

## Nonlinear Modelling of Economic Growth and Unemployment in South Africa

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**Abstract:** This study investigated the non-linear relationship between economic growth and unemployment in South Africa using quarterly data spanning from 1994Q1 to 2019Q4 with Okun's (1969) law serving as the foundation of the study. Prior studies conducted in South Africa using different methodologies have produced mixed results. Some studies have proven evidence of Okun's law, while others have not. Using the nonlinear autoregressive distributive lag approach proposed by Shin, Yu and Greenwood-Nimmo (2013), the findings suggest that although unemployment does not explain the changes in economic growth, it affects it positively. This implies that production due to capital intensive methods increases unemployment between 1 and 20 percentage points. However, in the short run, both positive unemployment and negative unemployment are negative and significant, suggesting that when unemployment decreases, economic growth increases. These key findings in the short run are consistent with Okun's law (1969). Therefore, the South African government and policymakers need to apply expansionary policies that will lead to the stimulation of higher and increased economic growth while reducing unemployment. It is evident that the use of capital-intensive methods in the long run results in jobless growth, but in the short run, job creation results in a decrease in unemployment and the economy produces at the level of full employment.

**Keywords:** Okun; capital; nonlinear distributive lag (NARDL); South Africa

**JEL Classifications:** B41; E22; E24

### 1. Introduction

The two vital macroeconomic variables that measure the success of a country's economy and are crucial for economic policy are economic growth and employment (Soylu *et al.*, 2018). Among the several economic challenges that face South Africa, the two that rank high are low economic growth and high unemployment. Since the transition of the economy in 1994, economic growth of South Africa has remained volatile, while the labour market continues to be

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challenged by high unemployment rates (Bhorat *et al.*, 2014). On annual terms, real GDP for the period 1994 was at 3.4 percent and in 2018 it was at 0.8 percent (World Bank, 2020).

According to Statistics South Africa (2020), the economy of South Africa recorded its first recession in 2008 Q4 to 2009 Q2 due to the global financial crises and the second recession took place from 2018 Q1 to 2018 Q2 and in 2019, the economy contracted by 0.2 percent. This has been the lowest economic growth since 2009 when the economy managed to grow by an estimate of 1.5 percent (StatsSA, 2020). The GDP growth rate of South Africa as stated in the National Development Plan (2030) needs to grow at a rate averaging over 5 percent. It may, however, be difficult to achieve this desired growth rate in the midst of persistent unemployment.

The official rate of unemployment increased from 17 percent in 1994 to 29 percent in 2019 (StatsSA, 2019). The expanded unemployment rate, which includes discouraged work-seekers, was at 38.7 percent in 2019 (Tradingeconomics, 2020). The greater impact has been on the youth of the country. According to the quarterly labour force survey (2019), the total number of unemployed youths aged between 15 and 34 constituted 63.4 percent in the first quarter of 2019. Evidence of the challenge of unemployment in South Africa is found among many school-leavers and graduates who cannot find employment (Banda *et al.*, 2016). This can be attributed to job creation (Meyer, 2014).

In 2010, the government introduced the new growth path (NGP) framework to be the driver of job creation and the driver of high economic growth in the country (Economic Development, 2011). The new growth path target is to reduce the official rate of unemployment from 25 percent to 14 percent in 2020 and to a further 6 percent by 2030 (NDP, 2030). However, South Africa's unemployment reached an astounding record of 29 percent in 2019Q4 (StatsSA, 2019). It is without a doubt that the economy is faced with an economic growth and an unemployment challenge that is daunting. A question to ask is, why are these two macroeconomic variables continuing to be problematic to solve post-apartheid era?

Nagel (2015) indicates that the traditional economic models that analyse the determinants of unemployment do not influence economic growth, while the models that analyse the factors that determine economic growth do not impact on unemployment. Another issue is that most studies investigate the connection between unemployment and economic growth by employing linear models and conclude that the relation is symmetric, while studies that have used asymmetric modelling confirm that asymmetry exists mainly in the long run between economic growth and unemployment.

Therefore, the objective of this study is to investigate the non-linear relationship between economic growth and unemployment in South Africa by employing the

nonlinear autoregressive distributive lag (NARDL) approach proposed by Shin, Yu and Greenwood-Nimmo (2013). The study is divided as follows: section 2 covers the theoretical literature while section 3 covers the empirical literature. Section 4 outlines the methodology, section 5 presents the results and section 6 concludes the study.

## 2. Theoretical Framework

Okun (1962) proposed an inverse relationship between unemployment and economic growth. Okun states that when economic growth increases, unemployment decreases. Equally so, when economic growth declines, then unemployment increases. However, if the growth gap where actual growth reaches potential economic growth is closed, then the economy grows, leaving unemployment unchanged. Okun's law is modelled in equation (1) below:

$$\Delta y_t = \beta_0 + \beta_1 \Delta un_t + \varepsilon_t \quad (1)$$

Where: actual and potential output is given as  $\Delta y_t = (y - y^*)$  and  $\Delta un_t = (un - un^*)$  is actual unemployment and full employment.

## 3. Empirical Literature

The relationship between economic growth and unemployment has received much attention in South Africa. Studies conducted by Marinkov and Geldenhuys (2007), Leshoro (2013), Phiri (2014), Banda and Choga (2015), Banda, Ngirande and Hogwe (2016), Mazorodze and Siddiq (2018) and Makaringe and Khobai (2018) have employed different methodologies and data to analyse Okun's law in South Africa. A brief review of these studies and the results found is provided in this study.

Marinkov and Geldenhuys (2007) applied detrending methods to evaluate Okun's law in South Africa from 1970 to 2005, and found evidence of both symmetry and asymmetry between output and unemployment. Marinkov and Geldenhuys (2007) concluded that economic growth should increase in South Africa to solve the unemployment problem. Leshoro (2013) used quarterly data from 2001 to 2012 to study the direction of causality between economic growth and employment in South Africa. The Toda Yamamoto causality test found evidence of causality from economic growth to employment, but no causality is found from employment to economic growth.

Phiri (2014) applied the momentum threshold autoregressive to model asymmetry in South Africa. The findings suggest that there is an inverse relationship between economic growth and unemployment consistent with Okun's law. Furthermore, the

test of causality reveals that, in the long run, there is a unidirectional relationship from unemployment to economic growth. Banda and Choga (2015), with the aid of quarterly data from 1994 to 2012, examined the impact of unemployment and economic growth in South Africa. The applied Johansen cointegration test findings suggest that unemployment and economic growth move together in the long run. Furthermore, the VECM results suggest that economic growth stimulates unemployment positively.

Banda *et al.* (2016) analysed the impact of economic growth and unemployment in South Africa covering the period 1994 to 2012. The long- and short-run results found provide evidence that when economic growth increases, unemployment increases. Mazorodze and Siddiq (2018) estimated the non-linear effects of the unemployment rate and cyclical output in South Africa. The results indicate that there is evidence of an asymmetric relationship in the long run, while, in the short run, there is a symmetric relationship. Makaringe and Khobai (2018) apply the autoregressive distributive lag test and the results confirm Okun's law of a negative relationship between economic growth and unemployment both in the short- and long run in South Africa.

## 4. Methodology

### 4.1. Model Specification and Data Source

The study adopts the theoretical model proposed by Okun (1962) and it is modified by including investment in equation (2) as follows:

$$y_t = \beta_0 + \beta_1 un_t + \beta_2 inv_t + \varepsilon_t \quad (2)$$

Where  $y_t$  represents the economic growth of South Africa,  $un_t$  is the unemployment rate,  $inv_t$  is the investment rate and the coefficients are represented by  $\beta_0$ ,  $\beta_1$  and  $\beta_2$ . Quarterly data covering the period 1994Q1 to 2019Q4 was taken from the South African Reserve Bank (SARB). The data series were taken in their natural logarithm form (in percentages). The data period was chosen based on data availability and to assist in analysing the behaviour of the macroeconomic variables since the economy transitioned in 1994.

### 4.2. Unit Root Test

To de-trend the variables of interest, the modified Dickey Fuller GLS test proposed by Elliot, Rothenberg and Stock (1996) is employed. The Dickey Fuller GLS test of stationarity has more powers than the ordinary ADF test (Shi, Li & Alexiadis, 2012). The Dickey Fuller GLS equation is stated below:

$$\Delta X_t^d = \phi X_t^d + \sum_{i=1}^p \varphi_i \Delta X_t^d + \mu_t \quad (3)$$

Here,  $\Delta X_t^d$  represents the detrended variable,  $\emptyset$  is the intercept of the DF-GLS test,  $X_t^d$  is the same as the ADF test and its critical values. The DF-GLS test, as an extension of the ADF test, employs the linear time trends in the data.

### 4.3. Nonlinear Asymmetric Modelling

To analyse the proposed empirical model, the equation estimated in (2) can be turned into a nonlinear long-run regression in equation (4) by transforming the independent variable to take the form  $(\beta^+ un_t^+)$ ,  $(\beta^- un_t^-)$  and  $(\beta^+ inv_t^+)$ ,  $(\beta^- inv_t^-)$ .

$$y_t = \beta^+ un_t^+ + \beta^- un_t^- + \beta^+ inv_t^+ + \beta^- inv_t^- + \varepsilon_t \quad (4)$$

To determine the nonlinear cointegration model of the study, equation (2) and (4) are combined to form equation (5).

$$y_t = \beta_0 + \beta_1 y_t + \beta_2^+ un_t^+ + \beta_3^- un_t^- + \beta_4^+ inv_t^+ + \beta_5^- inv_t^- + \varepsilon_t \quad (5)$$

In equation (5), the variables  $un_t$  and  $inv_t$  are decomposed into the partial sum of positive and negative changes of  $un_t$  (6) and  $inv_t$  (7) are captured in model (5).

$$un_t^+ = \sum_{k=1}^t \Delta un_k^+ = \sum_{k=1}^t \max(\Delta un_k, 0), un_t^- = \sum_{k=1}^t \Delta un_k^- = \sum_{k=1}^t \min(\Delta un_k, 0) \quad (6)$$

&

$$inv_t^+ = \sum_{k=1}^t \Delta inv_k^+ = \sum_{k=1}^t \max(\Delta inv_k, 0), inv_t^- = \sum_{k=1}^t \Delta inv_k^- = \sum_{k=1}^t \min(\Delta inv_k, 0) \quad (7)$$

Equation (8) indicates the asymmetric parameters in the long run.

$$\beta^+ = -\beta_1^+ / \beta_0, \beta^- = -\beta_1^- / \beta_0 \quad (8)$$

To estimate the unrestricted error correction model of the nonlinear ARDL form, equation (5) is transformed and this is indicated by equation (9):

$$y_t = \beta_0 + \beta_1 y_{t-1} + \partial^+ un_{t-1}^+ + \partial^- un_{t-1}^- + \partial^+ inv_{t-1}^+ + \partial^- inv_{t-1}^- + \sum_{k=1}^{p-1} \theta_k \Delta y_{t-k} + \sum_{k=0}^{q-1} (\pi_k^+ \Delta un_{t-j}^+ + \pi_k^- \Delta un_{t-j}^- + \pi_k^+ \Delta inv_{t-j}^+ + \pi_k^- \Delta inv_{t-j}^-) + \varepsilon_t \quad (9)$$

Here,  $\beta_0, \beta_1, \partial^+, \partial^-$  represent the long-run coefficients; the short-run coefficients are represented by  $\pi_k^+, \pi_k^-$  and the unrestricted error correction model is captured by  $(\pi_k^+ \Delta un_{t-j}^+ + \pi_k^- \Delta un_{t-j}^- + \pi_k^+ \Delta inv_{t-j}^+ + \pi_k^- \Delta inv_{t-j}^-)$ . The standard Wald test is used to estimate the long-run  $\partial^+ = \partial^- = 0$  and short-run coefficients  $\pi_k^+ = \pi_k^- = 0$ .

## 5. Analysis of Results

### 5.1. Unit Root Results

The Dickey Fuller GLS test results presented in Table 1 show that all the variables are stationary and are integrated of the same order  $I(1)$  at the 10 percent level of significance.

**Table 1. Dickey Fuller GLS results**

Variables	Constant	Constant + Trend
$\Delta$ GDP	-0.777456 (-1.614554)	-2.855918** (-2.743000)
$\Delta$ UN	-11.26503** (-1.614656)	-11.29218** (-2.738000)
$\Delta$ INV	-12.89124** (-1.614656)	-13.22144** (-2.738000)

*Note: Values in () indicate the \*\*10% level of significance critical value*

### 5.2. Non-linear Asymmetric Results

The results of the non-linear bounds test presented in Table 2 report that the F-statistic is 10.71306. This is above the  $I(1)$  of all indicated critical values (1%, 2.5%, 5% and 10%). Therefore, the study fails to reject the null hypothesis and concludes that the variables are cointegrated in the long run. Table 3 indicates the decomposed partial sum of positive and negative estimate changes of unemployment and investment in the long run.

**Table 2. Non-linear Bounds Results**

F-statistic: 10.71306		Critical values							
		1%		2.5%		5%		10%	
$k$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	
4	3.29	4.37	2.88	3.87	2.56	3.49	2.2	3.09	

The long-run estimates in Table 3 below show that positive unemployment and negative unemployment have a positive and insignificant relationship with economic growth. This indicates that economic growth increases by 20 percent when stimulated by a one percent increase in unemployment, while the negative unemployment indicates that a one percentage increase will stimulate economic growth by 1 percent. These findings suggest that, in the long run, economic growth increases due to investment in capital intensive methods, which leads to jobless growth.

**Table 3. Non-linear Long-Run Results**

Variable	Coefficient ( $\beta$ )	Standard error	t-Statistic	Probability
$un_t^+$	0.205682	0.148769	1.382565	0.1704
$un_t^-$	0.019352	0.135993	0.142304	0.8872
$inv_t^+$	-0.017700	0.045117	-0.392326	0.6958
$inv_t^-$	0.013982	0.039348	0.355346	0.7232

The asymmetry of positive investment and economic growth in Table 3 is found to be negative, suggesting that economic growth falls by one percent when there is a percentage change to positive investment. This reveals that, in the long run, real investment such as machinery depreciates due to wear and tear. Therefore, sufficient investment is needed to replace the depreciation hence a decline in growth is realised. On the other hand, the asymmetric relationship between negative investment and economic growth is positive and insignificant, indicating that a one percentage increase in negative investment will stimulate economic growth by 1 percent.

**Table 4. Non-linear Short-Run Results**

Variable	Coefficient ( $\beta$ )	Standard error	t-Statistic	Probability
$\Delta un_t^+$	-0.505900	0.213759	-2.366684	0.0202
$\Delta un_t^-$	-0.599102	0.267828	-2.236894	0.0279
$\Delta inv_t^-$	0.154680	0.026477	5.842031	0.0000
CointEq (-1)	-0.766963	0.092997	-8.247151	0.0000

The short-run results in Table 4 report that there is a negative and significant relationship between economic growth and the changes of positive and negative unemployment. The results are in line with Okun's (1969) law, which suggests that when unemployment decreases, economic growth increases. Furthermore, the results are in line with the findings of Marinkov and Geldenhuys (2007), Phiri (2014) and Makaringe and Khobai (2018). The coefficient of negative investment is positive and significant, implying that the increase in investment will stimulate the economy by 15 percent in the short run. The high speed of adjustment of 76 percent indicates that the short-run disequilibrium speedily corrects itself to equilibrium.

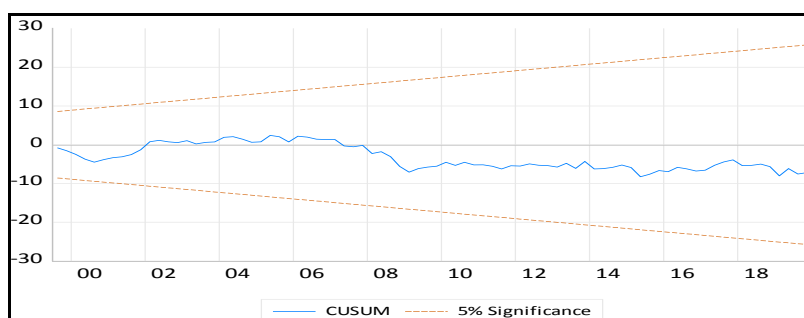
### 5.3 Diagnostics results

The diagnostic results in Table 5 show that the model specified for South Africa is adequately chosen. The study fails to reject the null hypothesis of the tests conducted and concludes that the model is well specified.

**Table 5. Residual and Stability Tests**

Test	Statistic	Prob	Null hypothesis ( $H_0$ )	Conclusion
Jarque-Bera normality test	0.34105	0.8432	Residuals are normally distributed	Accept $H_0$
Breusch-Godfrey serial correlation LM test:	0.03143	0.9691	No serial correlation	Accept $H_0$
Breusch-Pagan-Godfrey heteroscedasticity test	1.17096	0.3168	Homoscedasticity	Accept $H_0$
Ramsey RESET test	0.94595	0.3308	No omitted variable bias	Accept $H_0$

The CUSUM graph in Figure 1 shows that the parameters in the model are stable. This is because the CUSUM line lies within the 5 percent level of significance. This suggests that there is absence of instability for the period 1994 to 2019 in South Africa, because the coefficients are stable.

**Figure 1. CUSUM Graph**

## 6. Conclusion

This study investigated the non-linear modelling of economic growth and unemployment using quarterly data spanning from 1994Q1 to 2019Q4 in South Africa. Okun's (1969) law served as the foundation of the study. Using the NARDL approach proposed by Shin, Yu and Greenwood-Nimmo (2013), the findings suggest that there is a positive and insignificant relationship between economic growth and (positive and negative) unemployment. This implies that production with the aid of capital-intensive methods increases unemployment between 1 and 20 percent. However, in the short run, both positive unemployment and negative unemployment are negative and significant, suggesting that when unemployment decreases, economic growth increases. Therefore, in the short run, the South African policymakers should focus on job creation policies that will increase participation of individuals in the economy. The increase in absorption



will lead to the reduction of unemployment while stimulating economic growth. However, as the economy gradually investments in capital intensive methods unemployment will increase. As such, when they economy progresses individuals (both employed and unemployed) must further their technological skills so that in the long run they can adapt to the changes.

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