of the shadow economy in Nigeria. These highlight that controlling the expansion of shadow economic activities in Nigeria would, among other things, require stronger institutional frameworks and the extension of financial intermediation services such as credit supply to the informal sectors. We check the robustness and reliability of our claims by re-estimating our models using the FMOLS technique, following Esaku (2021a) and Menegaki (2019). The results of the robustness check are presented in columns 3 and 4 of Table 5. It can be observed that our first hypothesis is again confirmed by the FMOLS under different measures of income inequality. Accordingly, the results exhibit a significantly positive relationship between income inequality and the shadow economy in Nigeria.

5.4 Short Run Estimates of the Income Inequality-Shadow Economy Nexus

Proceeding from the long run estimation, we re-parameterize our model into an ECM equation and estimate equation (5) to obtain the short-run and ECT for our models. The results are shown in Table 6, where column 1 provides estimates for the Gini coefficient while column 2 shows the results for Theil index. Both models indicate that income inequality positively reinforces the shadow economy in Nigeria in the short run. Moreover, the results are statistically significant at 1%. Therefore, increasing income inequality measured by gini and theil by one unit each raises shadow economic activities in Nigeria by 0.669% for Gini and 0.30% for Theil in the short run. This finding concurs with the submissions in Esaku (2021a). These results support our initial findings in the long-run estimation.

Therefore, these findings suggest that in the short and long run, the shadow economy in Nigeria is responsive to changes in income inequality. Furthermore, the size of the impact of income inequality on the shadow economy in Nigeria is larger in the short run. While this

Table 6: Short Run Estimates

Variables	ARDL Model (1) Gini	ARDL Model (2) Theil Index
Income inequality	0.669***	0.300***
	(0.162)	(0.078)
Government expenditure	0.111	0.141
	(0.079)	(0.082)
Unemployment	0.519***	0.471***
	(0.126)	(0.127)
GDP growth	0.068*	0.067
	(0.035)	(0.038)
Corruption	-0.747	-0.498
	(0.438)	(0.448)
Bureaucratic quality	-0.329	-0.386
	(0.277)	(0.293)
Financial development	-0.350	-0.511
	(1.126)	(1.212)
$ECT_{(-1)}$	-0.932***	-0.903***
	(0.137)	(0.143)

Statistical significance is denoted by ***, 1%; **, 5%; and *, 10%; standard errors are in parentheses.

confirms our second hypothesis, it shows that in the long run, changes in the shadow economy may be accounted for by other factors, hence reducing the influence of income inequality. However, for policy interventions aiming to curb the expansion of informal economic activities in Nigeria, mechanisms for effective redistribution of income or reducing income inequality should entail both short- and long-run dynamics.

Tuning to our control variables, Table 6 further shows that the unemployment rate has a positive and significant effect at the 1% level in influencing the shadow economy in the short run. For instance, a 1% change in the unemployment rate raises the Nigerian shadow economy by 0.519% and 0.471% in models 1 and 2, respectively. This finding reinforces our initial assertion that high unemployment rate is a key push factor for joining the shadow economic activities in Nigeria. As Ogbuabor and Malaolu (2013) assert, unemployed Nigerians often engage in the informal economy to survive until they find gainful employment in the formal

economy. Furthermore, we find a relatively weak positive economic growth-shadow economy nexus at the 10% level in model 1 in the short run. However, we do not find significant evidence for other control variables in our models in the short run.

Finally, the reliability of the ARDL technique is conditional on how significant the long run disequilibrium correction mechanism is. This mechanism is called the speed-of-adjustment mechanism or error correction term and shows how fast movements away from long run equilibrium are adjusted per period. To check for this, we reparametrize the ARDL model and present the lagged error correction term (ECT_{-1}) in Table 6. As is consistent in the literature, the coefficient of the adjustment term must be negative and statistically significant. Accordingly, the ECT coefficients show that movements away from long-run equilibrium in models 1 and 2 are corrected with 93% and 90% adjustment speed, respectively, at a 1% significance level. The fast adjustment speed in both models shows that all variables quickly converge to long-run equilibrium. We then proceed to check the stability of our estimations and the reliability of our results for informed policy recommendations.

5.5 Diagnostic tests

Making informed conclusions from the preceding evidence on the impact of income inequality on the shadow economy in Nigeria requires our estimates to be stable. Hence, we present the results of the model stability and reliability tests in Table 7 and the subsequent cumulative sum of recursive residuals (CUSUM) and its squared (CUSUMSQ) plots.

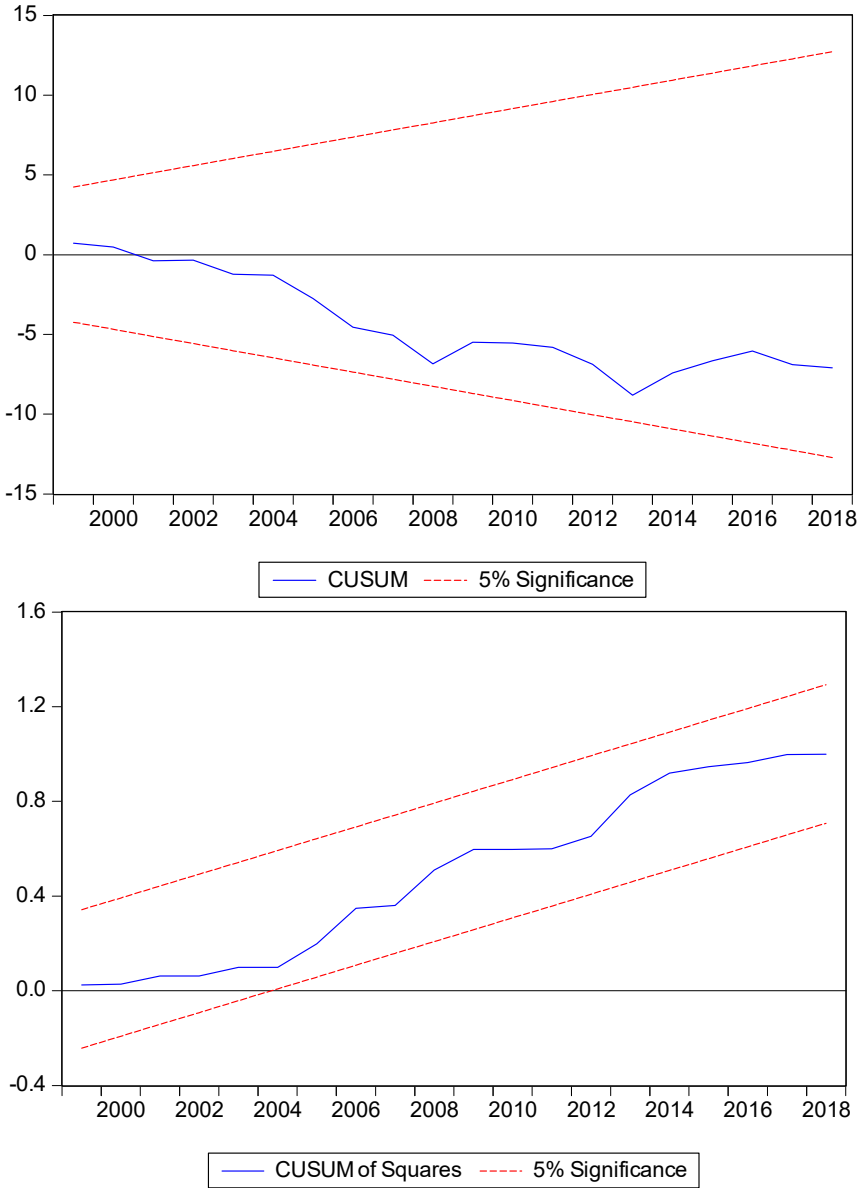
From Table 7, we used the Breusch-Godfrey test to assess serial correlation, the Breusch–Pagan–Godfrey test for heteroskedasticity, and the Jarque-Bera test for normality. In all three tests, we find no evidence to reject the null hypotheses of no serial correlation and that our models are homoscedastic and our samples are normally distributed. Hence, our findings are not driven by bias, and our estimates are reliable.

Table 7: Diagnostic Tests

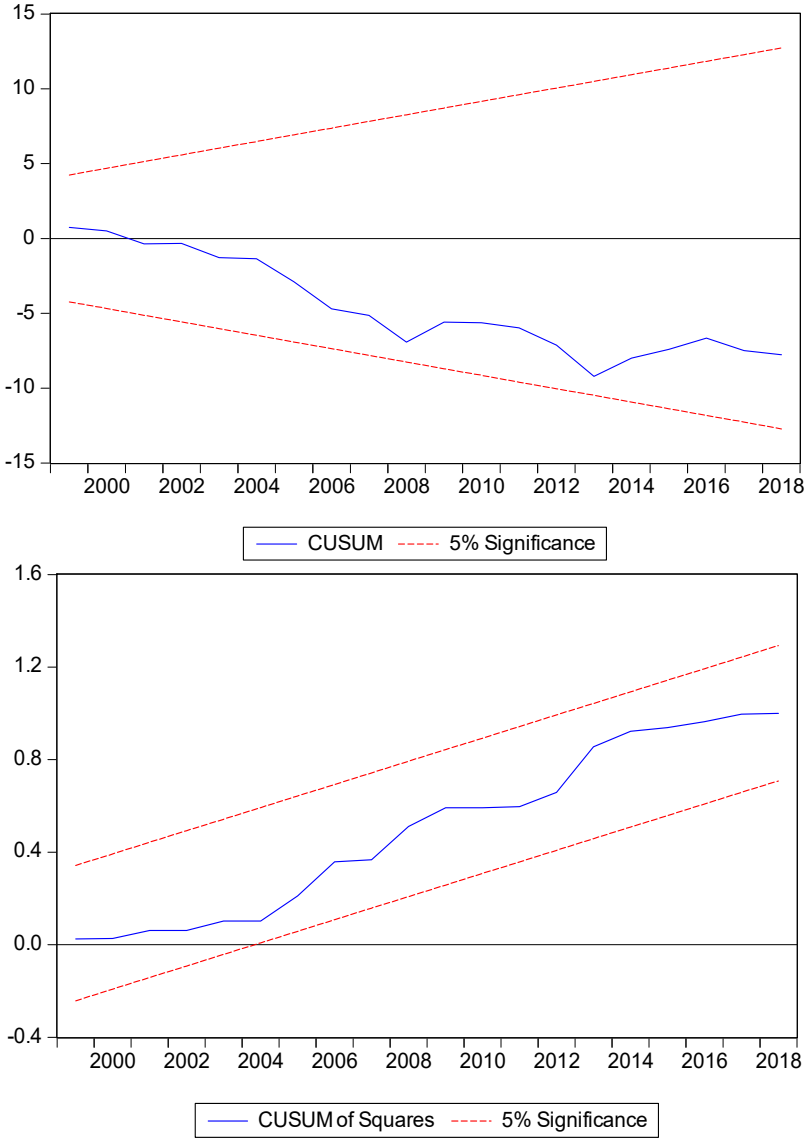
Tests	Model (1)	Model (2)
Serial correlation; Breusch-Godfrey	0.504	1.148
obs*rsquared	2.093	4.337
Heteroskedasticity; BP	0.145	0.206
obs*rsquared	2.988	4.060
Normality JB	0.375	0.376
Prob	0.829	0.829

Furthermore, both the CUSUM and CUSUMSQ plots for both ARDL models exhibit model stability at a 5% level of significance. This is evident from the movement of the residual line between the upper and lower boundaries in all plots. Therefore, our models are stable for drawing meaningful conclusions.

Model 1



Model 2



6 Conclusions

A large-sized shadow economy often serve as a means of informal employment and earning in many developing countries. However, studies have highlighted the economic costs of such economic engagements, such as reduced taxed revenue for governments and other impediments to development. To understand the causes of shadow economic practices, we investigated the effect of income inequality in Nigeria using the ARDL cointegration technique and annual data

from 1991 to 2018. The findings of the study significantly indicate that unequal income distribution leads to expansion in the size of the Nigerian shadow economy in both the short and long runs, other things being equal. This finding lends credence to the argument that large income disparity between the rich and the poor in Nigeria is one of the factors that push the poor into informal economic activities chiefly for survival. Furthermore, we also found that increasing unemployment partly raises the shadow economy in Nigeria. This finding indicates that unemployment may be both a consequence of and a reason for increasing income inequality, thereby leading to an expanding shadow economy in Nigeria. Moreover, we found that controlling the expansion of shadow economic activities in Nigeria would, among other things, require stronger institutions and the extension of credits to the informal sector by financial institutions. Lastly, our results are robust and reliable under different measurements of income inequality and an alternative long run estimation technique.

The findings in this study are useful for policy design and implementation. For instance, policymakers need to understand that curbing the expansion of the Nigerian informal economy and expanding the government's revenue require addressing the causes of income inequality in the country. One of these causes may be the expanding unemployment level in the country. Hence, providing avenues for gainful employment or deliberate efforts towards formalizing the small and medium scale firms that account for more than 80% of jobs in Nigeria should be given renewed attention. This is likely to address income inequality and economic informality in both the short and the long runs. Furthermore, strengthening institutions and easing access to formal financial services such as access to credit for formal enterprise establishment and expansion should also be considered.

Despite the importance of our findings, our study is limited by the fact that the literature has indicated multiple causes of the expansion of the informal economy, which were impossible to cover in a single study. Furthermore, the study only used data for 28 years, which may be too short a time period for understanding the historical connections between the shadow economy and income inequality in Nigeria. Moreover, narrowing the study to Nigeria alone precludes us from making generalized conclusions regarding the income inequality-shadow economy nexus. However, these limitations lay the foundations for future research. For instance, we are also interested in understanding the specific effect of corruption on the size of the shadow economy and how the shadow economy, in turn, relates to the Nigerian economic growth.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal ties that may seem to have influenced the work reported in this paper.

Table A1: Definitions of the variables used in the empirical analysis

Variables	Description
Dependent variable	
Shadow economy	Percentage of GDP, averaging over all shadow economy estimates reported in Medina and Schneider (2019).
Explanatory variables	
Gini index	Measure the proportion of income that each population decile captures using the Gini index. Standardized World Income Inequality Database (SWIID), UNU-WIDER.
Theil index	Measures the share portion of income distributional spread at decomposed components (between-group and within-group). Standardized World Income Inequality Database (SWIID), UNU-WIDER.
Control variables	
GDP per capita growth	Real GDP per capita (in constant 2005 US dollars)- World Bank-WDI
Unemployment rates	The share of unemployed people in the active population. ILO.
Government expenditure	The total of goods and services exports and imports expressed as a percentage of GDP (in constant US dollars, 2011). World Bank-WDI
Financial development	Individual business and firm's ability to receive financial services. IMF's Financial Development Index database.
Institutional quality variable	
Bureaucratic quality	It measures the institutional strength and quality of a country on a 4-ponit scale (1-4). International Country Risk Group (ICRG), The PRS Group.
Corruption	It measures the abuse of entrusted power (politicians, government officials, public servants, business people or members of the public) for private gain in a country. On a scale of 0-100, with zero indicating high levels of corruption and 100 indicating low levels. Transparency International

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