The Long-run Response of Under-five Mortality to Corruption: Evidence from Nigeria

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Abstract

The importance of health to a nation and its citizens cannot be over-emphasised. Better health contributes to human capital development and enhances labour productivity, all of which promote economic growth. Reducing under-five mortality remains one of Nigeria's major challenges in the health sector and the country has achieved little in her fight against corruption. Despite the co-existence of corruption and high under-five mortality in Nigeria, empirical research on the connection between these two undesirables is minimal. We evaluate the long-term response of under-five mortality to corruption in Nigeria by using an Augmented ARDL (AARDL) method to analyse quarterly data for the 2000-2021 period. There is an evidence of a long-term relationship between corruption and under-five mortality alongside control variables including health expenditure, income growth and rural population, based on cointegration tests. The empirical results confirm that improving corruption control lowers long-term under-five mortality. Furthermore, greater openness to trade and higher spending on public health reduce long-term under-five mortality, while a growing rural population contributes to it. Thus, we recommend measures that lower corruption to reduce long-term under-five mortality in Nigeria.

Keywords

Under-five mortality, corruption, Augmented ARDL, Nigeria.

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Introduction

The role of better health on economic development in both developed and developing economies has long been recognised. Better health contributes to a nation's human capital development and raises labour productivity, leading to higher economic

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growth rates (Becker, 2007; Linden and Ray, 2017; Lio and Lee, 2016). Improvement in the health status of individuals (and lowering child mortality) around the world is one of the Millennium Development Goals. Whereas governments and international aid organisations have committed vast resources to health projects/programmes, corruption makes it difficult to achieve better health outcomes including lowering under-five mortality in many countries (Lio and Lee, 2016; Sommer, 2019).

The pervasive nature of corruption in the health sector not only threatens public sector reform efforts and/or health programmes, it also limits the capacity of nations to achieve Sustainable Development Goal 3 (García, 2019), and the 2030 Agenda for Sustainable Development which includes the attainment of universal health coverage. Corruption promotes income and health inequalities, the embezzlement and diversion of funds allocated to public health, contract inflation by government officials, and the supply of substandard drugs and medical equipment. Coupled with these, are the de-motivation of health workers, limiting patients' access to quality and affordable healthcare, all of which can lead to worsening health outcomes such as under-five mortality (Chattopadhyay, 2013; García, 2019; Lio and Lee, 2016; Sommer, 2019; Swaleheen, 2019; Vian, 2008). By contrast, reducing corruption fosters better and more efficient resource allocation to the health sector, leading to the improved health status of the populace (Makuta and O'Hare, 2015).

Nigeria is one of the leading contributors to under-five mortality due to diseases such as pneumonia, diarrhoea and malaria, and lack of access to quality treatment, amongst others (Popoola, 2018; UNICEF, 2023). In addition, it is one of the nations with the lowest public expenditure on health and high levels of corruption (Sommer, 2019; Transparency International, 2015). Supporting the claims of reputable agencies such as Transparency International, authors have reported that corruption thrives in every facet of Nigeria's economy and it has hindered the country's capacity to attain higher levels of development (Abu and Karim, 2021; Abu and Staniewski, 2021; Abu et al., 2021; 2022a; 2022b).

Notwithstanding the relatively high corruption in Nigeria (Abu et al., 2021; 2022a; 2022b) and the country's under-five mortality (Popoola, 2018; UNICEF, 2023), researchers have done little to explore the empirical relationship between the two undesirable phenomena in the Nigerian context. Interestingly, most studies have submitted that rising corruption tends to promote under-five mortality (Gupta et al., 2000; Holmberg and Rothstein, 2009; Li et al., 2018; Lio and Lee, 2016). However, a study by Makuta and O'Hare (2015) appears not to support the claim that lowering corruption reduces under-five mortality, particularly in Sub-Saharan Africa. Their finding aligns with the "sand the wheels" hypothesis, and re-echoes the beneficial role of corruption in countries with weak institutions. Thus, this research attempts to fill this gap by investigating the response of under-five mortality to corruption in Nigeria using the novel Augmented ARDL (AARDL) method.

1. Literature Review

Research on how corruption is manifested in the health sector has increased over the years in both developed and developing regions of the world (Gupta et al., 2002; Sommer, 2019; Vian, 2008). The literature suggests that high levels of corruption negatively impact the health sector in a number of ways. Corruption ensures that monies allocated for the provision of healthcare are embezzled by public officials, and substantial funds meant for the

payment of health practitioners' wages, the purchase of essential equipment and drugs, and upgrading health facilities are stolen (Dryer, 2006; Engberg-Pedersen et al., 2005; Global Corruption Report, 2006; Lewis, 2006). The limited resources available due to corruption result in poor remuneration of health workers, which in turn pushes some doctors and nurses to demand kickbacks from patients, most of whom are poor, to augment their low wages (Holmberg and Rothstein, 2011; Lewis, 2006; Sommer, 2019). Coupled with this is the inadequate provision of healthcare that makes it very difficult for citizens to access and/or afford quality health service whenever the need arises (Holmberg and Rothstein, 2011; Lewis, 2006; Pandolfelli and Shandra, 2013; Sommer, 2019). The implications of this are increased vulnerability and the exposure of many, including infants, to diseases such as cholera, pneumonia, diarrhoea, measles, polio, etc., leading to under-five mortality.

On the other hand, the "grease the wheels" hypothesis (Huntington, 1968; Leff, 1964; Leys, 1965), further popularised by Lui (1985), Beck and Maher (1986), Lien (1986), and Méon and Sekkat (2005), suggests that corruption may improve efficiency and accelerate the process of service delivery especially in countries with weak and/or ill-functioning institutions. Given that inefficient bureaucracies or government officials constitute barriers to economic activities, offering bribes to them can help circumvent bottlenecks and enhance the efficiency of the system, leading to economic growth. Thus, the offering of bribes by patients seeking healthcare can reduce the hours they spend waiting to see doctors and other medical practitioners. In addition, bribes might be seen as complementing/augmenting the poor wages earned by health workers, and thus increase their motivation to deliver service in an efficient manner. This can lead to improved health outcomes, including lower under-five mortality.

Efforts have been put into searching for the empirical connection between corruption and under-five mortality, and most of such studies have concentrated on multi-nation and employed panel data. Interestingly, the studies reported that reducing the level of corruption or controlling corruption lowers under-five and/or infant mortality. For example, Lin et al. (2014) employed the fixed effects (FE) method to assess the impact of quality of governance (inclusive of corruption) on under-five mortality in 149 nations from 1996 to 2010, and concluded that raising governance quality (reducing corruption) lessened under-five mortality.

Using a similar estimation procedure, Vaidean et al. (2021) confirmed that controlling corruption reduced under-five mortality in EU nations over the 2005-2020 period. Also, applying ordinary least squares (OLS) and two-stage least squares (2SLS) estimators to panel data, Gupta et al. (2000) and Li et al. (2018) reported that infant/child and under-five mortality decreased with greater corruption control during the 1985-1997 and 1995-2012 periods, respectively, across countries.

Other studies, including those of Holmberg and Rothstein (2009), Hanf et al. (2011), Lio and Lee (2016), and Sommer (2019), found that reducing corruption lowers under-five mortality. However, Makuta and O'Hare (2015) indicated an insignificant influence of less corruption on under-five mortality in Sub-Saharan African (SSA) nations during the 1996-2011 period based on the 2SLS estimation method. A summary of empirical research on the relationship between corruption and under-five mortality is reported in Table 1.

Table 1. Summary of empirical research on corruption and under-five (and infant) mortality

Author(s)	Country(ies)/Period	Method/Model	Major Findings
Lio and Lee (2016)	119 countries (2005-2011)	2-way FE and 2SLS	Less corruption lowers under-five and infant deaths.
Makuta and O'Hare (2015)	43 SSA countries (1996-2011)	2SLS	Corruption appears insignificant in explaining under-five mortality.
Li et al. (2018)	150 countries (1995-2012)	OLS, FE and 2SLS	Corruption gives rise to infant and under-five mortality.
Lin et al. (2014)	149 countries (1996-2010)	FE	Quality of governance (inclusive of corruption) is negatively related to under-five mortality.
Gupta et al. (2000)	Cross country (1985-1997)	OLS and 2SLS	Greater corruption control reduces infant and child deaths.
Holmberg and Rothstein (2009)	120 countries	Regression	Improvement in the fight against corruption lowers under-five mortality.
Hanf et al. (2011)	178 countries (2008)	Multivariate regression	A falling corruption level lowers under-five mortality.
Factor and Kang (2015)	133 countries (2003 and 2009)	SEM	A rising corruption level is related to poorer health outcomes.
Vaidean et al. (2021)	27 EU countries (2005-2020)	FE	A rising level of corruption promotes under-five mortality.
Sommer (2019)	90 middle and low-income countries (1996-2019)	2-way FE	An increasing corruption level is related to high infant deaths.

Note: FE = Fixed Effects; OLS = Ordinary Least Squares; 2SLS = Two-Stage Least Squares; SEM = Structural Equation Modelling

Source: own elaboration

A review of the literature on corruption and under-five mortality reveals that most studies concentrated on a multi-country sample such as the EU or SSA, developing and developed, or middle and low-income nations. Almost all the studies concluded that corruption contributes to the deaths of under-fives. However, empirical studies on the relationship between corruption and under-five mortality with respect to Nigeria are almost non-existent. Thus, this research fills the gap in the literature by exploring the

relationship between corruption and under-five mortality in Nigeria using the novel Augmented ARDL (AARDL) method to analyse quarterly data for the 2000-2021 period.

2. Methodology

2.1. Theoretical framework

The literature suggests that corruption not only reduces public sector-provided services such as health and education, it also raises the price thereof (Gupta et al., 2000; Shleifer and Vishny, 1993). Coupled with this, is the reduction in government revenue and inadequate investment in human capital that accompanies public sector corruption (Ehrlich and Lui, 1999; Hindriks et al., 1999; Shleifer and Vishny, 1993). All of these have dire consequences for the quality of services provided by the government (Bearse et al., 2000; Gupta et al., 2000).

The health sector is one of the main victims of corruption due to the demand for healthcare and the scope of procurement (Knox, 2009; Sommer, 2019). Corruption promotes the theft of medical equipment and drugs bought with public funds, increases the supply of substandard medicines and employment of incompetent professionals, lowers health spending, and encourages the diversion of public funds away from the health sector (Delavallade, 2006; Factor and Kang, 2015; Gupta et al., 2000; Lio and Lee, 2016; Mauro, 1998; Sommer, 2019; Swaleheen et al., 2019). These result in the spread of infectious and communicable diseases and poorer health outcomes including increased infant and under-five mortality (Cockcroft et al., 2008; Factor and Kang, 2015; Vian, 2008; Vian et al., 2010). Controlling corruption, however, fosters quality healthcare delivery, and consequently leads to an improvement in the health status of citizens including a reduction in child and under-five mortality (Gupta et al., 2000; Li et al., 2018; Lin et al., 2014; Lio and Lee, 2016). On the other hand, corruption in the form of bribery can serve as motivation for health practitioners or workers and accelerate the delivery of healthcare, leading to a reduction in under-five mortality. Thus, it can be posited that under-five mortality (*UFM*) is affected by corruption (*COR*). The model capturing this postulation is:

$$UFM_t = \beta_0 + \beta_1 COR_t + \mu_t \qquad (1)$$

Besides corruption, factors including income level and/or growth, openness to trade, expenditure on health and rural population can impact under-five mortality (Hanf et al., 2011; Li et al., 2018; Sommer, 2019). For example, as a nation witnesses growth in its wealth or income (*GDPG*), it will have more resources to spend on programmes (such as the provision of potable water and sanitation and health awareness campaigns) that lead to an improvement in health status (Biggs et al., 2010). In addition, income growth lessens poverty and increases an individual's capacity to afford quality medical care, leading to an improvement in health conditions and a reduction in infant mortality (Anand and Ravallion, 1993; Biggs et al., 2010; Bokhari et al., 2007; Pritchett and Summers, 1996).

Moreover, public health expenditure (*HEXP*) tends to be related to infant deaths (Gupta et al., 2003). Low-income households rely heavily on public spending on health compared to their wealthy counterparts. Hence, any increase in government spending on health raises the health status of low-income earners (Bidani and Ravallion, 1997; Bokhari et al., 2007; Deolalikar, 1995; Gallet, 2017; World Bank, 1995). However, certain authors argued that public spending on health does not guarantee an improvement in the health conditions of the populace (Filmer and Pritchett, 1999; Gupta et al., 2000; Terrelonge, 2014).

Furthermore, openness to trade (*TRD*) can determine under-five mortality (Sommer, 2019). Countries such as Nigeria that depend heavily on the trade and export of primary products face declining revenue due to low and fluctuating commodity prices. The inability of these nations to raise substantial revenue contributes to the poor funding of health and other socio-economic programmes (Shen and Williamson, 2001; Sommer, 2019). Toeing this line of argument, certain studies have reported a significant relationship between trade dependence and low quality of life and mortality (Cutright and Adams, 1984; Dixon, 1984; London and Williams, 1990; Ragin and Bradshaw, 1992). Notwithstanding the above, some research has suggested that involvement in external trade has fostered economic growth and significantly raised the quality of life of citizens (Evans, 1987; Gereffi and Fonda, 1992).

Furthermore, the percentage of the population living in rural areas (*RPOP*) is another factor than can dictate under-five mortality. Rural dwellers have less access to medical facilities relative to their urban counterparts, thus making them highly vulnerable to diseases which can cause child mortality. However, an increasing urban population or urbanisation is associated with lower under-five mortality (Li et al., 2018; Vaidean et al., 2021). Thus, considering these factors, the new under-five mortality model is re-specified as:

$$LUFM_t = \beta_0 + \beta_1 COR_t + \beta_2 GDPG_t + \beta_3 TRD_t + \beta_4 HEXP_t + \beta_5 RPOP_t + \varepsilon_t \quad (2)$$

where *L* is the log introduced to reduce skewness.

The formulated hypotheses are:

H_0: There is no significant long-run impact of corruption on under-five mortality in Nigeria.

H_1: There is a significant long-run impact of corruption on under-five mortality in Nigeria.

2.2. Data and econometric methods

The constraints faced by this research lie in the lack of adequate of data (i.e., n<30) necessary for time-series analysis. Data on under-five mortality is available from the year 2000, and corruption from 1996 only. Data on the remaining series, however, are available for a considerable period. This problem is resolved via the conversion of yearly data for all variables from 2000 to 2021 to quarterly data via Gandolfo's (1981) interpolation procedure. Hence, a higher number of observations are available for 2001:1-2020:4 (i.e. n=80) due to the elimination of the first and last years of the original series during interpolation. This procedure has increasingly been adopted in empirical studies constrained by insufficient data (Abu et al., 2022a; 2022b; Baharumshah et al., 2006; Baharumshah and Rashid, 1999). Moreover, interpolated series do not lead to any bias in estimates computed from cointegrated vectors even if the sample is small (Smith, 1998; Tang, 2008).

Data were obtained from two sources, namely the World Development Indicators (WDI) and World Governance Indicators (WGI) of the World Bank. Corruption data is from the WGI, while income or GDP growth, rural population, trade and health expenditure are from the WDI. Corruption (*COR*) is proxied by the WGI corruption index and it has a range of -2.5 to +2.5, with lower values signalling higher (or lesser control of) corruption, and vice versa. Income growth (*GDPG*) is

measured by growth of real GDP per capita, health expenditure (*HEXP*) is government health spending share in real GDP, under-five mortality (*UFM*) is captured by the number of under-five mortality per 1,000 live births, trade openness (*TRD*) is the summation of the share of exports and imports in real GDP, and rural population (*RPOP*) is measured as the rural population growth rate.

2.3. Unit root test

Prior to AARDL model estimation, we conducted unit root test using both Augmented Dicker-Fuller (ADF) and Phillips-Perron (PP) tests to test the null hypothesis of the unit root in the series. This test is important in order to guide against generating results that are unreliable or invalid. The ADF test (Dickey and Fuller, 1979) is conducted via the equation:

$$\Delta y_t = \alpha + \rho y_{t-1} + \theta_1 \Delta y_{t-1} + \cdots + \theta_k \Delta y_{t-k} + \varepsilon_t$$

y_t denotes series, and ε_t the error term. The null hypothesis (H_0) to be tested is:

$\rho = 0$ (presence of unit root in the series)

Also, a complementary test, i.e. the PP test (Phillips and Perron, 1988), was conducted. These statistics are compared to the critical values of 1%, 5% or 10% to either reject or accept H_0.

2.4. Augmented ARDL (AARDL) bounds method for testing cointegration

The cointegration test was performed via the Augmented ARDL (AARDL) bounds test approach. The AARDL method of McNown et al. (2018) is an extended version of Pesaran et al.'s (2001) linear ARDL. The upgraded version of the model warrants an additional *F*-test (or *t*-test) on lagged independent variable(s). Goh and McNown (2015) illustrated that it is insufficient to compute only the *F*-test statistic on the coefficients of overall variables and the *t*-test statistic on the lagged dependent variable coefficient (i.e. two cointegration tests) as proposed by Pesaran et al. (2001). They claimed that the results based on these tests can lead to different degenerate cases.

Degenerate case #1 occurs where the lagged level of the dependent variable turns out to be insignificant, while degenerate case #2 arises if the lagged level of the independent variable(s) is not significant in Equation 3. Interestingly, McNown et al. (2018) and Sam et al. (2019) stated that if degenerate cases are not addressed, the results based on the-test and/or *F*-test will be misleading. Therefore, McNown et al. (2018) introduced an extra or complementary test (*F**-test) to be performed on the lagged level of explanatory variables in order to resolve these degenerate cases.

Adopting these three tests is critical in distinguishing amongst degenerate and cointegration cases (Sarker and Khan, 2020). Like the conventional ARDL, the advantages of the AARDL model over conventional tests of cointegration (Engle and Granger, 1987; Johansen and Juselius, 1990) lie in its applicability to series with mixed order of integration (i.e. I[0] and I[1]) as long as none are integrated to order two (i.e. I[2]). Other merits of the AARDL model include its appropriateness for estimating relations between variables which have finite samples and flexibility for variables to have different optimal lags, addressing the endogeneity problem, and using a single reduced-form equation to estimate the long-run and short-run coefficients simultaneously. The model (p, k_1, k_2, k_3, k_4, k_5) is specified as:

$$\begin{aligned}\Delta LUFM_t = \delta_0 &+ \sum_{i=1}^{p} \delta_{1i}\, \Delta LUFM_{t-i} + \sum_{i=0}^{k_1} \delta_{2i}\, \Delta COR_{t-i} + \sum_{i=0}^{k_2} \delta_{3i}\, \Delta GDPG_{t-i} \\ &+ \sum_{i=0}^{k_3} \delta_{4i}\, \Delta TRD_{t-i} + \sum_{i=0}^{k_4} \delta_{5i}\, \Delta HEXP_{t-i} + \sum_{i=0}^{k_5} \delta_{6i}\, \Delta RPOP_{t-i} + \beta_1 LUFM_{t-1} \\ &+ \beta_2 COR_{t-1} + \beta_3 GDPG_{t-1} + \beta_4 TRD_{t-1} + \beta_5 HEXP_{t-1} + \beta_6 RPOP_{t-1} \\ &+ \varepsilon_t \end{aligned} \tag{3}$$

The three tests of cointegration are conducted via testing these null hypotheses (H_0):
F-test on lagged level of all variables:
H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$
t-test on the lagged level of the dependent variable:
H_0: $\delta_1 = 0$
*F**-test on the lagged level of the independent variables:
H_0: $\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$

For the first two tests, the *F*-statistic (on lagged level of all variables) and the *t*-statistic (on the lagged level of the dependent variable) computed are compared to Pesaran et al.'s (2001) upper and lower critical bounds. H_0 is not accepted should the computed *F*-statistic and *t*-statistic be larger than the upper bound (i.e., I[1]). In contrast, H_0 is accepted where the computed *F*-statistic and *t*-statistic are smaller compared to the lower bound (I[0]). The decision will be inconclusive in any event that the *F*-statistic and *t*-statistic lie between I(0) and I(1). Also, for the third test, the computed *F**-statistic (on the lagged level of independent variables) is compared with Sam et al.'s (2018) critical values. If the *F**-statistic is higher compared to the upper bound, H_0 is not accepted. In contrast, H_0 is not rejected if *F**-statistic falls below the lower bound. To establish cointegration among the variables (and an absence of any degenerate case), the three tests are required to be significant. Upon the establishment of a cointegrating relation, long-run coefficients are estimated based on the model:

$$LUFM_t = \theta_0 + \theta_1 COR_t + \theta_2 GDPG_t + \theta_3 TRD_t + \theta_4 HEXP_t + \theta_5 RPOP_t + \varepsilon_t \tag{4}$$

Also, to estimate the short-run coefficients, the analysis makes use of an error-correction model written as:

$$\begin{aligned}\Delta LUFM_t = \beta_0 &+ \sum_{i=0}^{p} \beta_{1i}\, \Delta LUFM_{t-i} + \sum_{i=0}^{k_1} \beta_{2i}\, \Delta COR_{t-i} + \sum_{i=0}^{k_2} \beta_{3i}\, \Delta GDPG_{t-i} \\ &+ \sum_{i=0}^{k_3} \beta_{4i}\, \Delta TRD_{t-i} + \sum_{i=0}^{k_4} \beta_{5i}\, \Delta HEXP_{t-i} + \sum_{i=0}^{k_5} \beta_{6i}\, \Delta RPOP_{t-i} + \psi_1 ECT_{t-1} \\ &+ \varepsilon_t \end{aligned} \tag{5}$$

ECT represents the error-correction term, and its coefficient, ψ_1, measures the speed of adjustment needed to restore equilibrium in the long-run if there is any deviation in the short-run.

2.5. Diagnostic and stability tests

Post estimation or diagnostic tests are carried out to check the reliability of the results. They include the Breusch-Godfrey serial-correlation test, the Breusch-Pagan-Godfrey heteroscedasticity test, and the Ramsey RESET mis-specification test. Also, the test of stability of the model and parameters estimated is carried out via the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMQ). The estimated parameters and the model are adjudged unstable should the CUSUMQ plots break in the lower and/or upper bounds (Greene, 2003; Tang and Lean, 2007).

3. Discussion of Results

The main aim of this research is to evaluate the response of under-five mortality to corruption over the long-term in Nigeria. Given that time series are employed for analysis, the data were subject to a stationarity test. If the test results reveal that all variables are stationary at I(1), then the findings suggest possible cointegration among the variables. Thus, the analysis will proceed with a cointegration test. The results of the unit root tests (Table 2) based on ADF and PP methods demonstrate that all variables do have a unit root (i.e. non-stationary), but turned out stationary taken after their first difference.

Table 2. Results of the unit root (stationarity) test

	ADF		PP	
Variable	Level	1st diff.	Level	1st diff.
LUFM	-2.2676	-12.4259***	-0.3174	-3.7699***
COR	-1.7765	-4.0480***	-1.3530	-4.0480***
GDPG	-1.9683	-5.4507***	-1.5260	-5.4507***
TRD	-1.5460	-3.0986**	-1.8119	-4.7138***
HEXP	-1.8354	-4.9273***	-1.5175	-4.9273***
RPOP	-1.2565	-3.6054***	-0.9520	-3.7939***

**** and ** signify a rejection of the null hypothesis of the unit root (non-stationarity) at 1% and 5%, respectively. L is the log*

Source: own elaboration

The results of the cointegration test based on the three tests (Table 3) confirm the existence of a long-run relationship amongst the variables as the *F*-statistic (18.63), *t*-statistic (7.19), and *F**-statistic (20.94) are greater than their corresponding upper bounds at the 1% level of significance.

Table 3. Results of the cointegration test

Function = *f(LUFM / COR, GDPG, TRD, HEXP, RPOP)*						
	10%		5%		1%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistic=18.6295*** (overall or lagged level of all variables)	2.26	3.35	2.62	3.79	3.41	4.68
t-statistic=7.1916*** (lagged dependent variable)	2.57	3.86	2.86	4.19	3.43	4.79
*F**-statistic=20.9364*** (lagged independent variables)	1.86	3.39	2.24	3.90	3.05	5.02

**** signifies the rejection of the null hypothesis of no cointegration at 1% level. L denotes the log*

Source: own elaboration

The results based on the AARDL method (Table 4) show that an improvement in the control of corruption (*COR*) by one unit in the long-run lowers under-five mortality by 0.02% at the 1% level of significance. This empirical revelation is in line with prior research (Gupta et al., 2000; Hanf et al., 2011; Holmberg and Rothstein, 2009; Lio and Lee, 2016; Li et al., 2018; Vaidean et al., 2021). Thus, reducing corruption goes to decrease the theft of medical equipment and drugs purchased with public monies, reduce the supply of counterfeit medicines and hiring of incompetent professionals, and raise public spending on health programmes including judicious use of funds allocated to the health sector. These reduce the spread of infectious and communicable diseases, improve the health status of the population and lower under-five mortality. Thus, if the Nigerian government sustains the war against corruption and reduces such instances in the health sector, there will be an improvement in healthcare delivery and health outcomes, leading to a lower level of under-five mortality.

Also, greater openness to trade (*TRD*) appears to lower under-five mortality in the long-run. Increased openness to trade in the long-run by 1% reduces under-five mortality by 0.003% at a 1% level of significance. This outcome aligns with early research (Evans, 1987; Gereffi and Fonda, 1992). This outcome implies that as Nigeria and her citizens engage in more external trade and generate high revenues/incomes, it will raise the capacity of households to afford the basic necessities of life such as decent housing, quality education, a balanced diet and improved healthcare, to mention a few. These in turn raise the standard of living of citizens, reduce their vulnerability to diseases, and consequently lower under-five mortality.

In addition, increasing public spending on health (*HEXP*) by one unit in the long-run causes under-five mortality to reduce by 0.016% at the 1% level of significance. This discovery supports previous and related works (Bidani and Ravallion, 1997; Bokhari et al., 2007; Deolalikar, 1995; Gallet, 2017; World Bank, 1995). This suggests that an increase in government spending on healthcare will improve the health of the populace, especially low-income households who rely heavily on public spending on health, leading to a decline in deaths among under-fives.

Furthermore, an increase in rural population (*RPOP*) by 1% in the long-run, raises under-five mortality by 0.012% at the 1% level of significance. This finding signifies that the majority of a growing rural population,

including children, have limited access to medical facilities and are subject to public health programmes that are grossly inadequate. This, in turn, increases the vulnerability of a significant number of the populace including infants to diseases that can cause under-five mortality. However, rising urbanisation increases access to healthcare, leading to fewer deaths among under-fives (Li et al., 2018; Vaidean et al., 2021).

Table 4. Results of the AARDL model (Dependent variable: *ΔLUFM*)

Long-run model		Short-run model	
Regressor	Coeff./Std. Error	Regressor	Coeff./Std. Error
C	0.3802*** (0.0033)	$\Delta LUFM_{-1}$	0.3787*** (0.0945)
COR	-0.0235*** (0.0051)	$\Delta LUFM_{-2}$	0.2515** (0.1032)
GDPG	-0.0001 (0.0003)	$\Delta LUFM_{-3}$	0.2857*** (0.0884)
TRD	-0.0025*** (0.0006)	*ΔCOR*	0.0005** (0.0002)
HEXP	-0.0160*** (0.0037)	*ΔGPDG*	-0.2320*** (0.0659)
RPOP	0.0117*** (0.0002)	*ΔRPOP*	0.4320*** (0.0001)
		$\Delta RPOP_{-1}$	-0.0157** (0.0041)
		$\Delta RPOP_{-2}$	-0.0102** (0.0044)
		$\Delta RPOP_{-3}$	-0.0117*** (0.0037)
		ECT_{-1}	-0.0214*** (0.0019)
R^2	0.9999		

Results of diagnostic (post-estimation) tests	
Test Statistic	Results
Serial Correlation: χ^2	2.5777[0.2756]
Heteroscedasticity: χ^2	6.8625[0.9399]
Mis-specification: F-stat.	0.7067[0.4039]

****, **, and * signify statistical significance at 1%, 5% and 1%, respectively. signifies the log. [ ] denotes standard error*

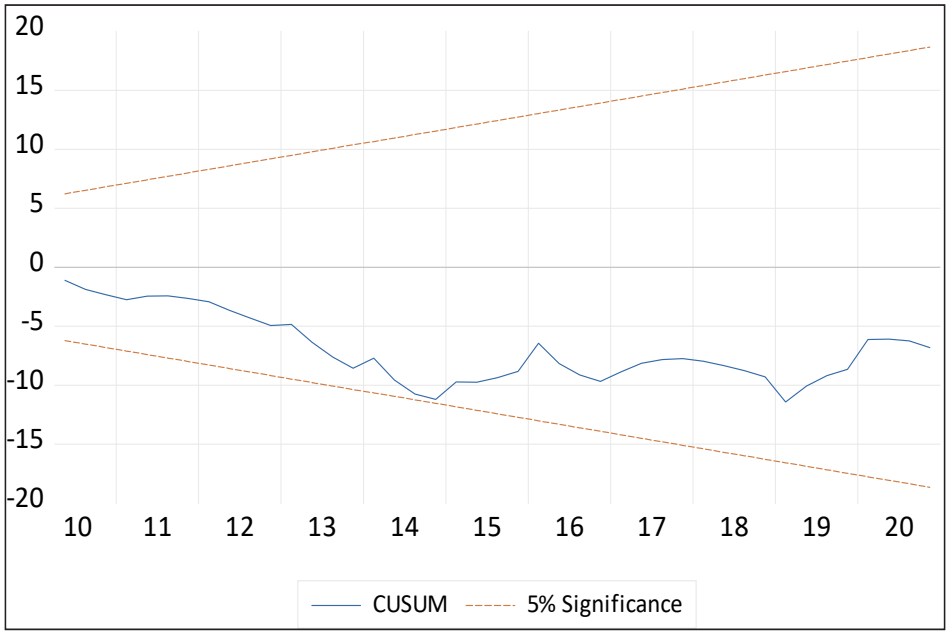
[ ] signifies probability values

Source: own elaboration

Although not the main focus of this research, the short-run results confirm that lowering corruption raises under-five mortality at the 5% level of significance, thus supporting the beneficial role of corruption in countries with weak institutions in the short-term (Huntington, 1968; Leff, 1964; Leys, 1965). Furthermore, improving income growth in the short-term reduces deaths among under-fives at the 1% level of significance. Moreover, a growing rural population contributes significantly to under-five mortality at the 1% level of significance. This outcome suggests that an increase in the rural population reduces the access of many, including children, to healthcare due to a lack of such facilities. This, in turn, contributes to the outbreak of diseases which raise under-five mortality. The *ECT* (error correction term) lagged by one period appears significant with the expected sign at the 1% level of significance, suggesting that 0.02% of deviation from equilibrium is corrected during the fourth quarter of the year.

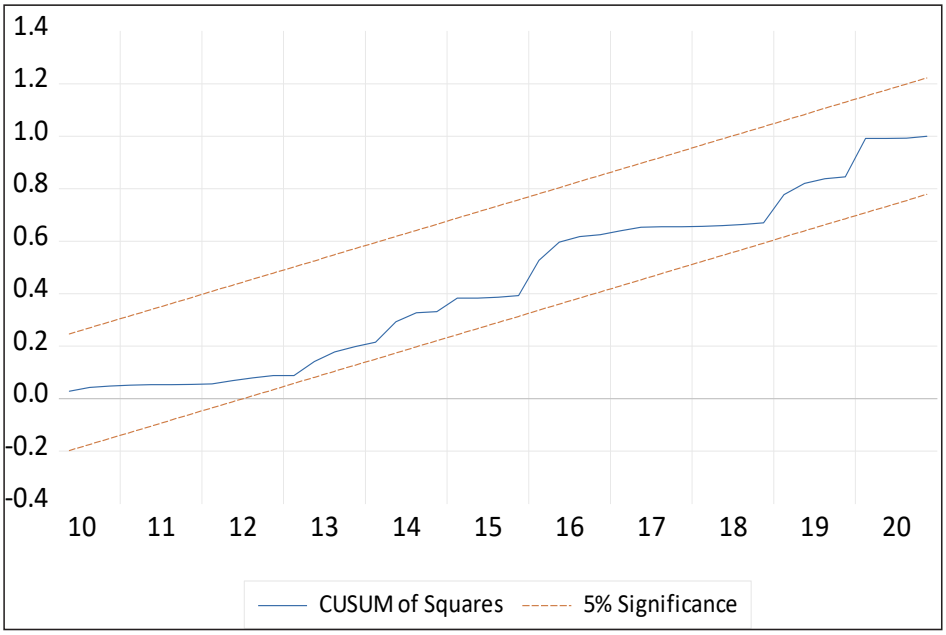
The diagnostic tests, namely serial-correlation, heteroscedasticity and mis-specification tests (Table 4), establish that the residuals are uncorrelated and homoscedastic, and the estimated model is correctly specified at the 5% level of significance. The results of the stability test based on CUSUM and CUSUMQ tests (Figure 1 and Figure 2) confirm that the plots lie within the boundaries at the 5% level of significance. Thus, both the estimated model and parameters depict long-run stability.

Figure 1. Plots of the cumulative sum of recursive residuals



Source: own elaboration

Figure 2. Plots of the cumulative sum of squares of recursive residuals



Source: own elebotarion

5. Conclusion

Corruption remains one of Nigeria's major challenges and the country has not been spared the problem of under-five mortality. This study evaluates the long-term influence of corruption on under-five mortality by applying the novel Augmented ARDL method to Nigeria's quarterly data for the 2000-2021 period. There is an evidence of a long-term relationship between corruption and under-five mortality alongside variables including health expenditure, income growth, openness to trade and rural population based on cointegration tests. Improving corruption control lowers long-term deaths among under-fives. This finding implies that if the Nigerian government sustains its efforts to reduce corruption, it will lower income and health inequalities, lessen embezzlement and the diversion of public funds allocated to health. Also, less corruption will guarantee the supply of standard drugs and medical equipment, counter contract inflation by government officials, and increase patients' access to quality and affordable healthcare. These can go a long way to boosting health outcomes such as lower under-five mortality. The negative influence of openness on under-five mortality suggests that as Nigeria intensifies efforts to engage in external trade, it will benefit the country by fostering economic growth. The sustained expansion of the economy will raise citizens' income and capacity to afford quality healthcare, resulting in lower under-five mortality. The positive impact of a growing rural population on under-five mortality indicates that a rising number of rural dwellers will only put more pressure on the already scarce medical facilities and further limit their access to healthcare. There is no doubt that this will increase their vulnerability to diseases which contribute to under-five mortality. Thus, we recommend measures that

lower corruption to reduce deaths among the under-five cohort.

Corruption in the health sector can be reduced via increased funding of anti-graft bodies and continuous training of their personnel. This will enhance their capacity and effectiveness in detecting, apprehending and prosecuting corrupt individuals. Also, the judicial system needs to be overhauled/revamped so that corruption and related cases can be dispensed without unnecessary delay and offenders sanctioned appropriately. In addition, the Nigerian government should increase cooperation with the international community in its fight against corruption. This will ensure that those who have stolen the nation's wealth and stashed it abroad can be arrested and brought back to Nigeria to face justice, while illegally acquired assets kept in foreign banks are repatriated. These measures, if complemented with policies that foster income growth, raise public spending on health, and promote foreign trade and urbanisation, can reduce deaths among under-fives in Nigeria in the long-term.

Although this research has unravelled the impact of corruption on under-five mortality in Nigeria, it has some limitations which future studies can improve upon. First, the study uses only one measure of corruption, i.e. World Governance Indicators' control of corruption. Therefore, future research can employ different measures of corruption including the Transparency International corruption perception index and the International Country Risk Guide control of corruption. In addition, the present study did not consider insecurity (which has become a daily occurrence in Nigeria) as a potential driver of under-five mortality. Hence, future studies should determine the likely effect of insecurity on under-five mortality.

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