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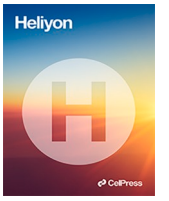

Economic growth, unemployment and poverty: Linear and non-linear evidence from South Africa

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ABSTRACT

The majority of South Africa's population lives in the same economy as poverty, even though the country's first democratic elections in 1994 not only lit a candle of hope but also helped to abolish poverty. One of the main hurdles to reducing poverty is economic growth, while unemployment is one of the mutual friends with poverty. Therefore, in this study, unemployment and economic growth were included as explanatory variables, while poverty was used as the dependent variable. To understand how unemployment and economic growth affect poverty, Autoregressive Distributed Lags (ARDL) and non-linear Autoregressive Distributed Lags (NARDL) models were used through the time series data from 2000Q1 to 2021Q4. Based on linear evidence, the findings of the study supported the idea that economic growth reduces poverty in the long-run, while unemployment inflates poverty in the long-run. The asymmetric evidence confirmed that although negative shocks of economic growth reduce the poverty rate, the positive shocks of the former reduce the poverty rate. On the other hand, poverty rates rise concurrently as a result of both positive and negative shocks of unemployment rates. Thus, it is advised that policymakers increase social investment to help urban and rural residents, particularly women and children, escape poverty.

1. Introduction

Despite different strategies triggered at reducing poverty by international, national, and local, policy managers. Poverty continues to exist, unabated and is a reality for many people worldwide. According to Ref. [1], more than 1.3 billion individuals were living in multifaceted poverty in 2020. Most of this poverty has its roots in rural areas in Africa. 80% of the world's population lives in extreme poverty, and poverty is concentrated in rural areas of Africa. In the same demographic, 40% of people live in transitory poverty, 60% of whom are chronically poor especially in remote locations [2]. Africa's economic powerhouse and a major hope for sustainable development in Sub-Saharan Africa (SSA), is South Africa (SA). Unfortunately [3], reports that more than 18.2 million people in SA live in extreme poverty. Even though most immigrants come from the same continent and Asia (particularly from Zimbabwe, Mozambique, Nigeria, Malawi, Lesotho, Eswatini, Pakistan, India, and China), they come for a variety of reasons, including education, political stability, employment opportunities, and economic changes [4]. However, particularly in deeply rural regions, poverty, inequality, slow growth, and high unemployment rates are unavoidable facts of life. In the African continent the number of the poor headcount has increased by 135 million between 1990 and 2015 [1]. The necessity and rationale for this study stems from the reality that poverty is concentrated in the deep rural communities of Africa. However, poverty is not the only problem in African countries; South Africa is

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also characterised by the worst unemployment experience and has been experiencing slow growth for the past years. As a result, it is ranked first in the world in countries with the highest unemployment experience [3]. Therefore, it is important to analyse how these worst experiences in real economic activities contribute to poverty in South Africa.

The economy of South Africa continues to experience several problems related to poverty. High inequality, which is accurately explained by the Gini coefficient of 0.65 in 2021, [5]. Persistently high unemployment, weak growth, and excessive food inflation are now the main causes of poverty. In 2021, South Africa changed its three poverty levels to consider a variety of factors, including inflation rates. In South Africa, poverty continues to be concentrated in rural regions and among women who are responsible for caring for families and children.

The 17 Sustainable Development Goals (SDGs) form the basis of South Africa's national development plan (NDP). The redistribution of income to reduce extreme poverty is one of the NDP 2030's goals; however [1], have already predicted that Africa will not succeed in eradicating poverty by 2030. Rural residents continue to rely heavily on social security benefits, which helps to reduce food insecurity. However, most people living in rural areas continue to lack access to other essential services. The rural household has limited access to housing, clean water, and has no job possibilities, long commutes, and inadequate infrastructure.

[6] defined poverty as a state in which persons cannot meet their most basic requirements; this capacity is multifaceted because there are many levels of poverty. Absolute poverty, also known as extreme poverty, is a circumstance in which persons lack even the most essential items for their existence, such as food, housing, and clothing, to name a few. Relative poverty, on the other hand, is found when persons have access to necessities, but lack the other things they need to survive. Poverty also entails exclusion from making decisions pertaining to one's dignity, and being deprived of one's basic human rights, [7].

There are additional measurements known as poverty lines; to put it simply, persons should utilise poverty lines as their daily minimal incomes to meet their fundamental needs. The international daily threshold for an income is $1.90, according to the [8]. However, the South African poverty lines employed in this study comprise the effects of inflation, and the international standard does not enable persons to meet the basic needs in this economy [8]. The poverty thresholds in South Africa are as follows: after accounting for inflation in 2021 per person per month: the food poverty threshold (FPL) is R624, the lower-bound threshold (LBPL) is R890, and the upper-bound threshold (UBPL) is R1335 [3]. However, no poverty line is a perfect measure of income among individuals [6].

Most studies in the literature have indicated the validity of economic growth in reducing poverty. At the same time, according to the NDP, economic growth should hover around an average of 5% as the years approach 2030. Numerous studies have indicated the importance of economic growth to reduce poverty [9–11], to mention a few. Some of them have maintained the validity of growth, and also indicated that it is not enough to manage poverty [12–14]. However, some studies have found no significant impact of growth on poverty reduction [15].

Unemployment is one of the measurement problems in SA that has been stubbornly high since the advent of democracy, but the policies applied in SA have failed to reduce it. However, addressing unemployment has received considerable attention from institutions following the recent pandemic. Accordingly, the NDP has focused on reducing unemployment to 6% by 2030. The literature has validated the positive relationship between unemployment and poverty [16–18]. However, some studies have observed a negative relationship between the variables [19].

Considering the context mentioned above, this study will examine how poverty, unemployment, and economic growth are related, building on the work of [10,20]. Additionally, in the light of discrepancies in the literature, this study sought to re-establish the link between poverty and economic growth as well as the relationship between unemployment and poverty. Although most researchers have assumed that there is a linearity regarding the link between the variables, the study also investigated the variables' linearity and non-linearity. To obtain a more accurate understanding of the topic under study and greater explanatory power, an asymmetrical relationship between the variables should be assumed. According to Ref. [21] the linear regression model may produce false findings when there are non-linear relationships present. Hence, to combine the benefits while minimising the shortcomings of each model, this study made use of both linear and non-linear methodologies, in addition, to identify which measure best explains the relationship between poverty, unemployment, and economic growth, the study used various poverty lines as dependent variables. The remaining sections of this study are as follows: Section 2 covers the literature review, the methodology is highlighted in Section 3, Section 4 presents the results and discussion, and lastly, Section 5 provides the concluding remarks.

2. Literature review

The basic needs theory, also known as the theory of human motivation, was developed by Ref. [22] and it divides the needs into due steps that need to be fulfilled before assuming others. In this theory, a human being is regarded as a stimulus-seeking organism with the basic needs to survive. This section will cover the theory of needs, which is the main focus of this study. For example, the first needs to be fulfilled by a human being are survival needs, such as food, water, shelter, clothing, warmth, rest, and shelter; they are called psychological needs, [23]. The first step is followed by a series of needs in the second step, namely, security needs, the third step comprises love, the fourth step entails esteem needs and finally, the fifth and last step involves self-actualisation and education. Although these needs will not be covered as variables in this study, the gross domestic expenditure (GDE) in the model, the needs mentioned above, will be considered when explaining the persistence of poverty.

After receiving significant aid during the lockdown, people lost their jobs, and the unemployment rate as a lagging indicator of the business cycle, has continued to remain above 30%. Those with extensive experience were able to withstand the negative effects of the lockdown, however, the majority of young people, inexperienced workers, and rural women were affected adversely [24]. This suggests that most persons who had experienced temporary poverty in rural regions, eventually fell into chronic poverty. Since unemployment is still high today, rural unemployment does not respond to the GDP growth even when the economic growth is

favourable. This is in line with [2] who has argued that even economies that have fast-growing economies, fail to reduce poverty.

Studies examining the connection between economic growth, unemployment, and poverty are proliferating in the literature [25]. confirmed, for instance, that there is no causality link between growth, unemployment, and poverty. The study used the Granger causality test, the error correction model (ECM), and the Johansen cointegration model with secondary data acquired between 1985 and 2015. Regarding the model's short-run perspective, a positive correlation between poverty and unemployment was identified in this study. On the other hand, certain studies support the correlation between the two variables, such as Okun's law, which could be between poverty and unemployment, poverty and economic growth, or unemployment and economic growth. Only the first two associations discussed before are of interest to this investigation.

As a result, the following discussion will address the connection between poverty and unemployment solely, while the connection between poverty and economic growth will be addressed later. The link between unemployment and poverty is controversial. For instance Ref. [17], used a multiple regression model in Indonesia to show that the two factors mentioned above had a positive connection [18]. confirmed similar findings using the same methods in the same economy. The ARDL model supported the claim of [26] that a 1% rise in unemployment increases poverty by 0.61%. However, even though [16] used the same methodology and adopted the same data, the outcomes were statistically insignificant. As a result, it is simple to see that the studies that have been cited have reached the same conclusion when they all employ the same method to estimate the same model. The idea, which states that when more individuals lose their jobs, more people fall into poverty conforms with the highlighted findings. According to Ref. [19], multiple linear regression analyses using secondary data gathered from 2011 to 2016, revealed a negative association between unemployment and poverty. However, some research, including a study by Ref. [27], showed no correlation between poverty and unemployment in the Indonesian province of Yogyakarta.

The following studies investigated the connection between poverty and economic growth and confirmed that there is a negative correlation between the two factors. For instance Ref. [11], used the VECM model to analyse data from 1960 to 2016 and found that a 1% increase in economic growth resulted in a 2.4% decrease in poverty. The model used in the study's significance also specifies the long-term link between the two variables.

In the same context [26], used the ARDL model, and found that a 1% increase in economic growth causes a 0.94% decrease in the poverty rate. The same conclusions of the study by Ref. [13] were confirmed in Asia, where it was shown that poverty reduction through economic expansion had no effect, both before and after the Asian financial crisis. Industrial development in Asia is important for GDP growth because it is the second largest contributor to growth, but it is less important for reducing poverty. Similar findings were found in the UK, where [12] found that there was a limited possibility for growth to reduce poverty over the 2000 to 2008 study period.

Similar views were expressed by Ref. [10] regarding the negative correlation between the two variables under investigation. The study also emphasised how poverty and unemployment are positively correlated. In addition, the VAR model was applied using data spanning the years 1980–2016. Importantly [28], found the same results using two different methodologies, the first of which is the multiple regression model that has been used in several studies and the difference indifferences model, which is being utilised for the first time in this body of literature. Regarding the economies of East Africa, specifically Kenya, Rwanda, Uganda, Burundi, and Tanzania, the panel study also found a negative correlation between the two variables under analysis. Nevertheless [15], countered several studies with their findings, which showed that poverty in Nigeria is not reduced by growth. The study used the straightforward OLS to arrive at the conclusions mentioned above.

According to Ref. [14], economic expansion is a useful but insufficient instrument for reducing poverty. The data covered the years 1990–2018 and, with the aid of ARDL and VECM approaches [29], confirmed the existence of a short- and long-term negative association between growth and poverty. Additionally [30], found the same results in 18 local municipalities in the South African province of Mpumalanga; growth reduced poverty but not income disparity.

3. Methodology

The research relied on a quantitative research paradigm that is in line with positivism and assumes that variables that are available in a time series format, can be reduced to empirical indicators that reflect reality accurately. Therefore, the ARDL model (linear regression) and NARDL model were combined in this study to examine how poverty behaves in relation to the explanatory variables of economic growth and unemployment, which are discussed in the following section. Poverty is measured by the food poverty line, lower-bound and upper-bound poverty lines.

Table 1
Description of variables.

Variables and presentation	Dependent/independent	Model	Measure
Food poverty (FPR)	Dependent	ARDL	No of people
Lower Bound Poverty (LBP)	Dependent	NARDL	No of people
	Independent	ARDL	
Upper Bound poverty (UBP)	Dependent	NARDL	No of people
	Independent	ARDL	
Gross Domestic Expenditure (*GDE*)	Independent	Both	%
Unemployment Rate (Un)	Independent	Both	%

Source: Authors compilation

4. Data and description of variables

The factors discussed in this section includes the number of persons living below the poverty line and the rate of food insecurity as shown by Table 1 below. The data in the table below was extracted from two sources Gross Domestic Expenditure (GDE) from the Federal Reserve Bank of St Louis (FRED), whereas the rest was sourced from Easy data (Quantec).

The second was the lower-bound poverty line, which represents those who are below it. The number of persons who live below the third poverty line is shown by the indicator, the upper-bound poverty rate. After accounting for South Africa's inflation rates [3], provided all the poverty lines shown. There is no ideal poverty limit [8], yet the global poverty line of $1.90 per day is insufficient to meet basic needs in South Africa.

The poverty headcount ratio is the most widely used indicator of poverty [29–32]. [8] used the same economy's upper-bound poverty line, while [33] used the lower-bound poverty rate for SA. All the poverty lines were used in this study as a dependent variable for the NARDL model. As a result, the researcher was able to determine how both explanatory variables affected each headcount of people living below a certain poverty line. While the lower -bound and upper-bound were used as explanatory variables, FPR was only used under the ARDL. This was done to capture the impact of poverty as determined by the upper and lower bounds as well as other variables on the number of people who were food insecure. The theory of needs covers food as a basic need, and government programmes, like social security grants also address it; therefore, the headcount of food poverty is accurate. In addition, because the family income is calculated through expenditures, the country's economic growth was measured using this approach (GDE).

5. Empirical model

The following discussion of the ARDL model follows the systematic procedure of a model that captures both the variables' short- and long-run relationships in a situation where the variables are integrated of mixed orders. Again, it allows the application of the error correction mechanism explained by the explanatory variables. In the literature, a few studies, such as [26], have used this approach to investigate the three variables under investigation. However, none have applied both linear and non-linear relationships. The merit of the ARDL is that it requires series that are integrated of different orders I (0) and I (1), with no series rendered stationary after second difference (2). It is also providing robust estimates in small sample sizes, ultimately the ARDL model resolve the issue of endogeneity in time series analysis by incorporating lags of the endogenous variables compatible, since responses of dependent variables are rarely instantaneous. Equation (1) below depict the ARDL model at its functional form.

$$y_t = \alpha_0 + \sum_{i=1}^{p} \delta_j y_{t-i} + \sum_{i=0}^{q} \vartheta_i^{'} x_{t-i} + \gamma t + u_t \tag{1}$$

Where y_t is the dependent variable as a function of its lag term y_{t-i} and other explanatory variables x_{t-i} , p and q signify lag orders for the lagged variables in the model (independent and dependent). On the other hand, the coefficient of vectors for both independent and dependent variables are captured by δ_j and $\vartheta_i^{'}$ respectively. γ is the slope of the time trend t, lastly is the error term u_t which is normally distributed around its mean of zero and have a constant variance. Equation (2) below represent the long-run ARDL model including the variables involved in this study.

$$FPR_t = \alpha + \sum_{i=1}^{n} \omega_1 LBR_{t-p} \sum_{i=1}^{n} \omega_2 UBR_{t-p} + \sum_{i=1}^{n} \delta Un_{t-p} + \sum_{i=1}^{n} \vartheta GDE_{t-p} + \varepsilon_t \tag{2}$$

$i = 1, 2 \ldots p$ And t = 1, 2 … pIn the above equation food poverty rate (FPR) is the dependent variable, and is a function of lower boundary poverty rate (LBR), upper boundary poverty rate (UBR), unemployment rate (Un), and economic growth (GDE), α symbolises the constant term, The sum of lags are captured by $\sum_{i=1}^{n}$. ω_1 *and* ω_2 denotes the coefficients of the lower bound poverty rate and upper bound rate related to food poverty. whereas δ *and* ϑ denote the coefficients for unemployment and economic growth, respectively. The last term ε_t is the error term. The model above is performed to detect appropriate lags order of the model, followed by the bound test. Albeit there are various methods of estimating long-run cointegration in time series, however this study is confined to the bounds testing procedure proposed by Ref. [34] since it is upon estimation of an error correction model, which allows the interpretation of the rate of the adjustment process from its equilibrium in the long-run. The short-run error correction model is represented by equation (3) below.

$$\Delta FPR_t = \alpha + \sum_{i=1}^{n} \omega \Delta FPR_{t-p} \sum_{i=1}^{n} \omega \Delta LBR_{t-p} + \sum_{i=1}^{n} \omega \Delta UBR_{t-p} + \sum_{i=1}^{n} \delta \Delta Un_{t-p} + \sum_{i=1}^{n} \vartheta \Delta GDE_{t-p} + \lambda ECT_{t-1} + \varepsilon_t \tag{3}$$

The short-run coefficients are symbolised by the first difference operator, λ is the coefficient for the error correction mechanism it is anticipated to range between 0 and 1 and take a negative sign and be statistically significant. the ECT indicates how fast it takes for the disequilibrium of previous period is restored back in the current period.

Before the model is estimated, it is appropriate to conduct pre-estimation test formally known as diagnostic test in time series analysis. Thes study will test for unit root to avoid running spurious running regressions. The study relied on two of the most applied tests, namely, the Augmented Dickey-Fuller (ADF) and the Phillips Peron (PP). Both the tests are based on the null hypothesis of no unit root, and the decision criteria are to reject this null hypothesis if the corresponding probability value is less than the maximum 10%

level of significance. Since the variables exhibit a mixed integration as shown in the results section, this study resorted to an autoregressive distributed lag model (ARDL) whose bounds testing procedure by Ref. [34] is designed to test and estimate both short-run and long-run specifications when variables are integrated into different orders, as long as none of the variables is integrated into order 2. The following section covers the NARDL model.

5.1. Empirical model (NARDL)

In contrast with the conventional ARDL model, the NARDL captures the validity of both the positive and negative effects of shocks. When variables exhibit stationarity after adjusting for the initial difference, the asymmetric influence of the variable makes much more sense. The model has the advantage of applying the variables exactly as they are without using the difference operator, even if it is not applicable in situations where a variable is stationary after the second order I (2) [35]. According to some researchers, if the variables are differenced, it is possible to discover cointegration among the variables that do not actually exist [36]. Application of the non-linear ARDL is therefore valid because it is reasonable to infer that the variables are non-linear because the actual data might not show linearity. The following model is based on the work of [36], although the study differs in that it is interested in how unemployment and growth affect several measures of poverty namely FPR, LBR, and UBR as represented in equations (4)–(6) respectively.

$$FPR_t = \alpha_0 + \alpha_1 Un_t^+ + \alpha_2 Un_t^- + \alpha_3 GDE_t^+ + \alpha_4 GDE_t^- + \varepsilon_t \tag{4}$$

$$LBR_t = \alpha_0 + \gamma_1 Un_t^+ + \gamma_2 Un_t^- + \gamma_3 GDE_t^+ + \gamma_4 GDE_t^- + \epsilon_t \tag{5}$$

$$UBR_t = \alpha_0 + \varnothing_1 Un_t^+ + \varnothing_2 Un_t^- + \varnothing_3 GDE_t^+ + \varnothing_4 GDE_t^- + u_t \tag{6}$$

Where (FPR_t) is the food poverty rate as a dependent variable, Un_t, andGDE_t are unemployment and gross domestic expenditure as the regressors. Unlike the conventional ARDL, where linearity is assumed in the parameters, in this model, the variable of interest (output) and other regressors are decomposed into their positive and negative partial sums, as shown by equations (7) and (8).

$$X_t^+ = \sum_{i-1}^{t} \Delta X_t^+ = \sum_{i-1}^{t} MAX(\Delta Un_t, \Delta GDE_t,) \tag{7}$$

$$X_t^- = \sum_{i-1}^{t} \Delta X_t^- = \sum_{i-1}^{t} MIN(\Delta Un_t, \Delta GDE_t) \tag{8}$$

Negative variations for each regressor are represented by (X_t^-) whereas the positive deviations for each respective regressor, are captured by (X_t^+). The cointegrating vector for the long-run parameters to be estimated is represented by $(\alpha = \alpha_0, \alpha_1 \alpha_2, \alpha_3, \alpha_4)$ in equations (4)–(6) respectively. Equations (9)–(11) below represents the short-run error correction models (ECM) for each poverty line model. The ECT can range between 0 and -1 when there is a monotonic adjustment, or it can range from -1 to -2 when errors fluctuate around the long-run equilibrium in a dampening manner.

$$\Delta FPR_t = \alpha + \alpha_0 FPR_{t-1} + \alpha_1 Un_{t-1}^+ + \alpha_2 Un_{t-1}^- + \alpha_3 GDE_{t-1}^+ + \alpha_4 GDE_{t-1}^-$$

$$+ \sum_{i=1}^{p} \gamma_i \Delta \mathrm{FPR}_{t-1} + \sum_{i=1}^{q} \left(\theta_i^+ \Delta \mathrm{Un}_{t-1}^+ + \theta_i^- \Delta \mathrm{Un}_{t-1}^- + \theta_i^+ \Delta \mathrm{GDE}_{t-1}^+ + \theta_i^- \Delta \mathrm{GDE}_{t-1}^- \right) + \varphi \mathrm{ECT}_{t-1} + \mu_t \tag{9}$$

$$\Delta LBR_t = \alpha + \beta_0 LBR_{t-1} + \gamma_1 Un_{t-1}^+ + \gamma_2 Un_{t-1}^- + \gamma_3 GDE_{t-1}^+ + \gamma_4 GDE_{t-1}^-$$

$$+ \sum_{i=1}^{p} \gamma_i \Delta \mathrm{LBR}_{t-1} + \sum_{i=1}^{q} \left(\theta_i^+ \Delta \mathrm{Un}_{t-1}^+ + \theta_i^- \Delta \mathrm{Un}_{t-1}^- + \theta_i^+ \Delta \mathrm{GDE}_{t-1}^+ + \theta_i^- \Delta \mathrm{GDE}_{t-1}^- + \delta \mathrm{ECT}_{t-1} \right) + \mu_t \tag{10}$$

$$\Delta UPR_t = \alpha + \varnothing_0 UPR_{t-1} + \varnothing_1 Un_{t-1}^+ + \varnothing_2 Un_{t-1}^- + \varnothing_3 GDE_{t-1}^+ + \varnothing_4 GDE_{t-1}^-$$

$$+ \sum_{i=1}^{p} \gamma_i \Delta \mathrm{UPR}_{t-1} + \sum_{i=1}^{q} \left(\theta_i^+ \Delta \mathrm{Un}_{t-1}^+ + \theta_i^- \Delta \mathrm{Un}_{t-1}^- + \theta_i^+ \Delta \mathrm{GDE}_{t-1}^+ + \theta_i^- \Delta \mathrm{GDE}_{t-1}^- + \partial ECT_{t-1} \right) + \mu_t \tag{11}$$

The short-run lag orders are symbolised by p,q. The long-run coefficients ($\alpha_1 = -\beta_1 \div \beta_0$, $\alpha_2 = -\beta_2 \div \beta_0, \alpha_3 = -\beta_3 \div \beta_0, \alpha_4 = -\beta_4 \div \beta_0, \alpha_5 = -\beta_5 \div \beta_0, \alpha_6 = -\beta_6 \div \beta_0$) will represent the long-run influences of both negative and positive shocks in the independent variables. The same applies to the long-run coefficients for the equations (10) and (11). On the other hand, the effect of both negative and positive shocks in the independent variables on unemployment in the short-run will be captured by $\sum_{i=1}^{a} \theta_i^+$ (increase) and $\sum_{i=1}^{a} \theta_i^-$ (Decrease). Equations (9)–(11) are specified in such a way that it shows the asymmetric effect of independent variables shocks on poverty for both short-run as well as the long-run. The coefficient of the error correction is denoted by φ, it is expected to be negative and statistically significant. The null hypothesis for the long-run and short-run asymmetry using a Wald test are $\beta^+ = \beta^-$ to assess long-run asymmetry, the null hypothesis must be rejected and accepted in favour of the alternative stating, $\beta^+ \neq \beta^-$. Likewise, for the short-

run asymmetry the alternative hypothesis of $\sum_{i=1}^{a}\theta_i^+ = \sum_{i=1}^{a}\theta_i^-$ must be accepted. Intuitively, the presence of asymmetry both in the long-run and the short-run implies that the effects of the negative and positive shocks are not identical on poverty.

One of the benefits of applying the NARDL is that, alongside the above tests, we can also model the dynamic multipliers, to assess how the dependent variable adjusts to its long-run equilibrium given the negative and positive deviations on each independent variable as shown by Equation (12) below.

$$X_k^+ = \sum_{j=0}^{k}\frac{\partial Un_{t+j}}{X_{t-1}^+}, X_k^- = \sum_{j=0}^{k}\frac{\partial Un_{t+j}}{X_{t-1}^-}, \quad k = 0,1,2,3\ldots\ldots\infty \tag{12}$$

Note, as k $\rightarrow\infty$, $M_k^+ \rightarrow\alpha_1$ and $M_k^- \rightarrow\alpha_2$.

The procedure for the application of the NARDL requires that all the series are either integrated of order I (0) or I (1). There should be no order I (2). Therefore, the unit root test will be the first step in determining the order in which the underlying series are integrated. If stationarity is established among the series, then the Bound test will be applied to establish if there is long-run cointegration. Basically, cointegration will mean that there is a causal effect among the variables in the long-run. The long-run cointegration is tested using the [34] bound test that may use the F-stat hypothesis to test for a joint hypothesis or a t-stat that is used to test a single hypothesis. The F-stat hypothesis are outlined by equation 13, and 14 respectively as follows:

$$H_0^F : (\alpha = 0) \cap \left(\sum_{j=0}^{q}\beta_i = 0\right) \tag{13}$$

$$H_a^F : (\alpha \neq 0) \cup \left(\sum_{j=0}^{q}\beta_i \neq 0\right) \tag{14}$$

For the t-stat, the null hypothesis and alternative hypothesis are denoted by $\alpha = 0$ and $\alpha \neq 0$, respectively. The critical values depend on several factors, such as independent variables, their integration order, the number of short-run coefficients and the inclusion of the intercept and trend. Rejecting the null hypothesis (H_0^F or H_0^t) if the F-stat or T-stat is exceeding the upper bound of critical values at 1%, 5%, and 10%.

6. Discussion of the results

The following discussions test the foundation of the methodology described in the above section. The descriptive statistics results are presented in Table 2, and this indicates that all the variables show high volatility except for the GDE.

In particular, the table contains measures of central tendency, namely, the mean, the median, the maximum, and the minimum, the standard deviation, kurtosis, and skewness. The food poverty rate and unemployment hover around the same values in terms of the minimum and maximum values, indicating a high correlation between the two variables.

The study performed the ADF and PP tests for stationarity, and results are presented in Table 3. The Augmented Dickey-Fuller test has confirmed that all the variables that denote poverty, such as the food poverty rate, the lower-bound poverty rate, and the upper-bound rate, were found to be stationary after taking their first difference.

This means that despite being Africa's economic powerhouse, SA is still experiencing an upward trend of poverty. Equally important, unemployment rate is not stationary over time, falling into the trap of stationarity after taking its first difference. Both tests confirmed that all the variables were stationary after taking the first difference I (1), except for the GDE. The significant level of the statistical values is denoted by p-values (***), signifying a P-value that is less than 0.01. In the second and fifth columns, most values are without indications of p-values like (***) to denote that their P-values are above 0.1 and are considered insignificant. These findings necessitate the use of the bound test for cointegration and possibly, the autoregressive distributed lags model. The bound test emanates from the fact that the variables under the stationary test were stationary in different orders namely: I (1) and I (0) without variable that was found stationary after the second difference I (2). Table 4 shows the result of the bound test for long-run cointegration.

The F-statistics (6.66) in the table above exceeds the values of the lower and upper boundary in all the levels of significance and is

Table 2
Descriptive statistics table.

	Food poverty line	Unemployment	Lower-bound test	Upper-bound test	GDE
Mean	37.557	25.931	78.662	63.628	2.393
Max	48.734	35.133	86.608	74.055	19.429
Min	26.708	21.03	69.278	50.410	−17.007
Std.Dev	5.722	3.125	4.812	5.831	3.524
Skewness	0.837	1.316	0.265	0.222	−0.808
Kurtosis	3	4.687	2.058	2.774	17.669
JB test	10.278***	34.623***	4.104	0.908	789.500***
observation	88	88	88	88	88

Note: *** imply 1%significant levels.

Table 3
Unit root test.

Augmented Dickey-Fuller test stat (ADF)				Philip Perron (PP)		
Variable name	I (0)	I (1)	Order	I (0)	I (1)	Order
FPR	−2.037	−9.417***	I (1)	−2.037	−9.420***	I (1)
LBPR	−2.795	−5.938***	I (1)	−2.325	−9.761***	I (1)
UBPR	−2.0562	−9.579***	I (1)	−2.056	−9.603***	I (1)
UN	−0.7608	10.129***	I (1)	−2.4825	−14.53***	I (1)
GDE	−3.782***	–	I (0)	6.044***	–	I (0)

Note: *** imply 1% significant levels.

significant at 1%, which advocates the fact that there is long-run cointegration between the variables under investigation. In this regard, both long-run and short-run model will be estimated.

The long-run model results are shown by Table 5, which are the main outcome of interest for the ARDL model. The long-run coefficients are calculated by dividing each coefficient of the long-run by the short-run food poverty coefficient (1.069) in Table 6. A 1% rise in unemployment results in a 0.97% increase in food poverty in the long-run. The unemployment rate and the prevalence of food insecurity have been found to have a positive link [37]. This implies that many people will continue to live below the food poverty line if more people lose their jobs. This could be explained by the fact that there is a high dependence ratio in SA, where a household's primary breadwinner must also provide for his extended family in addition to his children. Bigger families in SA frequently fall short of the WHO recommended level of food security [38]. Food poverty is considerably more sensitive to unemployment (1.035) than other variables like LBR, UBR, and GDE growth. This may be explained by the fact that individuals who experience extreme poverty frequently lack other resources that would enable them to generate an income for subsistence expenses instead of focusing on employment. Hence, those families have found it challenging to survive due to poverty amplified by a shock like the previous COVID-19 pandemic. Again, this can be explained by the fact that the majority of people rely on careers like cleaning, security, waitering, babysitting, EPWP, housekeeping, and shopkeeping that do not pay enough to save for the future or build wealth [39]. These jobs, which are predominately carried out by Black people and Black women in particular, are not sustainable and do not offer appropriate benefits like UIF, medical assistance, and other things.

Moving on to the inertia of poverty, the lower-bound poverty rate and the food poverty rate have a negative association. Since individuals always try to go to bed on full stomachs at least, it follows that if many people can afford to spend money on food and other non-food related products, it suggests that more people tend to live over the food poverty level.

The link between the upper-bound poverty rate and the food poverty rate is positive; hence an increase in the upper-bound poverty rate of 1% will result in an increase in the food poverty rate of 0.77%. This suggests that people whose spending on non-food products is as low as their spending on food, and whose rise in quantity is entirely independent of persons living below the food poverty line. The GDE and food insecurity are inversely correlated, with a 1% increase in the GDE resulting in a 0.15% decrease in food insecurity. This figure (0.15) is significantly lower compared to the other factors discussed above, is consistent with [2] that have claimed that even in the African economies that are experiencing strong growth, the GDP expansion does not alleviate poverty.

Moving on to the short-run results in Table 6, the results are contrary to the long-run scenario and conforms with theory that a high food poverty rate causes people to be trapped in a cycle of poverty (poverty inertia) indicated by 1.06%. On the other hand, a rise in unemployment in the short-term reduces poverty, indicated by 0.825%. Further significance is the positive association between the short-run lower bound rate and food insecurity, indicated by 1.1%. Similarly, the short-term link between the upper bound rate and the rate of food poverty is negative. In contrast with this theory, the evidence shows that the GDE growth does not reduce the poverty rate [15], in the short-term and is indicated by 0.16%, this could be due to slow growth in SA. The error correcting term keeps the anticipated negative sign and a value of less than one as we move to the variable of interest. This means that every quarter, the independent variables correct 79.8% of the short-run mistakes in the direction of the long-run equilibrium. Table 7 below provides the diagnostic test results.

The p-value of the heteroscedasticity test indicates that we reject the null hypothesis that the errors are not normally distributed. Therefore, the test maintains the assumption of homoscedasticity of the errors. Once again, the P-value for the Breusch-Godfrey Serial Correlation LM Test, which is above 0.05, indicates that the model is free from a serial correlation. Furthermore, the RESET test indicates that the model has correctly specified through its p-value that is above 0.05. Lastly, the variables of the model are normally distributed in series; this evidence comes from the JB test, with a high p-value, as previously stated in the tests mentioned above. Equally important are the diagnostic tests on the parameter stability, which are presented below. Appendix A1 provides the CUSUM test of stability is used to test the stability model's parameters within a 5% significance level. The CUSUM line fluctuates within the 5%

Table 4
Bound test.

ARDL f(FPR=UN, LBR, UBR, GDE)	F-statistics	Significance	I (0)	I (1)
K = 4	6.665	10%	3.03	4.06
		5%	3.47	4.57
		1%	4.4	5.72

Note: K = 4 indicate the number of explanatory variables.

Table 5
Long-run equation.

Variable	Coefficient	T-stat
UN	1.035*** (0.109)	9.422
LBR	−0.646** (0.274)	−2.356
UBR	0.822*** (0.182)	4.497
GDE	−0.159** (0.182)	−2.202
C	18.769	1.32
@Trend	−0.176*** (0.031)	−5.715

Note: *** implies 1%, and ** 5%, significant levels. The figures in brackets are standard errors.

Table 6
Short-run Coefficients: ARDL model (6, 7, 8, 8, 2).

Variable name	Coefficient
D(FPR)	1.069
D(UN)	−0.825
D(LBR)	1.1
D(UBR)	−0.043
D(GDE(-1))	0.160 (0.044)***
D(@TREND())	−0.140*** (0.033)
ECM(-1)	−0.798*** (0.142)

Note: *** imply 1%, ** 5%, and * 10% significant levels. The figures in brackets are standard errors and (D) denotes the difference operator.

Table 7
Diagnostic tests.

Diagnostic test	F-stat	P- value
Jarque-Bera test	0.053	0.9736
Heteroscedasticity Test Breusch-Pagan-Godfrey	1.018	0.4736
Ramsey RESET	3.109	0.0852
Breusch-Godfrey Serial Correlation LM Test	1.138	0.3531

Sources: authors computation from estimation

significance level, signifying that the model is stable.

Non-linear Autoregressive Distributed Lags model.

The non-linear ARDL model is covered in this section. The discussion will begin with the bound test for long-run cointegration results in Table 8, then moves on to the long-run equation, the short-run equation, and finally the diagnostic tests. The lower-bound rate and upper-bound rate have been utilised as proxies for the poverty rate in the first, second, and third equations, respectively. The positive and negative shocks for unemployment and GDE are hence, explanatory variables.

The null hypothesis that there is no cointegration between the variables is rejected by the bound test for cointegration. The F-stat for the lower-bound rate is 5.858, and the F-stat for the food poverty rate is 7.874, both of which are statistically significant at the 1% level. Last, but not least, the F-stat for the upper-bound rate is 5.679, and it is statistically significant at the 5% level. There is a long-

Table 8
Bound test for NARDL model for FPR, LPR and UPR).

NARDL $f(\boldsymbol{FPR}, \boldsymbol{UN}^{+}, \boldsymbol{UN}^{-}, \boldsymbol{GDE}^{+}, \boldsymbol{GDE}^{-})$	F-statistics	Significance	I0	I1
K = 2	7.874	10%	3.03	4.06
		5%	3.47	4.57
		1%	4.4	5.72
NARDL $f(LBPR, UN^{+}, UN^{-}, GDE^{+} + , GDE^{-})$				
K = 2	5.858	10%	2.45	3.52
		5%	2.86	4.49
		1%	3.74	5.06
NARDL $f(UBPR, UN^{+}, UN^{-}, GDE^{+}, GDE^{-})$				
K = 2	5.6799	10%	3.03	4.06
		5%	3.47	4.57
		1%	4.4	5.72

Note: Authors computation.

term relationship between the variables, because of the models and factors stated.

Moving to the long-term equations models, the results are presented by Table 9, for each model. Basically this is the estimation of equations (4)–(6). From the results it can be seen that the rate of food insecurity rises both when unemployment is rising [37] and falling, indicating that regardless of whether unemployment is rising or falling, the rate of food insecurity will continue to rise. Yet, because 1.48 is bigger than 0.58 in actual terms, the poverty rate is substantially more resilient to negative shocks of unemployment rates, supporting the recent ARDL model findings. Given that the F-stat is significant at 5%, the Wald test results offer accurate insights into the asymmetry in the relationship between unemployment and food insecurity. The conclusions are clear in SA, where poverty has been a problem, both during periods of low unemployment and periods of high unemployment. According to Ref. [40], this may account for elders who are no longer employed and also for child poverty. These findings imply that access to employment in SA does not ensure the eradication of poverty.

On the other hand, as GDE rises, it lowers the long-term rate of food poverty by 0.463%; comparable long-term results were achieved from the ARDL model. The long-term, rising economic growth results in a decrease in food insecurity. It contends with [9,11], in the same manner that poverty will increase in the event of a negative shock to economic growth, lower economic growth causes a high rate of poverty in the economy. Therefore, growth is valid in the process of poverty reduction in the long-run. However, food poverty is more resilient to positive shocks rather than negative shocks.

Moving on to the lower-bound poverty rate, it is vital to note that both positive and negative unemployment shocks have an impact on poverty. For instance, a positive shock from unemployment increased poverty by 3.5%, but a negative shock increased it by 2.6%. This indicates that poverty at the lower end will continue to rise regardless of whether unemployment is rising or falling. This scenario could be linked to Ref. [41] who indicated that if unemployment continues to rise, the majority of people continue to live in poverty despite receiving some remittances, meanwhile if unemployment decreases due to part-time jobs or piece jobs, poverty continues unhindered to taste the foundation of their existence. The Wald test's findings offer a good understanding of the symmetry in the present-day impact of unemployment, on lower bound poverty, as the F stat was statistically insignificant.

Lower-bound poverty, however, is more responsive to positive than to negative shocks. Thus, those who are poorer than the lower-bound poverty line are more adversely impacted by rising unemployment rates. Because young people between 24 and 35 years of age, experience the highest rates of unemployment and poverty, this scenario may be related to them [40]. Once more, it might be related to the tourism and agricultural sectors where there is fierce competition, and the employment of labour is still higher than that of capital. On the other hand, a negative shock (contraction phase) led to a 1.7% increase in lower bound poverty rate in the long-term, and a positive shock (expansion phase) led to a 2.5% reduction in lower-bound poverty.

This indicates that economic growth is still relevant in the long-run for initiatives to reduce poverty; the existence of symmetry also supported the claim. When compared to negative shocks, the lower-bound poverty rate is more resilient. The period of the holiday season may be linked to positive shocks and in situations, like the 2010 FIFA World Cup, when economic activity was brisk, and many individuals were exposed to employment opportunities.

Regarding the upper-bound poverty rate, a positive shock in unemployment resulted in an increase of 0.36%, likewise a negative shock resulted in an increase of 2.7%. This may be connected to the circumstances to which a child is exposed in a household where at least one family member works and other children receive child support payments [8].

In contrast, a positive GDE shock caused a decrease of 1.01%, in upper-bound poverty whereas a negative shock caused a 1.6%

Table 9
Long-run equations for FPR, LBPR and UBPR.

Variable name	Coefficient	T-stat
Dependent variable: Food poverty rate		
UN_POS	0.582** (0.268)	2.177
UN_NEG	1.489*** (0.074)	20.070
GDE_POS	−0.463*** (0.112)	−4.142
GDE_NEG	0.231** (0.107)	2.146
C	44.720*** (0.593)	75.400
@Trend	0.316*** (0.077)	4.086
Dependent variable: Lower-bound poverty rate		
UN_POS	0.800*** (0.128)	6.240
UN_NEG	0.594*** (0.090)	6.570
GDE_POS	−0.557*** (0.125)	−4.469
GDE_NEG	0.396*** (0.124)	3.201
C	83.851*** (0.587)	142.752
Dependent variable: Upper-bound poverty rate		
UN_POS	−0.1542 (0.438)	−0.351
UN_NEG	1.162*** (0.154)	7.564
GDE_POS	−0.431** (0.209)	−2.054
GDE_NEG	0.689*** (0.199)	3.458
C	72.499*** (1.092)	66.364
@Trend	0.600*** (0.1332)	4.5031

Note: *** imply 1%, ** 5%, and * 10% significant levels. The figures in brackets are standard errors.

increase. This suggests that, in contrast to the food and lower-bound poverty rates, more people experience poverty during a recession and, ultimately, fewer people escape poverty during the expansion. Therefore, whether the economy is doing well or not, poverty will continue to increase. This is true for the South African economy, as good growth was seen in several sectors from 2010 to 2019 before being halted by the pandemic. However, growth was also seen in many sectors from 2000 to 2006, when it was disrupted by the GFC. While poverty is still a major issue in SA, economic growth increased to 4.9% in 2021 from −6.4% in 2020.

When it comes to the short-run results, the estimation of the Equations (9)–(11) coefficients are shown in Table 10 for each model. These coefficients are nothing more than the sum of shock lags for each variable. On the other hand, the variables where the *t*-test appears in the last column are those where just one shock lag was statistically significant, and the rest were not included on the table since they were not significant. When compared to other variables of relevance, the same variable is most affected by the latencies of food poverty, which demonstrates the prevalence of the poverty cycle. In the short-term, the positive shock of unemployment has a negative impact on food poverty, while the negative shock has a positive impact.

This is consistent with [2,15,15], who stated that economic expansion does not reduce poverty in other economies that do well in terms of growth in Africa. The positive shock of economic growth has a beneficial influence on food poverty rate in the short-run. Although the error correction term has been recorded as negative and statistically significant, the value of 1.32 indicates that the long-term equilibrium will be reached instead of monotonic adjustment. When the procedure is complete, the mistakes are decreased to long-term equilibrium with an extremely fast pace of adjustment of 0.33 each quarter. The errors vary around the equilibrium in a dampening fashion.

The latencies of the lower bound poverty rate on the same variable have a positive relationship, which we will discuss next. On the other hand, a positive shock like unemployment, lowers the lower-bound poverty rate, whereas a negative shock has the opposite effect. This indicates that, in the short-run, lower-bound poverty is more responsive to a negative shock than to a positive shock. Therefore, lowering unemployment in the short-run is a viable strategy to lower bound types of poverty. Going on to the economic expansion, GDE has a positive impact on the lower-bound poverty rate, but negative shocks have a negative impact. The error correction term has been negatively and statistically significant at a 1% level, the independent variables correct 59.1% of the dependent variable towards the long-run equilibrium following the short-term deviation.

Moving on, the positive shock of unemployment reduces the upper-bound poverty rate, whereas the negative shock decreases poverty in the short-term. Conversely, a positive shock regarding economic growth raises the upper bound poverty, while a negative shock lowers it in the short-term. The error correction term, which is entered negatively and is statistically significant, indicates that 49.1% of the dependent variable is corrected each quarter to return to long-run equilibrium after the short-run deviation. The Wald test has been featured in the discussion above pertaining to the long-run equations the results are provided in Table 11.

The Wald test results postulates that in all the models of the NARDL the effects of positive shocks and negative shocks in the independent variables is not identical on different poverty lines in South Africa. Table 12 presents results from the post-estimation diagnostic checks, which are necessary to ensure the reliability of the estimated results.

The evidence for all the regression models indicates that the residuals from the estimated models are free from autocorrelation, heteroscedasticity, model misspecification, and residual non-normality since the p-values are above the 5% significant level. Equally important is the CUSUM test for stability, which is presented graphically in Appendices A2 to A4. The CUSUM test is used to test the

Table 10
Short-run equations for FPR, LBPR and UBPR.

Variable Name	Coefficient	T-stat
NARDL (8, 5, 8, 7, 7) Dependent variable: Food Poverty Rate		
D(FPR)	3.055	
D(UN_POS)	−0.901*** (0.242)	−3.715
D(UN_NEG)	0.068	
D(GDE_POS)	0.368	
D@Trend	0.418*** (0.132)	3.161
ECM(-1)	−1.321*** (0.262)	−5.038
NARDL (5, 7, 2, 6, 7), Dependent variable: Lower Bound poverty rate		
D(LPR)	0.227** (0.098)	2.311
D(UN_POS)	−0.045	
D(UN_NEG)	−0.048	
D(GDE_POS)	0.49	
D(GDE_NEG)	−0.556	
ECM(-1)	−0.591*** (0.126)	−4.675
NARDL (1, 5, 7, 6, 7), Dependent variable: Upper Bound poverty rate		
D(UN_POS)	−0.427** (0.164)	−2.604
D(UN_NEG)	−0.123	
D(GDE_POS)	0.297	
D(GDE_NEG)	−0.721	
D(@Trend)	0.2960*** (0.084)	3.514
ECM(-1)	−0.493*** (0.118)	−4.164

Note: *** imply 1%, ** 5%, and * 10% significant levels. The figures in brackets are standard errors.

Table 11
Wald test.

Variable name	F-stat	Probability	Condition
Dependent variable: Food Poverty rate			
Unemployment rate 3.3189		0.0742	Long-run asymmetry
GDE	5.5590	0.0222	Long-run asymmetry
Dependent variable: Lower bound poverty rate			
Unemployment rate	0.046	0.8301	Long-run symmetry
GDE	0.067	0.7950	Long-run symmetry
Dependent variable: Upper bound poverty rate			
Unemployment rate	2.467	0.1215	Long-run symmetry
GDE	4.115	0.0470	Long-run asymmetry

Source: Estimation of the results

Table 12
Diagnostic test.

Diagnostic test	F-stat	P- value
Food poverty rate		
Jarque-Bera test	3.038	0.9489
Heteroscedasticity Test Breusch-Pagan-Godfrey	1.032	0.7182
Ramsey RESET	0.872	0.0776
Breusch-Godfrey Serial Correlation LM Test	0.7944	0.0881
Lower bound poverty line		
Jarque-Bera test	0.1048	0.2188
Heteroscedasticity Test Breusch-Pagan-Godfrey	34.441	0.4163
Ramsey RESET	3.294	0,3886
Breusch-Godfrey Serial Correlation LM Test	2.600	0.2630
Upper bound poverty line		
Jarque-Bera test	5.5946*	0.0514
Heteroscedasticity Test Breusch-Pagan-Godfrey	0.5860	0.9414
Ramsey RESET	0.0070	0.9337
Breusch-Godfrey Serial Correlation LM Test	2.2436	0.3141

Note: *** imply 1%, ** 5%, and * 10% significant levels. The figures in brackets are standard errors.

systematic movement of the model's parameters within a 5% significance level. As it can be seen in the appendices, both the CUSUM and CUSUM square line fluctuates within the 5% significance band. This means that the estimated models do not suffer from instability in the parameters.

The following discussions focus on the multiplier graphs, in Fig. 1, for example, there are three lines (bold black line, black-broken line and red line) there are explained in the figure. However, the red line is called the asymmetric plot, and is the subject of the discussion in this section. Around the red line are the 5% upper and lower bounds from which the asymmetric plot is allowed to hover (indicated by smaller dotted red lines). The dependent variables (food poverty rate, lower-bound and upper-bound poverty) respond to shocks produced by explanatory variables as shown in the following graphs (unemployment and GDE). Fig. 1 depicts the asymmetric plot, which illustrates the strong influence that a negative shock has on food poverty, is far from zero, but tends to hover around negative values over time.

Fig. 2's asymmetric plot also starts out far from zero, but over time, it behaves similarly to the positive shock, demonstrating the positive shock's dominance in the long-term reduction of food insecurity. Similar to how the asymmetric plot centers on the negative numbers, this shows that economic development alone would not end hunger.

The lower limit measure of poverty in the following Fig. 3 shows how it moves together with the positive shock in the long-term, indicating that the shock is dominating. Nonetheless, the movement fluctuates around the negative levels, indicating that this level of poverty reduction is insufficient.

The line of asymmetry in Fig. 4 starts far from zero and moves closer to zero over time, indicating that neither a positive nor a negative shock will predominate in the short-term. Long-term results demonstrate that the positive shock—in this case, high unemployment—brings people closer to poverty.

According to Fig. 5 below, the expansion phase has a short-lived impact on poverty, but the negative shock predominates in the long-run after the first seven quarters. In the short-run, the asymmetric plot moves similarly to the positive shock.

According to Fig. 6 below, even when growth is less important in reducing poverty, it becomes more relevant in trapping more people in poverty during a recession. The positive-shock wins out in the short-run, and the negative shock wins out in the long-run.

7. Conclusion

Despite its significance and the respect, it enjoys in terms of economic progress, poverty has been a problem for the South African economy. This study has reviewed how unemployment and economic growth affect poverty. In order to analyse the direct and indirect

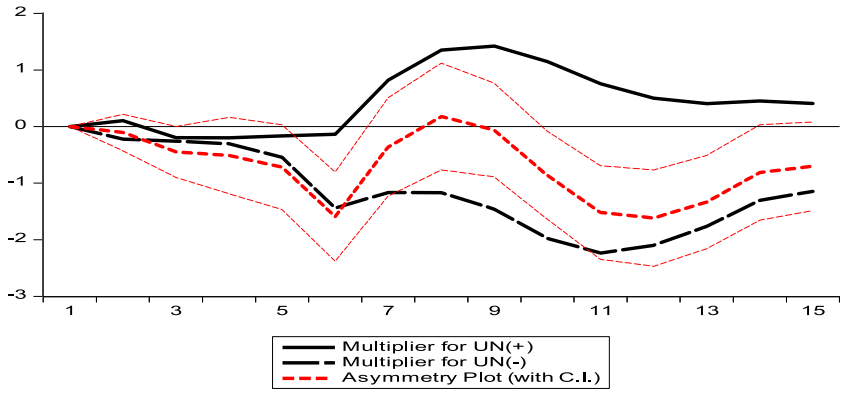

Fig. 1. Multiplier graph for food poverty rate.

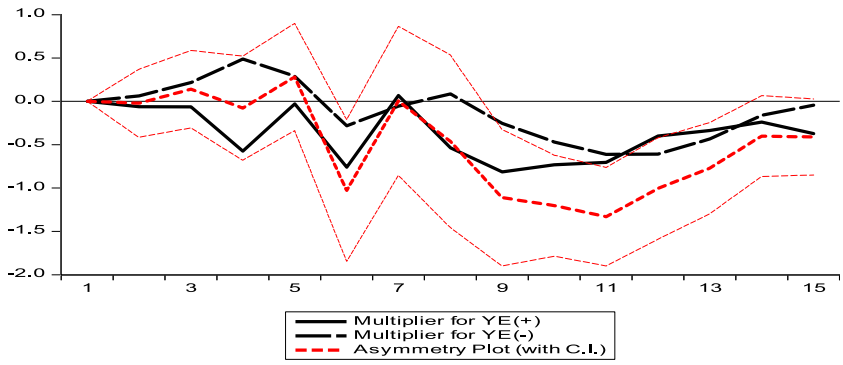

Fig. 2. Multiplier graph for food poverty rate.

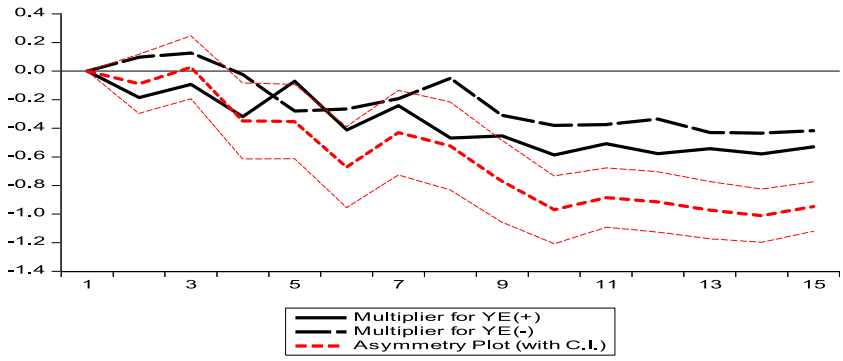

Fig. 3. Multiplier graph for lower bound poverty rate.

correlations between the variables, the study used both linear and non-linear approaches through the data stretching from 2000Q1 to 2021Q4. The explanatory factors of the non-linear model were divided into positive and negative shocks with regard to non-linear correlations. The findings of the bound test revealed that there is an existence of long-term relationship between unemployment, economic growth, and poverty in both linear and non-linear models. Unemployment (a positive shock) amplifies poverty in the long-run, while economic growth (a positive shock) reduces poverty in the long-run. In the light of the aforementioned findings, the asymmetric plots have indicated that economic growth alone is powerless to save people from poverty. To help urban and rural residents, especially women and children, escape poverty, the report advises policymakers to expand social investment. The lack of consensus in previous studies pertaining to the nature of the relationship between GDP, unemployment and poverty is indicative of the complexity of the issue of poverty in South Africa. As a result, it can be looked at from different perspectives. However, this study was limited to the effects of economic growth and unemployment. In this regard, future studies can look into the impact of corruption and education on poverty in more detail.

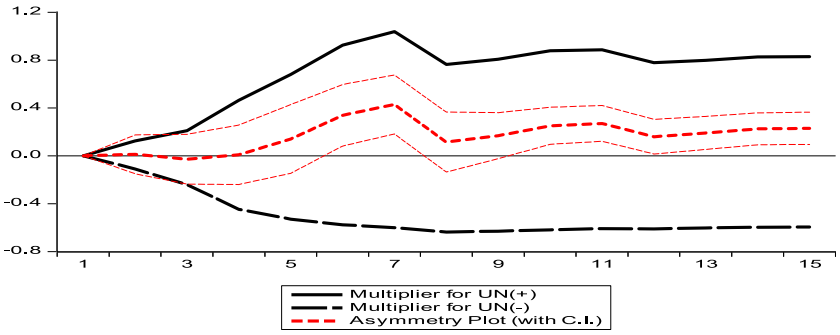

Fig. 4. Multiplier graph for lower bound poverty rate.

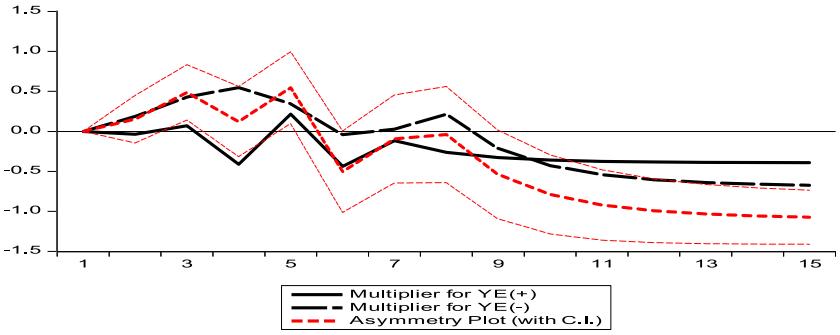

Fig. 5. Multiplier graph for upper bound poverty rate.

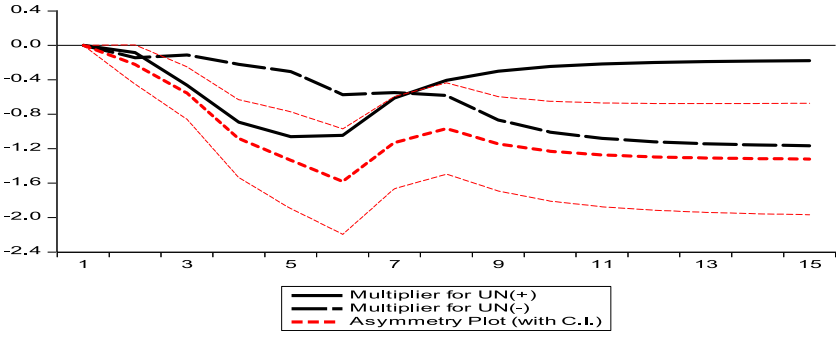

Fig. 6. Multiplier graph for upper bound poverty rate.

Author contributions

Mbongeni Ngubane: Wrote the paper, Conceived, and designed the experiments.
Siyabonga Mndebele: Analysed, interpreted data, and performed the experiments.
Irrshad Kaseeram: Contributed materials and analysis tools.

Data availability statement

Data are available on request through the authors' direct contacts, under some terms and conditions.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Mbongeni Ngubane reports financial support was provided by National Research Fund.

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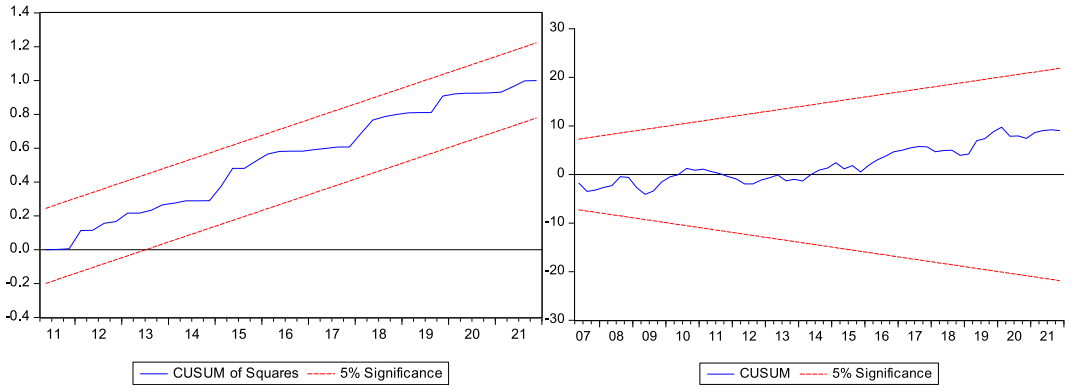
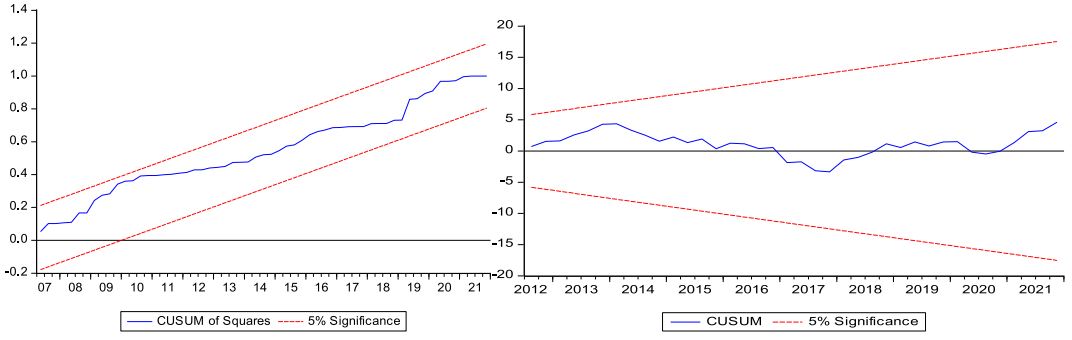
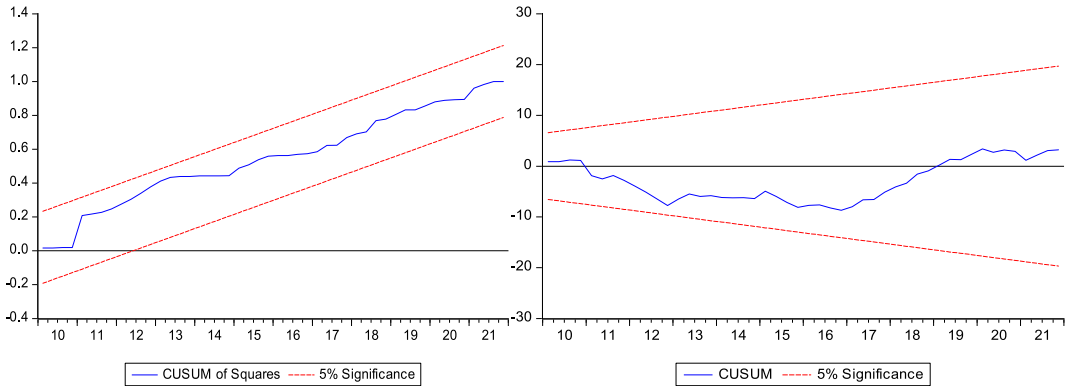
Appendix A1. ARDL model



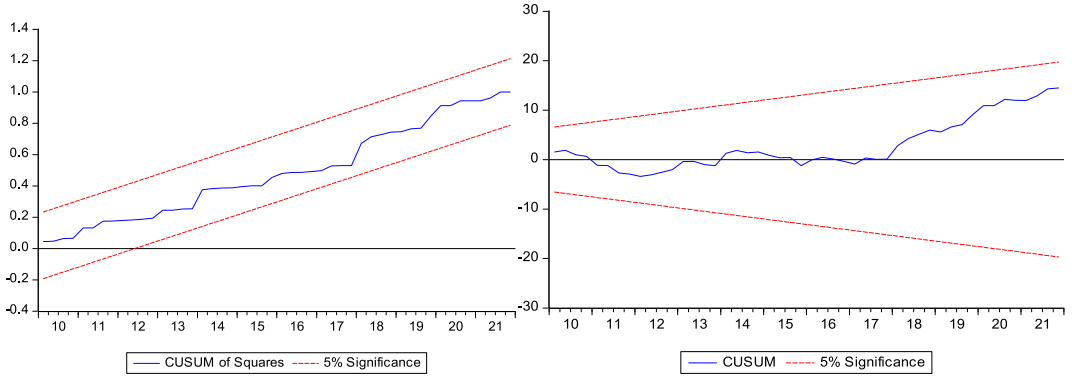
Appendix A2. FPL NARDL



Appendix A3. LBPL NARDL



Appendix A4. UBPL NARDL



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