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Exploring Informal–Formal Economy Linkages: New Evidence from the MIMIC Model Approach

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Abstract: This study investigates the size, dynamics, and macroeconomic implications of the informal economy (IE) in Nigeria, using a structural macro-modelling approach. The motivation stems from persistent macroeconomic underperformance in Nigeria, even with its rich resource endowments. This situation raises important questions about the economic activities that go unaccounted for outside of formal systems. While existing literature recognizes the importance of the informal sector in developing economies, it often lacks detailed, country-specific modeling frameworks that weave the IE into broader macroeconomic analysis. This study aims to bridge that gap by constructing and estimating a macroeconomic model that explicitly includes the informal economy to understand its interactions with key macroeconomic variables. Using the Multiple Indicators Multiple Causes (MIMIC) model, the study measures the size of Nigeria's informal economy and simulates the impacts of changes in macroeconomic policy variables. The findings reveal that the size of the IE ranged from 27.8% to 65.61% of the official GDP. However, its existence outside the tax and regulatory framework undermines fiscal performance and the effectiveness of monetary policy. Moreover, the model illustrates how shocks in the formal economy affect the informal economy differently, emphasizing the importance of dual-sector policy consideration. This study adds to the existing literature by offering a robust modeling framework for analyzing informality in an oil-dependent economy. The policy implications suggest that reforms in tax administration, financial inclusion, and targeted formalization strategies are essential for enhancing macroeconomic management and fostering inclusive growth in Nigeria.

Keywords: Informal economy; Multiple indicators multiple causes (MIMIC); Nigeria; Formal economy; Autoregressive distributed lag (ARDL) model

JEL: C32, C51, E26, H26, O17

1. Introduction

The informal economy (IE) represents a significant macroeconomic issue for developing countries, where it plays a much larger role in economic activity compared to its relatively marginal presence in more advanced economies, as highlighted by Elgin and Erturk (2019) and Schneider (2022). Informality [1] has gained interest in economics in recent times due to the perceived impact on the effectiveness of formal economic policies (Dell'Anno and Davidescu, 2018). On a global scale, its contribution to the world economy has been recognized as providing critical economic opportunities; however, integrating it into the formal sector is a significant policy challenge, especially in emerging and developing economies.

The IE is not generally as bad as perceived by the official economy. There is a stimulating effect as income earned in the IE often makes its way to the formal economy. For instance, studies by Schneider (2010) and Williams and Schneider (2016) show that two-thirds of the income earned in the informal economy is eventually spent in the formal economy. The informal economy includes all economic activities hidden from regulatory authorities for various reasons. The reasons could be regulatory, monetary, or institutional. However, for this study, the informal economy reflects on the legal, economic, and productive activities that are not coordinated through market mechanisms. If these activities were properly documented, they could significantly boost the official GDP.

Those operating in the IE manage to operate outside the formal framework, thus creating persistent externalities for the economy. The magnitude of these externalities remains ambiguous, largely due to the lack of consensus among researchers on a universally accepted definition and method for estimating all the components of the informal economy in Nigeria. From a policy perspective, especially for a developing country like Nigeria, it is crucial to measure and understand how the informal economy evolves, particularly since its size is thought to be quite substantial compared to other oil-producing countries.

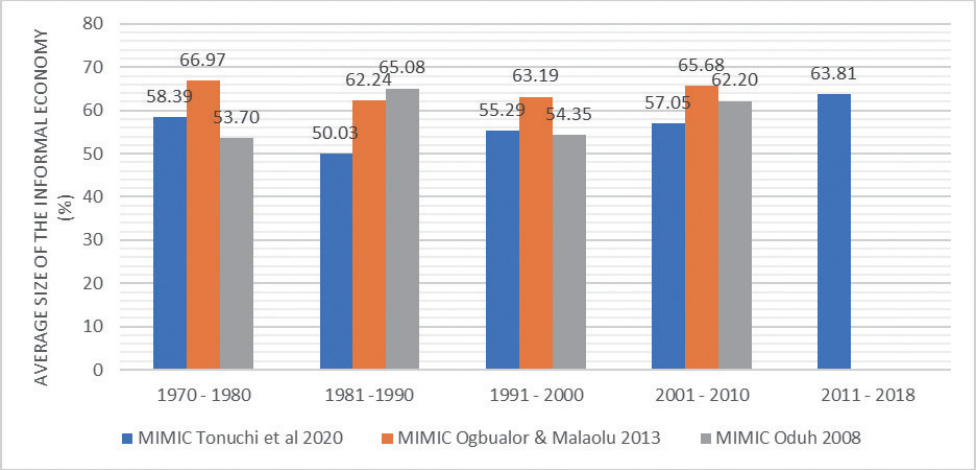
The ILO (2020) measured the size of the Nigerian IE in the past two decades to range from 51.3 to 72.9 percent of GDP. Studies with estimates for the size of the IE as a percentage of the GDP already exist (see **Fig. 1**). Oduh et al. (2008) estimated the size of IE to average 58.22 percent between 1970 and 2005, while Ogbuabor and Malaolu (2013) estimated the average stood at 64.58 percent between 1970 and 2013, and most recently, Tonuchi and Idowu (2020) estimated the average was 56.66 percent between 1970 and 2018. Therefore, an essential objective of this study is to identify the leading causes of the informal economy and the channels through which it interacts and affects the official Nigerian economy.

Schneider and Enste (2000) argue, when measuring the size of the IE, using a model approach generates acceptable results that fall within the range of difference between the underestimating micro-methods and the overestimating macro-methods. For this study, we have chosen the MIMIC approach for the following reasons: (a) the approach considers multiple indicators and multiple causes simultaneously, allowing us to select country-specific aggregates that reflect the macroeconomic characteristics evidenced from Nigeria; (b) the model approach allows us to model the informal economy as an unobservable (latent) variable; and (c) it treats the IE as an unobservable (latent) variable, which is consistent with existing literature.

To the best of our knowledge, no prior studies have empirically examined the interaction between the informal and formal economies in Nigeria across two different periods. Hence, we aim to fill this gap in the literature. We have estimated a growth model using the Autoregressive Distributed Lag (ARDL) Model proposed by Pesaran et al. (2001) to explore the potential asymmetric effect of the IE on the formal economy in both the short and long run. To sum up, our study has four objectives: first, to investigate the main determinants influencing the IE in Nigeria using the so-called Multiple Indicator and Multiple Causes (MIMIC) approach; second, to estimate the direction of causality between IE and GDP components by employing the Granger causality test, third to estimate the size of the informal economy by introducing country-specific aggregates, and finally to analyse the short-run and

[1] Throughout this paper, we will refer to informality as all the unregulated income-generating activities by governmental agencies and institutions. De Soto (1989) was one of the first authors to analyze informality for a developing economy using Peru as a case study.

long-run dynamics between the IE and the formal economy.



Source: Authors' Computation.

Fig. 1: Some existing estimates of the IE in Nigeria using the MIMIC model.

The remainder of this paper is structured as follows: the literature review is provided in section 2, which focuses on the informal economy worldwide. Section 3 is devoted to the empirical estimates of the informal economy in Nigeria, including the data, method of estimation, choice of variables, and estimation of results. Section 4 captures the estimation for the size of the Nigerian economy and the dynamic simulations for the interaction between the IE and the formal economy. We present the conclusions and possible policy implications in section 5.

2. Literature Review

The significance of informality in developing countries is now widely recognised. Both empirical and theoretical research on the informal economy has gained much attention in the literature. While numerous studies have attempted to measure the informal economy, a comprehensive definition of informality is still lacking. One commonly accepted definition comes from Smith (1994), who characterised the informal economy as a market-based production of goods and services, whether legal or illegal, that goes unnoticed in the official GDP calculations.[2] However, Smith's definition raises many questions, as illustrated in **Table 1**, which depicts a taxonomy of the types of informal economic activities in Nigeria. This categorization is insightful for refining our understanding of what might constitute an acceptable definition of the informal economy.

Table 1: A taxonomy of types of informal economic activities in Nigeria

Types of Economic Activities	Monetary transactions		Non-monetary transactions	
Illegal Activities	Oil bunkering, contract inflations, fraud, drug cartel and manufacturing, gambling, prostitution, smuggling, human trafficking, ghost working schemes in the Civil Service Commission, kidnapping, banditry, etc.		Theft for own use, barter of drugs, child trafficking, stolen goods, smuggling, production of drugs for own use, etc.	
	Tax Evasion	Tax Avoidance	Tax Evasion	Tax Avoidance
Legal Activities	Unreported income from self-employment, wages, and salaries from unreported work related to legal goods and services.	Non-remittance of employee pension, Employee discounts, and fringe benefits.	Barter of legal goods and services.	All do-it-yourself work with friends' and neighbours' support.

Source: Authors' comments, and the table structure is taken from Lippert and Walker (1997, p. 5) with additional remarks.

A working definition of the IE could encompass all legal and economic activities that would typically be taxable if reported to tax authorities. Over the past two decades, research into the size of the global informal

[2] This definition is taken from Dell'Anno and Schneider (2003) and Schneider (2005).

economy has expanded significantly. Yet, there remains a lack of consensus in the literature regarding the methods used to estimate the extent of informality. One influential paper by Schneider (2005) employed the MIMIC approach to document the size of the informal economy across 110 economies, including 23 transition economies, 21 developed OECD nations, and 66 developing countries. His findings indicate that, on average, the size of the IE as a percentage of GDP from 1990 to 2000 was 38 percent in transition economies, 17 percent in developed OECD nations, and 41 percent in developing countries, respectively.

Again, in a first attempt to assess the size and development of the underground economy for 157 countries from 1999 to 2013, Hassan and Schneider (2016b) found that unemployment, along with increased regulatory and tax burdens, are the main drivers of the underground economy. They concluded that as these aggregates rise, so do the activities within the underground economy, which aligns with earlier findings by Schneider et al. (2010). Their study encompassed a diverse range of economies, including high-income OECD, developing, Central Asian, and Eastern European economies, respectively, estimating that the informal economy averages about 33.8 percent of official GDP.

A strand of studies has also attempted to estimate the size and evolution of the informal economy in various countries. For instance, Dell'Anno et al. (2007) analysed the Portuguese informal economy from 1977 to 2004, revealing that the size of the IE varied from 29.6 percent of GDP in 1978 to 17.6 percent by 2004. Meanwhile, Dobre and Alexandru (2009) employed structural (MIMIC) models to estimate that the informal economy in Japan ranged between 8 and 11 percent of GDP from 1980 to 2008, thus highlighting the significant impact of tax burdens and their components on the informal economy.

In Morocco, Othmane and Mama (2016) applied the MIMIC approach to find that the shadow economy constituted 42.9 percent of GDP in 2015, with urbanization rate, tax burden, and rising corruption being crucial in its growth. Similarly, a study by (Hoa, 2019) on Vietnam indicated that the IE accounted for between 15 percent and 27 percent of GDP from 1995 and 2015, with an average annual growth rate of 1.2 percent. Most recently, findings from (Bennihi et al., 2021) suggest that the quality of institutions, the GDP per capita, the tax burden, and the agricultural sector are the main determinants of the IE in Algeria, and the results show that the average size of the IE was estimated at 33.48 percent of GDP.

In their study on the MIMIC model in Nigeria, Ogbuabor and Malaolu (2013) estimate that the informal economy accounts for about 53.6 – 77.2 percent of the GDP since 1970. Similarly, Tonuchi and Idowu (2020) reveal that informality has ranged from 47 to 67 percent between 1970 to 2018, with an average of 67 percent of GDP. They point out that Nigeria loses around 56 percent of its potential tax revenue yearly due to informality, thus concluding that high unemployment and regulation burden are the primary enablers of the informal economy in Nigeria. See Table A2 in the Appendix, which outlines the existing estimates of the IE in developing economies.

In conclusion, our study makes several distinct contributions to the existing literature apart from adapting the MIMIC model approach. First, we explore the dynamics between the informal economy and the official economy over both short and long-term periods using the Autoregressive Distributed Lag (ARDL) model. Second, we employ the Granger causality test to deepen our understanding of the strength and consistency of the causal relationships between these two economies. Finally, we introduce novel country-specific aggregates into our analysis, including GDP per capita, human capital index, household consumption, government final consumption, gross capital formation, among others.

3. Empirical Estimates of the IE in Nigeria

3.1 Data, Method of Estimation, and Choice of Variables

The data for this section emanates from the Penn World Table (PWT), World Development Indicator (WDI), Central Bank of Nigeria, World Bank Accounts Data, National Bureau of Statistics (NBS), and ILO estimates. The data collected consists of annualized macroeconomic time series that cover the period from 1981 to 2021.[3] The specific focus of this study was determined by the availability of data. To address the issue of outliers in the series, all variables were

[3] See **Table A3** in Appendix for a detailed description of the data sources.

log-transformed. The MIMIC model approach is used to identify the main determinants influencing IE in Nigeria, drawing on the statistical theory of latent variables and structural equation modelling. This approach was chosen over other methods in the literature to determine the causes and indicators of IE in Nigeria for several reasons.

3.2 Method of Estimation

This method is grounded in the statistical theory of unobserved (latent) variables. The MIMIC application aims to explore the relationships between the unobserved variable (IE) and observable variables by using their covariance information. As a result, the observable variables are categorized into causal and indicators of the latent variable. The MIMIC model aligns with the Linear Interdependent Structural Relationships (LISREL) models,[4] typically comprising two equations: the first being the measurement equation, which connects the unobserved variables to a set of observable indicators.

$$\eta_t = \gamma' x_t + \zeta_t \tag{1}$$

Where η_t is the latent variable, x_t is a (1 × q) vector of observable causal variables, γ is (1 × q) vectors of structural parameters, and ζ_t is the error term. The second equation specifies the causal relationship between the unobserved variable, and it is referred to as the structural equation, as depicted in **Fig. 2**. In this paper, there is one unobserved variable - the informal economy. It is supposed to be indirectly observable by a set of indicators of the latter, thus catching the structural dependence of the IE on variables.

$$y_t = \lambda \eta_t + \varepsilon_t \tag{2}$$

Where y_t is a (1 × p) vector of observed indicator variables, λ is a (1 × p) vector of regression parameters, and ε_t is a (1×p) vector of the measurement error term. The structural model (equation 2) determines the latent variable η_t by a set of exogenous causes that may be useful in predicting its size and movement, subject to a disturbance term ζ_t (Schneider and Buehn, 2013). The first step is to determine the relationship between the latent variable and its causal variables, and then estimate the size of the informal economy through the index. To estimate the size of the IE, it is necessary to convert the MIMIC index into an actual figure (Hoa, 2019). Following previous studies in the literature,[5] benchmarking is commonly used for this process. Accordingly, a benchmark[6] is determined by using the value of a year as a basis for conversion through the following formula:

$$\hat{\eta}_t = \frac{\tilde{\eta}_t}{\tilde{\eta}_x} \eta_x^* \tag{3}$$

Where, $\hat{\eta}_t$ is the standardized size of the informal economy, $\tilde{\eta}_t$ is the MIMIC index at time t calculated by the regression equation, $\tilde{\eta}_x$ is the MIMIC index in the base year calculated to the regression equation, and η_x^* is the size of the informal economy in the basic year. The MIMIC model approach of the informal economy estimated in this study uses six causal and four indicator variables. Hence, with the model, equations (1) and (2) are specified as follows:

$$\delta_t \begin{vmatrix} \gamma_1 & \gamma_{2?} & \gamma_3 & \gamma_4 & \gamma_5 & \gamma_6 \end{vmatrix} \bullet \begin{vmatrix} x_{1t} \\ x_{2t} \\ x_{3t} \\ x_{4t} \\ x_{5t} \\ x_{6t} \end{vmatrix} + \zeta_t \tag{4}$$

$$\begin{vmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \\ y_{4t} \end{vmatrix} \begin{vmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{vmatrix} \bullet \delta_t + \begin{vmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{vmatrix} \tag{5}$$

Substituting (2) into (1) yields a reduced-form equation that expresses the relationship between the observed causes and indicators. This is shown in equation (6)[7]

$$y_t = \Pi x_t + z_t \tag{6}$$

Where: $\Pi = \lambda\gamma'$ is a (4 x 6) reduced form coefficient matrix and $z_t = \lambda\zeta_t + \varepsilon_t$ is the reduced form vector of a linear transformation. For the initial specification (MIMIC 6-1-4), the structural equation to be estimated, defining the relationship between the latent variable (IE) and its causes, includes six manifested causes of the informality, given:

[4] There are pre-conditions using the MIMIC modelling approach. It begins with estimating an unknown phenomenon using two dimensions. The first dimension includes the causes (determinants), and the second dimension includes the effects (indicators).

[5] See: Ogbuabor and Malaolu (2013); Hassan and Schneider (2016); Tonuchi et al, 2020.

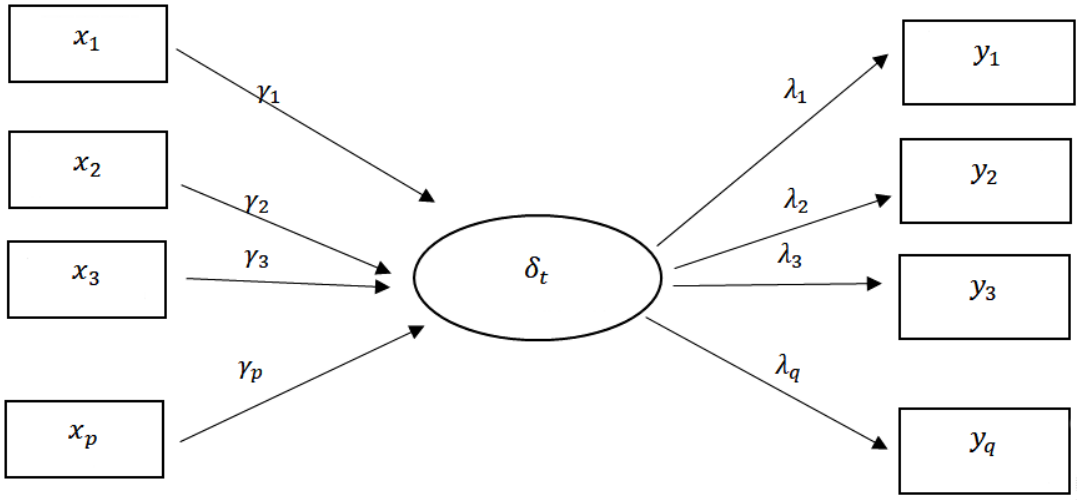
[6] See: Appendix for a more detailed discussion of the benchmarking procedure.

[7] As derived by Schneider and Buehn, 2013.

$$IE_t = \gamma_1 X_{1t} + \gamma_2 X_{2t} + \gamma_3 X_{3t} + \gamma_4 X_{4t} + \gamma_5 X_{5t} + \gamma_6 X_{6t} + \zeta_t \quad (7)$$

Where IE is the size of the informal economy in Nigeria and X_i are the different combinations of causes of the informal economy.

The MIMIC approach can be a valuable tool when analysing the informal economy. The approach, like other estimation methods used in measuring the size of the informal economy, has been criticized[8] by Tedds and Giles (2002) and Trevor (2005). However, despite these criticisms, the approach is more robust than others. The adopted approach has been applied by researchers (for instance, Schneider (2005); Macias and Cazzavillan (2010); Hassan and Schneider (2016a); Tonuchi and Idowu (2020), and Bennihi et al. (2021)) to estimate the size of the IE to date.



Source: Authors' Computation.

Fig. 2: The Structure of a MIMIC Model p-1-q

3.3 Choice of Aggregates

Deciding which aggregates to include in the study and MIMIC estimation was challenging, especially since many empirical studies have produced contentious results. With this in mind, we carefully considered the variables for our study, keeping data constraints at the forefront and aiming to align our findings with previous studies in the literature. Because of the micro and macroeconomic characteristics peculiar to the Nigerian economy, we have introduced two country-specific variables to our analysis: household consumption and human capital index, which we see as key drivers of the informal economy. Additionally, we also looked at total factor productivity, money supply, employment, and GDP growth rate as our indicator variables. However, the theoretical justifications for selecting these variables are discussed below.

3.3.1 The Causal Variables

Trade Openness: In the existing literature, trade openness is typically defined as the ratio of the total exports and imports of goods and services to the gross domestic product (GDP). It is expected that an increase in trade openness will correlate with a rise in informal activities (Schneider, 2005), therefore, leading us to anticipate a positive relationship for this variable. Hence, we propose the following hypothesis:

Hypothesis 1: The higher the level of trade openness, the higher the size of the IE, ceteris paribus.

Human Capital Index: The HCI measures how education and health contribute to the productivity of future workers, specifically, the children born today. It looks at how many years of schooling they get and the returns on that education. In the Nigerian case, there is a noticeable gap in this variable. To the best of our knowledge, this variable has yet to be included in studies related to the size of the informality in

[8] Some of the criticisms are that the approach does not rely on any micro-foundations. The approach is based on the use of certain ad-hoc econometric specifications thereby making it prone to measurement errors. Approach leads to unreliable estimated coefficients with respect to the model specification and sample size changes. However, the issue of instability disappears when the sample size increases (Dell'Anno, 2003).

Nigeria. A fall in the human capital index is expected to push more people toward informal work, as noted by Berniell (2017) and Bobba et al. (2021). So, we can expect a negative correlation. This leads us to our second hypothesis:

Hypothesis 2: The lower the level of human capital index, the higher the size of the IE, ceteris paribus.

Unemployment rate: Despite the existing literature, the relationship between the informal economy and the unemployment rate still needs to be clarified (Bennihi et al., 2021). Some studies, like those by Macias and Cazzavillan (2010) and Ene and Ştefănescu (2011), found a negative relationship in Mexico and Romania, respectively. In contrast, Medina and Schneider (2017) looked at 158 countries and found a positive relationship, as did Hoa (2019) in Vietnam. However, in the Nigerian context, Ogbuabor and Malaolu (2013) argue that there is a positive relationship between unemployment and the informal economy. They suggest that when the unemployment rate is high in the formal economy, it tends to boost the informal economy. Based on this, we propose the following hypothesis:

Hypothesis 3: The higher the level of unemployment rate, the higher the size of the IE, ceteris paribus.

Tax Burden: The tax burden refers to the percentage of tax revenue, both direct and indirect taxes, relative to GDP. In the existing literature, tax rates are often highlighted as key determinants influencing the informal economy and tax evasion. Consequently, it is assumed that a high tax burden[9] stimulates a strong motivation for people to participate in informal activities to avoid tax payments (Hoa, 2019), leading to an expected positive correlation. This brings us to the following hypothesis:

Hypothesis 4: Ceteris paribus, a higher tax burden correlates with a larger informal economy, IE.

Household Consumption: In the Nigerian case, there is a noticeable gap in the literature regarding household consumption, and to the best of our knowledge, the variable has yet to be included in studies measuring the size and dynamics of informality. Household consumption is a function of income. Thus, the intuition is that when household income falls, people start seeking alternative sources of income to smooth their consumption levels (Chukwu et al., 2024). A fall in household consumption is likely to push individuals towards the informal economy (Mapp and Moore, 2015), suggesting a negative correlation. Thus, we propose the following hypothesis:

Hypothesis 5: Ceteris paribus, the higher the level of household consumption, the lower the size of the IE.

Agricultural contribution to GDP: Taxing the agricultural sector in Nigeria poses challenges due to tax prevalence of subsistence activities in rural areas. Nevertheless, the contribution of agriculture to GDP is positively correlated with the informal economy. This connection can be attributed to limited access to credit schemes, mismanagement of specialized institutions, inefficiencies in the value chain systems, poor access to the market, and inadequate storage facilities for farmers in Nigeria. Thus, this relationship is supported by numerous studies on developing economies in the literature (Torgler and Schneider, 2007) and (Angour and Nmili, 2019). To this end, we can formulate the following hypothesis:

Hypothesis 6: Ceteris paribus, the higher the level of the agricultural sector, the higher the size of the IE.

3.3.2 The Indicator Variables

Total Factor Productivity: Few studies have employed total factor productivity as an indicator variable of informality in the literature[10]. Evidence revealed that total factor productivity is low in developing economies because of inefficiency in production, low technological know-how, low low-skilled labour force, and a high incidence of the informal economy (Hussien, 2016). In this study, we employ total factor productivity and expect a negative relationship with informality. For this variable, we can formulate the following hypothesis:

Hypothesis 7: Ceteris paribus, the lower the level of total factor productivity, the larger the informal economy.

GDP Growth Rate: In the literature, when applying Structural Equation Modelling (SEM), it

[9] Some economies with high tax rates, especially in Europe, still have a low informal economy; this can be credited to the role of effective and robust institutions.

[10] See: TONUCHI, J. E. & IDOWU, P. 2020. How large is the size of Nigeria's informal economy? A MIMIC approach. *International Journal of Economics, Commerce and Management.*

is common to fix a scale variable to estimate the other coefficients based on this scale. Typically, this variable is the formal economy, represented by the GDP (Hassan and Schneider, 2016a) and (Bennihi et al., 2021). Empirical evidence indicates that a relationship exists between GDP and informality in the literature. However, the effect of the relationship remains ambiguous, as some studies state a positive relationship while others state a negative relationship[11]. Vis-à-vis this study, the GDP growth rate is used, which is expected to have a negative relationship based on (Schneider et al., 2010). Therefore, this variable is fixed to be negative. Hence, we have formulated the following hypothesis:

Hypothesis 8: All things being equal, the higher the level of the GDP, the lower the size of the IE.

Employment Rate: Studies in the literature found a positive relationship between the employment rate and the informal economy (Schneider and Enste, 2000). Additionally, this study adopts the employment rate as an indicator variable, aligning with the findings of Ene and Ștefănescu (2011) and (Dell'Anno and Davidescu, 2018). A low employment rate in the formal economy tends to drive higher economic activities in the informal sector. In economic literature, this association is found to be positive. Based on this, we investigate this relationship in Nigeria by testing the following hypothesis:

Hypothesis 9: All things being equal, the higher the level of employment rate, the lower the size of the IE.

Money Supply: The monetary aggregate is a crucial indicator for economists. It represents the total amount of money circulating in the economy, including all forms of currency, banknotes, and deposits. This aggregate serves as the foundation for the monetary approach to estimating the size of the informal economy. Indeed, a basic assumption in the literature is that many informal transactions rely solely on cash rather than credit cards and cheques. Therefore, in line with Bennihi et al. (2021), we used real currency in circulation (M_1) and anticipate a positive correlation between M_1 and informality in Nigeria. For this variable, we propose the following hypothesis:

Hypothesis 10: The less currency the public holds, the smaller the size of the IE, ceteris paribus.

3.4 Estimations of Results

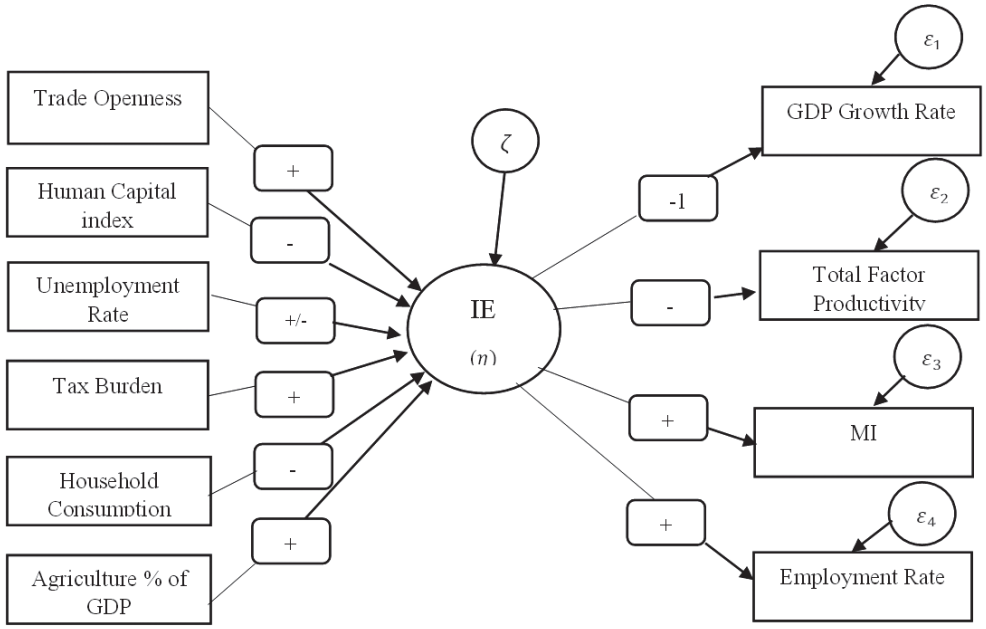
Next, we will look at the statistical properties of the time series data. **Table 2** provides a summary of descriptive statistics for the causal and indicator variables. From the descriptive statistics, it is observed that the output result of the time series is well-behaved. For example, the mean and median values are quite close to each other, except for the employment rate, which shows a bit more variation. The employment variable also has the widest range in the dataset. As expected, the skewness and kurtosis values fall within the anticipated range for all variables.[12] The Shapiro–Wilk univariate normality test indicates that trade openness, tax burden, household consumption, and GDP growth rate are normally distributed (p-value > 0.05). Consequently, as illustrated in **Fig. 3** below, the theoretical model of this study comprises six manifested causes, four manifested indicators, and one latent variable, which is the informal economy. Thus, in practical terms, the theoretical study model is (MIMIC 6-1-4).

3.4.1 Stationarity Test

Non-stationarity problems often occur when dealing with macroeconomic time series, thus leading to spurious results. However, to overcome this econometric problem, we take a close look at non-stationarity using a battery of unit root tests. This includes the conventional time series unit root tests like the Augmented Dickey and Fuller (ADF) and the Phillips and Perron (PP). Additionally, **Table 3** presents the output results regarding the stationarity properties derived from the ADF and PP unit root tests. The findings indicate that all variables were significantly stationary at the first difference, except for HCI, agriculture contribution to GDP, GDP growth rate, and currency in circulation, which were significantly stationary at levels of 5 percent.

[11] See: SCHNEIDER, F., CHAUDHURI, K. & CHATTERJEE, S. 2003. The size and development of the Indian shadow economy and a comparison with other 18 Asian countries: An empirical investigation. Working Paper., and HOA, N. T. 2019. How large is Vietnam's informal economy? *Economic Affairs*, 39, 81-100.

[12] Skewness measures the level of asymmetry; that is, it measures the asymmetry that occurs when time series data deviates, while kurtosis measures the presence of outliers in time series data. Its value ranges from one to infinity.



Source: Authors' Computation.

Fig 3: Hypothesized MIMIC path for estimating the informal economy (MIMIC6-1-4)

Table 2: Descriptive statistics of the data from 1981 to 2021; yearly observations

Variables	Mean	Median	Min	Max	Skew	Kurtosis	S-W	Obs
Determinants								
TO	1.46	1.53	0.96	1.73	-1.10	3.32	0.949	41
HCI	1.53	1.49	1.20	1.97	0.22	1.54	0.891	41
Unemp	15.53	12.65	1.80	56.1	1.15	3.76	0.917	41
Tax burden	0.41	0.91	-1.12	1.29	-0.72	1.98	0.970	41
Hhcons	11.12	11.14	10.74	11.52	0.04	1.42	0.956	41
Agric	3.81	3.70	3.36	4.25	0.34	1.43	0.600	41
Indicators								
GDP_Gwtr	3.04	3.4	-13.13	15.33	0.82	4.62	0.986	41
TFP	0.37	0.37	0.12	0.69	0.14	1.71	0.877	41
M1	2.74	2.91	1.00	4.69	-0.21	1.68	0.918	41
Emp	79.83	87.1	26.43	98.2	-1.39	3.88	0.457	41

Note: TO, HCI, Unemp, Hhcons, Agric, GDP_Gwtr, TFP, M1, and Emp represent trade openness, human capital index, unemployment rate, household consumption, % of agriculture contribution to GDP, GDP growth rate, total factor productivity, currency in circulation, and employment rate, respectively. S-W is the Shapiro-Wilk test for normality; the critical value is W = 0.938 at a 5% significance level. Obs means observations.
Source: Authors' Computation.

Table 3: Unit root tests over the period from 1981 – 2021.

Variables	At levels			
	ADF		PP	
	I	I and T	I	I and T
Trade openness	0.179	1.575	0.008	1.833
HCI	2.160**	1.977	5.375***	2.020
Unemployment rate	0.893	2.391	0.682	2.660
Tax burden as % of GDP	0.540	0.606	0.434	0.606
Household consumption	1.054	2.087	0.890	2.545

Continuation Table:

Agric contribution % to GDP	2.410**	1.049	2.754**	1.112
GDP growth rate	1.995**	2.720	3.021**	4.030
TFP	1.173	2.913	1.198	2.530
Currency in circulation (M1)	2.439**	2.609	4.618**	2.079
Employment rate	0.475	5.147***	0.279	4.728***
	First difference			
	ADF		PP	
	I	I and T	I	I and T
Trade openness	4.426***	4.693***	7.669***	7.688***
HCI	0.831	0.077	1.738*	3.568**
Unemployment rate	4.194***	4.376***	6.598***	6.670***
Tax burden as % of GDP	3.727***	5.505***	5.507***	6.872***
Household consumption	4.381***	4.603***	6.860***	6.903***
Agric contribution % to GDP	2.844***	3.736**	5.092***	6.066***
GDP growth rate	4.972***	5.301***	10.375***	10.604***
TFP	4.368***	4.698***	6.409***	6.885***
Currency in circulation (M1)	0.697	2.400	0.813	2.620
Employment rate	10.080***	11.706***	13.778***	15.866***

Note: Significance is indicated as follows: ***, **, and * for 1%, 5%, and 10%, respectively. I represent the model with an intercept only, I and T represent the model with an intercept and trend, ADF and PP are Augmented Dickey-Fuller and Phillips-Perron unit root tests, respectively.
Source: Authors' Computation.

3.4.2 Results of the MIMIC Model

The MIMIC estimation results for Nigeria, covering the years from 1981 to 2021, are presented in **Table 4**. The findings are satisfactory as they contain the estimation results, which include all causal variables with the expected statistical theoretical signs. While the indicator variables may not be statistically significant, they still reflect the anticipated theoretical signs. In line with the study of Hassan and Schneider (2016a) and Bennihi et al. (2021), several models were evaluated to determine the best fit. Three of these models are presented in **Table 4**. Based on the selection criteria, model 1, that is, MIMIC 6-1-4, is considered the optimal model. The RMSEA is estimated to be 0.072 with a p-value exceeding 5 percent, and the SRMR is found to be 0.083, indicating that both indicators fall within the acceptable range. The goodness-of-fit indicators, TLI and CFI, are estimated at 0.880 and 0.791, respectively, suggesting that the so-called MIMIC model is well-fitted for Nigeria.

Table 4: Estimation results of the MIMIC model throughout 1981-2021

	Model 1 6-1-4		Model 2 6-1-2		Model 3 6-1-3	
Determinants						
TO	2.101**	(0.029)	0.912*	(0.052)	1.016*	(0.063)
HCI	-0.971*	(0.318)	-0.417**	(0.303)	-0.314***	(0.032)
Unemp	1.142**	(0.019)	0.157***	(0.148)	0.356***	(1.231)
Tax Burden	1.749**	(0.041)	1.932***	(0.082)	1.803***	(0.582)
Hhcon	-0.107*	(0.272)	-0.041*	(0.062)	-0.126***	(1.013)
Agriculture	-0.169**	(0.018)	-0.125***	(1.061)	-0.148*	(0.214)
Indicators						
GDPgwtr	-1		-1		-1	
TFP	-0.180**	(0.001)	-0.041***	(0.014)	-0.056***	(0.021)

Continuation Table:

M1	0.021**	(0.030)		
Emp	0.087**	(0.046)	0.015***	(0.039)
Model fit indicators				
Chi-Square	49.697		35.329	56.281
P-value	0.110		0.103	0.201
RMSEA	0.072		0.109	0.088
P-close	0.025		0.027	0.002
CFI	0.791		0.513	0.388
TLI	0.880		0.309	0.177
SRMR	0.083		0.108	0.111

Note: Significance is indicated as follows: ***, **, and * for 1%, 5%, and 10%, respectively.
Source: Authors' Computation

After conducting and estimating the MIMIC model statistical tests, the overall results show that the model satisfies the SEM's stability conditions. The estimated coefficients are statistically significant except for the human capital index and household consumption. However, a significant result worth mentioning is that agriculture (percentage contribution to GDP) has an inverse relation with the informal economy in Nigeria, which is the opposite of the initial expectation. This means that when there is a boom in the agricultural sector in Nigeria, the informal economy expands. This finding might be explained by workers in Nigeria (both in private and public sectors) engaging in agricultural activities (most times through proxies) to increase their earning power. Although they have their primary income streams in the formal economy, they still undertake informal activities, hiring labour to work on farmlands.

Starting with the determinants, trade openness, as expected, is positive and significant in the selected model. A one percent increase in trade openness will cause a 2.1 percent increase in IE. Furthermore, as expected, HCI is found to impact the informal economy negatively, but is insignificant. A fall in HCI increases informal activities by 0.97 percent. As expected, the unemployment rate is positive and highly significant in the selected model. This result depicts that the unemployment rate influences the size of the informal economy in Nigeria. A one percent increase in unemployment increases the size of the IE by 1.14 percent. Another important causal variable is the tax burden, which is found to impact the IE positively and significantly. All things being equal, due to a high poverty incidence and inequality gap in Nigeria, a one percent increase in the tax burden increases the size of the IE by 1.74 percent in the selected model. This finding conforms with Ogbuabor and Malaolu (2013).

For the causes affecting the state of the informal economy, household consumption impacts the informal economy negatively and less significantly. All things being equal, a one percent fall in household consumption leads to a 0.11 percent stimulation (rise) of the informal economy. Historically, agriculture was the backbone of Nigeria's economy until crude oil was discovered in the Niger Delta (Chukwu et al., 2025). From the MIMIC output result, this variable negatively affects the informal economy. The impact is significant in the selected model. Ceteris paribus, a one percent increase in the agricultural sector leads to a 0.17 percent decrease in Nigeria's informal economy. [13] In recent years, the Nigerian government has been making efforts to diversify the economy away from oil production, and the agricultural sector is one of the critical sectors that the government is relying on to reduce reliance on oil exports.

As for the indicator variables, they all show the expected signs. Notably, the currency in circulation is a strong indicator of high informal activities in Nigeria, and it is statistically significant at the 5 percent level. A one percent increase leads to a 2 percent increase in IE

[13] Although data suggests an inverse association, this does not accurately reflect the true nature of these variables in Nigeria. The high concentration of the informal economy in the agricultural sector is due to its highly unorganized structure and the weak control and governance capacity of local governments, particularly in rural areas. This creates an ideal environment for shadow economic activities to thrive. Reflecting on the Lewis Dual Model, both variables' relationship is positive.

activities, confirming that Nigeria's informal economy is highly cash-based. These findings are consistent with the work of Tonuchi and Idowu (2020). It also suggests that as technology is adopted in the banking system to promote cashless transactions, informal economy activities tend to decline. Lastly, all these findings are summarized in **Table 5**, where our hypotheses are confirmed, and the established signs align with prior studies.

Table 5: Results of Hypothesis Testing

Variable Names	Hypothesis	Expected Signs	Results
Trade Openness	Hypothesis 1	Positive	Confirmed
Human Capital Index	Hypothesis 2	Negative	Confirmed
Unemployment Rate	Hypothesis 3	Positive	Confirmed
Tax Burden	Hypothesis 4	Positive	Confirmed
Household Consumption	Hypothesis 5	Negative	Confirmed
Agric. Contribution to GDP	Hypothesis 6	Negative	Confirmed
Total Factor Productivity	Hypothesis 7	Positive	Confirmed
GDP Growth Rate	Hypothesis 8	Negative	Confirmed
Employment Rate	Hypothesis 9	Positive	Confirmed
Money Supply (M1)	Hypothesis 10	Positive	Confirmed

Source: Authors' Compilation.

4. The Size of the Nigerian Informal Economy

In estimating the size of Nigeria's informal economy, we will focus on the causal variables that are significant at the 5 percent level, as highlighted by Tonuchi and Idowu (2020). Based on the chosen MIMIC model, we can express the structural equation of this model as follows:

$$\tilde{\eta} = 2.101^{*}_{x1t} + 1.142^{*}_{x3t} + 1.749^{*}_{x4t} - 0.169^{*}_{x6t} \quad (8)$$

Equation (8) provides an estimate of the informal economy's size in Nigeria. To make this estimate meaningful, we need to calculate the size of the shadow economy as a percentage of GDP. This final step is called a benchmarking technique (for a more detailed discussion on the benchmarking procedure, see the Appendix). The benchmarking process requires that we evaluate equation (8) on a specific benchmarked year. To ensure that our results regarding the size of the informal economy in Nigeria are objective, we will adopt the year 2000[14] as the base year, following the average findings of two studies by Hassan and Schneider (2016a) and Tonuchi and Idowu (2020). According to Hassan and Schneider (2016a), the estimated Nigeria's informal economy size at 56.21 (that is, $\tilde{\eta}_{2000} = 56.21$).

This value will serve as our reference point for estimating the size of the informal economy in the study. For instance, to determine the informal economy for 2021, we start by calculating the MIMIC index for the informal economy for 2021 and 2000 by substituting the values in equation (8) for both years.

$$\eta_{2000} = 2.101*1.69 + 1.142*1.12 + 1.749*0.91 - 0.169*3.68 = 5.7994$$

$$\eta_{2021} = 2.101*1.43 + 1.142*1.54 + 1.749*1.14 - 0.169*4.13 = 6.0590$$

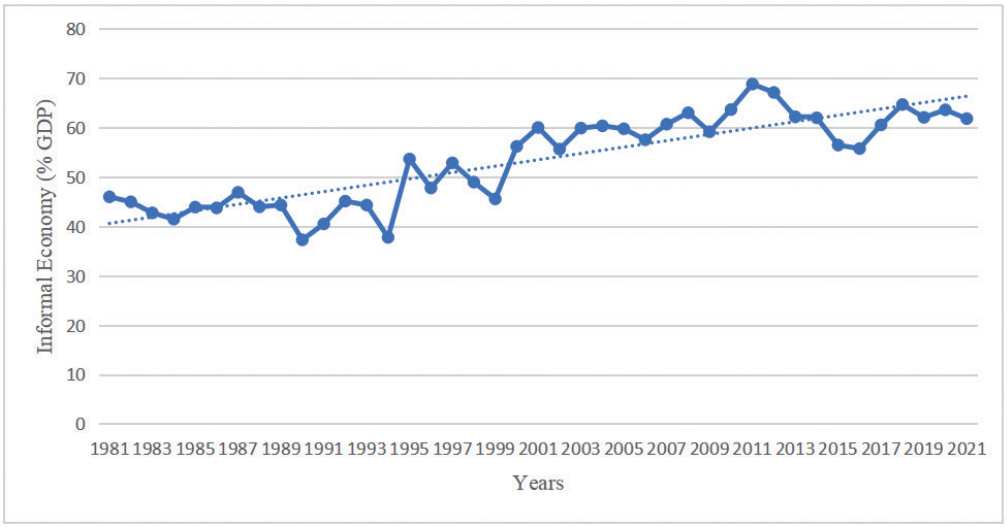
The above are the MIMIC indexes for 2000 and 2021. To calculate the size of the informal economy for 2021, we applied the formula in equation (3) adapted from the study of (Hoa, 2019). We simply replace the value above in the model to estimate the size of the informal economy in Nigeria.

$$\hat{\eta}_{2021} = \frac{\tilde{\eta}_{2021}}{\tilde{\eta}_{2000}} \eta^{*}_{2000} = \frac{6.0590}{5.7994} * 56.21 = 58.73\left(\%of\ GDP\right)$$

This process is repeated to estimate Nigeria's informal economy size from 1981 to 2021. **Fig. 4** below and **Table A1** in the Appendix represent the estimated size of the informal economy in Nigeria from 1981 to 2021, while **Fig. 5** shows the estimated size of the IE compared to previous estimations for Nigeria. It is worth noting that the IE during the period

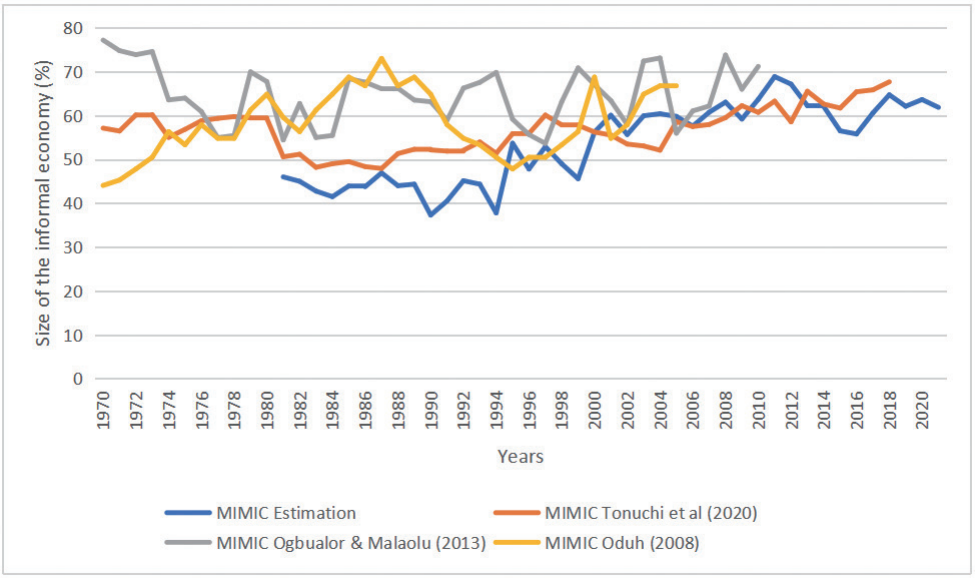
[14] This year is further used as a benchmarked year because the Nigerian economy experienced a structural and political change in its history. Political power was restored to a democratic structure after over 14 years of military rule and dictatorship.

under review varied between 27.80 percent and 65.61 percent, with an average of 47.52 percent. The lowest percentage was in 1983, while the highest was in 2011.



Source: Authors' Computation.

Fig. 4: Trend on the size of the informal economy in Nigeria (1981 – 2021)



Source: Authors' Computation.

Fig. 5: The size and evolution of IE in Nigeria compared to prior estimations

From **Fig. 4**, it can be detected that the activity of the IE often increases when there is a disruption to the formal economy. In a complex and diverse economy like Nigeria, this disruption could be political or economic reasons from a national or global perspective. This result is in line with Ogbuabor and Malaolu (2013) and Tonuchi and Idowu (2020), who contended that major economic and political disruptions in the official economy often led to a meteoric rise in the informal economy.

4.1 Empirical Estimation of the Influence of the IE on the Formal Economy in Nigeria

A growth model has been specified to measure the IE's influence on the formal economy in Nigeria. The model consists of GDP per capita ($gdppc_t$) taken as the dependent variable, while IE_t is the informal economy, that is, the variable of interest taken as a percentage of GDP.

Source: Authors' Computation.

Fig. 6: Relationship between IE and formal economy in Nigeria

Other independent variables considered include government final consumption (gfc_t), gross capital formation (gcf_t), trade openness (TO_t), and human capital index (HCI_t). Following economic theory, we log-transformed all these variables, allowing us to express the model mathematically as follows:

$$lgdppc_t = \gamma_0 + \gamma_1 IE_t + \gamma_2 gfc_t + \gamma_3 gcf_t + \gamma_4 TO_t + \gamma_5 HCI_t + \varepsilon_t \tag{9}$$

Where γ_0 is the intercept, γ_1, γ_2, γ_3, γ_4, γ_5 are the regression coefficients and ε_t is the error term. To estimate the model and differentiate between the long and short-run effects of the informal economy on Nigeria's formal economy, we will use equation (9) with the autoregressive distributed lag (ARDL) approach developed and modified by Pesaran et al. (2001) through the bounds testing approach. So, equation (9) can be written as follows:

$$\begin{aligned} Dlgdppc_t = {} & \beta_0 + \sum_{i=1}^{p1} \beta_{1i} Dlgdppc_{t-1} + \sum_{i=0}^{p2} \beta_{2i} DlIE_{t-1} + \sum_{i=0}^{p3} \beta_{3i} Dlgfc_{t-1} \\ & + \sum_{i=0}^{p4} \beta_{4i} Dlgcf_{t-1} + \sum_{i=0}^{p5} \beta_{5i} DlTO_{t-1} + \sum_{i=0}^{p6} \beta_{6i} DlHCI_{t-1} + \theta_1 lgdppc_{t-1} \\ & + \theta_2 lIE_{t-1} + \theta_3 lgfc_{t-1} + \theta_4 lgcf_{t-1} + \theta_5 lTO_{t-1} + \theta_6 lHCI_{t-1} + \varepsilon_t \end{aligned} \tag{10}$$

Where: β_0 is the constant; β_k means short-term dynamics, θ_k are the long-term coefficients, and D is the delay operator.

The ARDL approach requires that all variables are integrated of order zero 1(0) and one 1(1) only. We conducted the Augmented Dickey-Fuller and Phillips and Perron tests to confirm that all variables are integrated of order one 1(1) in the growth model. Additionally, we determine lag length for each variable of the ARDL (P1, P2, P3, P4, P5, P6) using the Akaike Information Criterion (AIC), with a maximum lag length of 2. The authors then employ the bounds cointegration approach to check for cointegration among the variables in equation (10).

We apply the F-statistic test of the joint null hypothesis of no cointegration $H_0 : \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq 0$ against the alternate hypothesis of the existence of cointegration $H_1 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = 0$. According to the bounds testing approach, we find that cointegration exists within the variables in the model when the calculated F-statistic value is larger than the upper critical bound. Conversely, if it falls below the lower critical bound, we conclude that no cointegration exists.

As per economic theory, we expect gross capital formation and trade openness to show a positive

relationship. In contrast, government final consumption and human capital index are expected to have a negative sign. As per the variable of interest, the literature is inconclusive about its effect on the formal economy, but a negative or positive effect is anticipated.

Table 6: Unit root tests for the growth model variables over the period from 1981 to 2021

Variables	At levels			
	ADF		PP	
	I	I & T	I	I & T
$lgdppc_t$	1.559*	1.187*	1.294**	2.697**
lIE_t	0.373	1.619	0.032	2.714
$lgfc_t$	0.374	1.880	0.279	2.005
$lgcf_t$	0.200***	3.738***	0.571***	4.032***
lTO_t	2.619	2.065	1.939	1.924
$lHCI_t$	2.058**	1.026**	0.129**	2.084**
	First Difference			
	ADF		PP	
	I	I & T	I	I & T
$lgdppc_t$	2.760***	5.643***	4.177***	4.701***
lIE_t	2.293***	3.895***	7.511***	7.410***
$lgfc_t$	3.051***	4.328***	6.313***	6.503***
$lgcf_t$	3.987*	4.526*	5.182**	5.631**
lTO_t	3.888***	4.363***	7.570***	7.686***
$lHCI_t$	2.714***	3.949***	3.687***	4.472***

Notes: Significance is indicated as follows: ***, **, * for 1%, 5%, and 10% respectively. I represent the model with an intercept only, I and T represent the model with an intercept and trend; ADF and PP are Augmented Dickey-Fuller and Phillip-Perron unit root tests, respectively.
Source: Authors' Computation.

Table 7: Bound Co-integration Test.

Calculated F-Statistic			
5.422	N = 39		
	Critical value bounds		
Significance	1(0) bound	1(1) bound	Cointegration
10%	2.26	3.35	
5%	2.62	3.79	Exists
1%	3.41	4.68	

Source: Authors' Computation.

4.2 Econometric Estimations

The output results from the ADF and PP unit root tests, as shown in **Table 6**, indicate that all variables are integrated at the first difference, that is, first-order 1(1) at the 5 percent significance level, except for trade openness, which is stationary at levels 1(0). Consequently, we use the ARDL bound cointegration test approach for estimation, as seen in **Table 7**. From the output result, the calculated F-statistic of 5.422 exceeds the upper bound critical value of 4.68 at the 1 percent significance level; therefore, confirming the presence of long-run cointegration.

Table 8 shows that, as anticipated, gross capital formation, government final consumption, and trade openness exhibit the expected signs both in the short and long run. However, the human capital index aligns with expectations in the long run but displays an unexpected sign in the short run. In the long run, all variables significantly impact the formal economy at a 1 percent level of significance, except for government final consumption and gross capital formation, which do not show statistical insignificant. Unsurprisingly, for

the variable of interest, the output results depict that the informal economy has an asymmetric effect on the formal economy. Specifically, as hypothesized, in the short run, the informal economy negatively impacts the formal economy, while in the long run, it has a significantly positive effect on the formal economy.

In the long run, the positive and significant effect of the IE on the official economy stems from the fact that the informal economy serves as a safety net for over 63 percent of poor households in Nigeria. Again, because the informal economy lacks bureaucracy and legalities, it is considered a refuge for informal economic activities, as it supports formal economic activities in the long run when the income and savings derived from IE engagements are expended on goods and services produced in the formal economy. Additionally, the CUSUM and CUSUM of squares graphs[15] indicate that the model is stable and are provided in **Figures A1 and A2** in the Appendix.

Table 8: ARDL (1 2 0 1 2 1) Long-run and Short-run Estimates

	Variables	Coefficient	Std Error	p > t
ADJ	$L1.lgdppc_t$	-0.35824***	0.01757	0.003
LR	$L1.lIE_t$	1.41841***	0.27206	0.000
	$L1.lgfc_t$	-0.02606	0.02333	0.274
	$L1.lgcf_t$	0.08328	0.09156	0.371
	$L1.lTO_t$	0.01930***	0.05751	0.002
	$L1.lHCI_t$	-3.87282***	0.89951	0.000
SR	$L1.lgdppc_t$	0.64176***	0.11784	0.000
	$D1.lIE_t$	-0.20444***	0.09819	0.047
	$L1D.lIE_t$	-0.17571***	0.07998	0.037
	$D1.lgcf_t$	0.07092***	0.02541	0.010
	$D1.lTO_t$	0.00726	0.02381	0.763
	$L1D.lTO_t$	0.06393***	0.02481	0.016
	$D1.lHCI_t$	3.11769***	0.78638	0.001
	_cons	-0.23684***	0.26533	0.038
R^2	0.7812			

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01. Dependent variable: Dlgdppc. The number of observations = 39.
Source: Authors' Computation.

4.3 Causality Analysis

The Granger causality test is employed to further probe into the robustness of the causal relationship [16] between the two economies, that is, the informal economy and the components of GDP (components of the formal economy) in Nigeria. The causal relationship is portrayed in **Fig. 6**, showing the growth rates for both economies. Intuitively, the idea of the Granger causality test is to show the directional causality between informality and the components of the GDP time series.

Table 9 above describes the results of the Granger causality. Here, the arrow shows the direction of the causality tested. It is found that there is unidirectional causality among the components of GDP and the variable of interest (informal economy). The results show a unidirectional causality in which GDP per capita Granger causes the informal economy in Nigeria. This result aligns with Bennihi et al. (2021). Further, there is a unidirectional causality in which the informality Granger causes household consumption in Nigeria. Similarly, a unidirectional causality exists in which the informal economy Granger causes government spending. A unidirectional causality exists in which the informal economy Granger causes the investment. Conversely, there is a unidirectional causality in which net (export) revenue Granger causes the informal economy in Nigeria.

[15] The blue line lies between the 5% critical line, hence, proving the stability of the model.

[16] In this case, a relationship can be either unidirectional or bidirectional.

Table 9: Granger causality test

Variables	The direction of Granger Causality	Variable	Results	P-Values
IE_t	→	$GDPPC_t$	1.3787	(0.2166)
$GDPPC_t$	→	IE_t	2.3968	(0.0407)
IE_t	→	$HHCON_t$	5.6957	(0.0074)
$HHCON_t$	→	IE_t	0.9748	(0.3876)
IE_t	→	$GOVTSP_t$	3.2377	(0.0516)
$GOVTSP_t$	→	IE_t	0.4346	(0.6511)
IE_t	→	INV_t	11.0348	(0.0002)
INV_t	→	IE_t	1.2163	(0.3089)
IE_t	→	NX_t	1.1184	(0.3385)
NX_t	→	IE_t	3.5352	(0.0403)

Notes: 1. () means the p-values. 2. IE, GDPPC, HHCONS, GOVTSP, INV, and NX represent the Informal economy, GDP Per Capita, Household Consumption, Government Spending, Investment, and Net (export) revenue, respectively.
Source: Authors' Computation.

5. Conclusions and Policy Implications

This paper observed that informal activities are strongly persistent and predominant in Nigeria. The quantitative analyses revealed that the size of the informal economy ranges between 27.80 and 65.61 percent, with an average size of 47.52 percent of the official GDP, and it has continued to increase over the past ten years. From a positive viewpoint, based on the MIMIC approach, trade openness, tax burden, unemployment, and agriculture play highly significant roles and are critical drivers of IE. The insignificant relationship between human capital index, household consumption, and the Nigerian IE is somewhat unsurprising because of the peculiarities of the Nigerian economy. To the best of our knowledge, these two variables have not been accounted for in prior studies.

Following the trend on the size and development of the informal economy, the authors discovered that while the IE has been rising steadily in Nigeria, it frequently surges during periods of political or economic shocks, as seen in 1999 – 2000, 2007 – 2008, 2015 – 2016, and 2019 – 2020. One of the obvious impacts of the informal economy is the loss of tax revenue in Nigeria. All things being equal, an increase in the size of the IE leads to a loss in tax base and a potential plummeting of tax revenue. It is seen that the Nigerian government has lost an average of 53.5 percent of potential tax revenue to the informal economy since 1981. Overall, the MIMIC estimations for informality in Nigeria produce stable results, which are comparable to Ogbuabor and Malaolu (2013), Hassan and Schneider (2016a), and Tonuchi and Idowu (2020).

Concerning the interaction between the IE and formal economy, economic growth theory variables were introduced, and we modelled it across two time horizons obtained from the ARDL bounds test approach. Estimated results show a negative effect of the IE on the formal economy in the short run, whereas a positive relationship was established in the long run. Further findings show that the formal economy Granger causes the informal economy in Nigeria, and it is a unidirectional causal relationship. This suggests that when policymakers propose policies to stimulate the formal (official) economy, a portion of stimulus funds is lost to the informal economy, thus reducing policy effectiveness (Bennihi et al., 2021).

Contrary to the general belief, the IE may also boost economic activities due to its dynamic nature and capacity to adjust to economic situations, as opposed to the formal economy, which is marred by bureaucratic bottlenecks. Hence, this is evident from the long-run positive impact of IE on the formal economy. From a normative perspective, the policy recommendations that follow from this paper are to review the tax administrations through reforms, boost economic welfarism (Pareto optimality), improve the quality of health and education infrastructure across the six geopolitical zones, and adopt technologies to curb the illicit business activities and cash-based transactions. Most importantly, the cost of formality needs to decrease with the reduction of corrupt practices in the system, which will simultaneously increase the cost of informality.

It may be appropriate to consider that reforms

in institutional values are the first step toward the crackdown on the informal sector. Finally, our paper has contributed to the empirical literature on the informal economy in Nigeria by providing a database of the contribution of the share of the IE to GDP over the period 1981 to 2021. Thus, the estimates from this paper can be used in the macroeconomic model to gain insights into how informality affects critical economic aggregates.

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Appendix

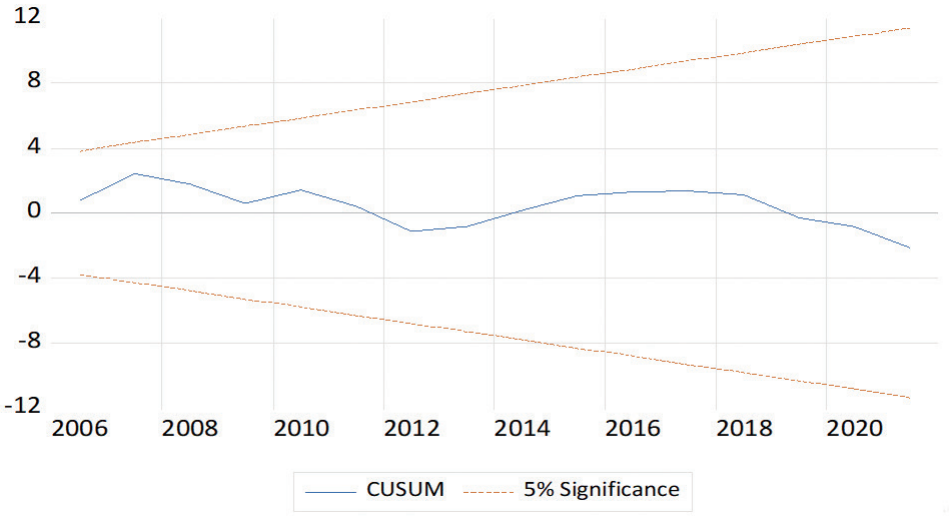

Figure A1. CUSUM

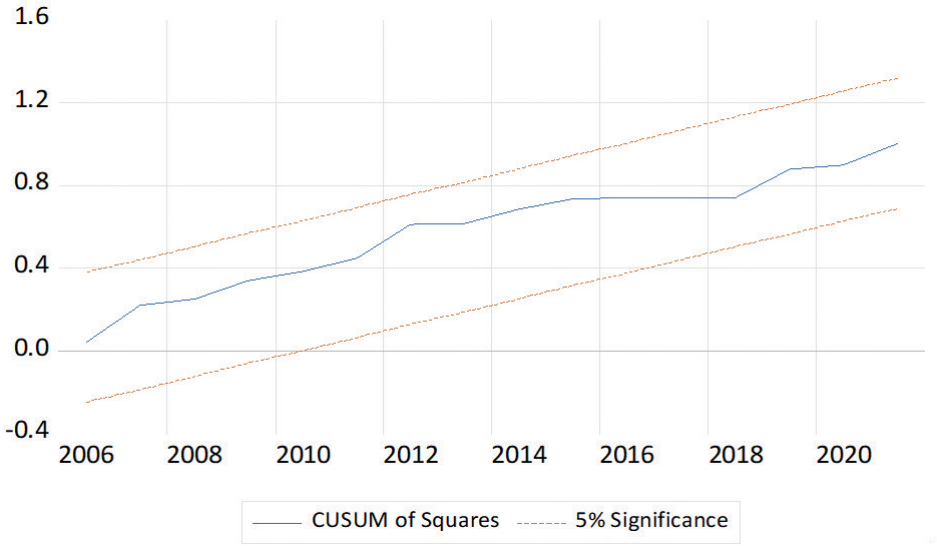

Figure A2. CUSUM of Squares

Table A1: Size of the Informal Economy in Nigeria (1981 – 2021)

Years	GDP (₦ Billion)	Size of Informal Economy(₦ Billion)	Informal Economy(% GDP)
1981	15258	7017.15	45.99
1982	14985.08	6740.29	44.98
1983	13849.73	5920.76	42.75
1984	13779.26	5715.64	41.48
1985	14953.91	6566.26	43.91
1986	15237.99	6666.62	43.75
1987	15263.93	7160.31	46.91
1988	16215.37	7131.52	43.98
1989	17294.68	7666.73	44.33
1990	19305.63	7197.14	37.28
1991	19199.06	7777.54	40.51
1992	19620.19	8852.63	45.12
1993	19927.99	8834.08	44.33
1994	19979.12	7546.11	37.77
1995	20353.2	10921.53	53.66
1996	21177.92	10118.81	47.78
1997	21789.1	11522.08	52.88
1998	22332.87	10936.41	48.97
1999	22449.41	10230.20	45.57
2000	23688.28	13315.18	56.21
2001	25267.54	15170.63	60.04
2002	28957.71	16114.97	55.65
2003	31709.45	19000.30	59.92
2004	35020.55	21145.41	60.38
2005	37474.95	22402.53	59.78
2006	39995.5	23021.41	57.56
2007	42922.41	26062.49	60.72
2008	46012.52	29001.69	63.03

Continuation Table:

Years	GDP (₦ Billion)	Size of Informal Economy(₦ Billion)	Informal Economy(% GDP)
2009	49856.1	29504.84	59.18
2010	54612.26	34771.63	63.67
2011	57511.04	39596.35	68.85
2012	59929.89	40236.93	67.14
2013	63218.72	39328.37	62.21
2014	67152.79	41641.45	62.01
2015	69023.93	38984.72	56.48
2016	67931.24	37885.25	55.77
2017	68490.98	41484.99	60.57
2018	69799.94	45160.56	64.7
2019	71387.83	44324.70	62.09
2020	70,014.37	44543.14	63.62
2021	72183.09	44638.02	58.73

Source: Authors Computations

Table A2: Existing estimates of the IE in developing economies

Authors	Scope of Study	Methodology	Estimates (Average)
Country-based estimates			
Macias and Cazzavillan (2010)	1970 - 2006	VECM	30% of GDP
Ogbuabor and Malaolu (2013)	1970 - 2010	MIMIC	64.6% of GDP
Schneider and Hametner (2014)	1980 - 2012	CDA	41.5% of GDP
Zaman and Goschin (2015)	1999 - 2012	OLS	31.5% of GDP
Othmane and Mama (2016)	1999 - 2015	MIMIC	42.9% of GDP
Nguyen (2019)	1995 - 2015	MIMIC	21% of GDP
Gamel, Rambeli, Jalil, Viswanathan (2019)	1972 - 2012	ARDL based on CDFM	42.5% of GDP
Bouriche and Bennihi (2020)	1980 - 2019	CDA	21% of GDP
Tonuchi, Peters and Olufunso (2020)	1970 - 2018	MIMIC	67% of GDP
Bennihi, Bouriche, and Schneider (2021)	1980 - 2017	MIMIC	33.5% of GDP
Panel-based estimates			
Schneider (2004)	1999 - 2003	MIMIC	32.7% of GDP
Schneider (2005)	1990 - 2000	MIMIC	17% in OECD, 41% in transition countries
Elgin and Oztunah (2012)	1960 - 2008	DGE	33.1% of GDP
Quintano and Mazzocchi (2014)	1995 - 2010	SEM	39.4% of GDP
Hassan and Schneider (2016)	1999 - 2013	MIMIC	33.8% of OECD
Abd El Aziz and Zaki (2019)	2000 - 2017	MIMIC	19.98% of GDP

Notes: VECM: Vector Error Correction Model, MIMIC: Multiple Indicators Multiple Causes, CDA: Currency Demand Approach, OLS: Ordinary Least Squares, ARDL: Autoregressive Distributed Lag, DGE: Dynamic General Equilibrium, SEM: Structural Equation Models.
Source: Authors' Computations

Table A3: Variables in the MIMIC model.

Variables	Sources	Definitions
Employment rate	Penn World Table (PWT)	The total number of people who are formally employed by possessing a formal contract. The rate is calculated as % of total population.
Agriculture value added as % of GDP	World Development Indicators	Agriculture value-added is the net output of the sector calculated as % of GDP.
Unemployment	International Labour Organization	Measure of the unemployment rate, that is, the share of the non-employed labour force in the total labour force.
Trade Openness	World Bank Accounts Data	Openness is the sum of exports and imports of goods and services measued as a share of gross domestic product.
Tax Burden	The series is extracted from the Central Bank of Nigeria (CBN) Statistical Bulletin	It is often referred to as tax-to-GDP ratio. It is measured as the proportion of a country's economic output (Gross Domestic Product) that is collected in taxes. It is calculated using the following formula below: Tax Burden = (Total Tax Revenue/ GDP) x 100
GDP Growth Rate	World Development Indicators	Annual percentage growth rate of GDP at market prices based on constant local currency.
Total Factor Productivity	Penn World Table (PWT)	It means the efficency with which inputs are transformed to outputs, considering all factors of production. TFP takes account improvements in processes, technological advancements, and other factors that cannot be attributed directly to increases in factors of production.
Money Supply (M1)	Central Bank of Nigeria (CBN)	Money supply is the total money in circulation in an economy, consisting of currencies, banknotes and overnight deposits. M1 is the most liquid portion of money supply.
Human Capital Index	World Development Indicators	HCI is a metric employed to measure the level of human capital development in an economy. It includes knowledge, health, skills and other characteristics of individuals that improve their productivity for social and economic development.
Household consumption	World Development Indicators	Household consumption is a fundamental component of a nation's Gross Domestic Product (GDP) and a key indicator of economic well-being. Therefore, it is regarded as the total spending by household agents on goods and services to satisfy their wants and needs.

Source: Authors Compilations.

Benchmarking Procedure

From a methodological perspective, a conclusive measure or step is essential to determine the size of the informal economy in a meaningful way, specifically as a percentage of the Gross Domestic Product (GDP). Thus, this conclusive measure or step is known as a benchmarking procedure. Various benchmarking procedures are employed to calibrate the index; however, a consensus on the superiority of any one procedure has not been reached.[17] This additional step requires a prior estimation of the informal economy's size to be available. Hence, an external approximation of the relative size of the informal economy in Nigeria at the base year (= 2000) is extracted (Hassan and Schneider, 2016). The subsequent benchmarking procedure is then employed to calibrate the ordinal estimates into cardinal values and then transform this index into percentage units (real values).

$$\hat{\eta}_t = \frac{\tilde{\eta}_t}{\tilde{\eta}_{base\ year}} \eta^*_{base\ year} \quad (1)$$

Where, $\tilde{\eta}$ represents the MIMIC index value at time t according to the structural equation **(1)**; $\tilde{\eta}$ *base year* is the MIMIC index value for the base year, which is 2000 in the model; η^* *base year* is the prior estimation of the size of the informal economy in the base year, that is,

[17] For further details on the different benchmarking procedures, see: DELL'ANNO, R. & SCHNEIDER, F. 2003. The Shadow Economy of Italy and other OECD Countries: What do we know? *Journal of public finance and public choice*, 21, 97-120.

2000. Based on the application of the benchmarking procedure, we can compute the final estimates of the informal economy's size as a percentage of GDP throughout the given period of the investigation and track its evolution from 1981 to 2021.

Conclusively, the MIMIC model[18] holds an edge over other alternative methods because it simultaneously considers many observable and measurable factors related to the complexity and unrecorded aspects of the informal economy. Therefore, to estimate the size of the informal economy for the sample we reviewed, we utilized the Maximum Likelihood method in STATA 18 software.

[18] For a more detailed explanation of the MIMIC methodology and its assumptions, refer to Hassan and Schneider (2016).