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ABSTRACT: Despite Okun's law being hailed one of the most fundamental pieces within macroeconomic policy paradigm, empirical evidence existing for the Kingdom of Swaziland remains virtually non-existent. Our study fills this void/hiatus in the literature by examining Okun's law for the Swazi Kingdom by using the nonlinear autoregressive distributive lag (N-ARDL) model applied to data collected over 1991 to 2017. To ensure robustness of our empirical analysis, we further apply the Corbae-Oularis (C-O) filter to extract the gap variables required for empirical estimates. Remarkably, we find strong evidence for nonlinear Okun's trade-off between unemployment and output growth in Swaziland with this trade-off being stronger during recessionary periods compared to expansionary periods. Much-needed policy enlightenment is drawn for Swazi authorities from our findings.

Keywords: Okun's law; Nonlinear autoregressive distributive lag (N-ARDL) model; Swaziland; Sub-Saharan African (SSA) country; Corbae-Oularis filter.

JEL Classification Code: C22; C32; E24; O40.

1 INTRODUCTION

Of recent, international bodies such as the International Monetary Fund (IMF) and the World Bank have taken a keen interest on the Kingdom of Swaziland which was recently struck with a severe fiscal crisis which bore a multitude of adverse economic repercussions on the economy. Indeed, the source of the budget crisis can be alluded to the infamous global financial crisis of 2007-2008 which sparked the global recession period of 2009 as well as the sovereign European debt crisis of 2010. In the face of a deteriorating global economy, trade activities within the Southern African Customs Union (SACU) region had drastically plummeted and the smaller SACU members like Swaziland and Lesotho were the most affected on account of their fiscal dependence on SACU revenues. The severity of these events is reflected in Swaziland's economic performance over the last decade, with economic growth deteriorating from 6% to 2% between 2006 and 2017 and unemployment rising from 22% to 26% within the same period. By simple arithmetic computation, this would imply a 4% reduction in GDP growth has been accompanied by a 4% increase in unemployment which can be further interpreted as a 1 for 1 trade-off between the two variables.

In our paper we examine whether the observed '1-for-1' negative relationship between economic growth and unemployment in Swaziland is incidental or coincidental. To this end we examine whether Okun's law holds for the Swazi Kingdom and in doing so, our study makes three noteworthy contributions to the empirical literature. Firstly, and as far as we are concerned, this becomes the only empirical study to investigate the validity of Okun's law for Swazi time series data. Secondly, and to the best of our knowledge, our study is the first in the general empirical literature to use the nonlinear autoregressive distributive lag (N-ARDL) model recently introduced by Shin et al. (2014) to estimate the long-run and short-run cointegration relations between unemployment and economic growth. As will be observed in the literature review presented in the following section, the literature has been more recently inclined towards the possibility of a nonlinear Okun's relationship on the basis of reasonably sound theoretical arguments. The perceived nonlinear dynamics within Okuns law provide our justification for relying on a nonlinear cointegration framework. Lastly, and as best as we know, this study will be the first to use the Corbae and Oularis (2006) filter to extract the ‘gap’ variables required for estimation purposes. This filter is favoured on the premise/grounds of producing superior extracting properties of cycles and trends within time series variables in comparison to other traditional filters.

Against this backdrop, we structure the rest of our paper as follows. The following section presents a brief review of the associated literature. Section 3 of the paper outlines the empirical framework whereas the data and the empirical analysis are presented in section 4 of the paper. The study is concluded in section 5.

2 LITERATURE REVIEW

In a Cowles foundation paper presented in 1962, Okun (1962) demonstrated on how unemployment in the United States, between the period of 1947 and 1960, tended to fall by a one percentage point for every 3 percentage point rise in economic growth. This inverse relationship between unemployment and economic growth has been more popularly branded as the Okun’s law and has been perceived as an important link between labour markets and the product market. Excellent reviews of the flurry of empirical works providing empirical support for a Okun’s law is provided in the contributions of Siyal et al. (2013) and Phiri (2015). More recently there has emerged a handful of academics who have contended that linear Okun’s specification is inconsistent with basic Keynesian principles in which variations in unemployment and output differ depending on whether the economy is in the upswing or downswing of the business cycle. The resulting speculation of a nonlinear Okun’s law is further grounded on three main arguments. Firstly, a nonlinear Okun’s specification is highly consistent with the notion of a nonlinear Phillips curve in which the ‘sacrifice ratios’ differ during different phases of the business cycle. Secondly, the nonlinear Okun’s specification is further important for the recently advocated asymmetric monetary policy rules in which infer that linear based policy rules produce misleading signals concerning the appropriate policy stance (Shaling, 2004). Lastly, a nonlinear Okun’s specification is considered flexible enough to capture output costs that that are cyclically sensitive yet precise enough to use in complex structural macroeconomic models (Filardo, 1998).

From a theoretical perspective, the nonlinear dynamics between unemployment and economic growth can be traced to seminal work of Palley (1993) and further expounded upon in the works of Campbell and Fischer (2000) and Lang and De Peretti (2009). The general theoretical underpinnings insinuate that certain micro-foundations, such as contracts, existing within by heterogeneous firms aggravate asymmetric adjustments in the cycles of job creation and job destruction. More recently, an increasing number of empirical academics have taken advantage of developments in econometric cointegration modelling techniques to validate nonlinear Okun dynamics within the time series data (Lee (2000), Viren (2001) and Harris and Silverstone (2001) for OECD countries, Crespo-Cauresma (2003) and Holmes and Silverstone (2008) for the US, Phiri (2014) for South Africa). We make note that a majority of these nonlinear studies rely on the momentum threshold autoregressive (MTAR) model of Enders and Granger (1998) and Enders and Siklos (2001). Whilst MTAR nonlinearity is established in the cointegration error of the regression, the model retains linearity in the long-run regression parameter estimates. As mentioned in the introduction, our study makes use of the N-ARDL model of Shin et al. (2014) which is nonlinear in both the short-run and long-run parameters. We outline the empirical dynamics of the nonlinear Okun's specification in the following section of the paper.

3 EMPIRICAL FRAMEWORK

In exploring Okun's law for the Kingdom of Swaziland we implement the following 'gap' specification:

$$(U - U^T) = \alpha + \beta(Y - Y^T) + e_t \qquad (1)$$

Where U is the unemployment rate, Y is the GDP growth rate, U^T is the trend component of unemployment, Y^T is trend component of output growth, α is the regression intercept, β is the Okun's coefficient which is presupposed to be negative and significant and e_t is the regression term with properties $e_t \sim N(0, \sigma^2)$. A contentious issue in the literature concerns the measure of potential unemployment and output, (i.e. $(U - U^T)$ and $(Y - Y^T)$, which are unobservable and must be extracted from the actual unemployment and output growth time series. Popular choices from the previous literature for from extracting these unobservable variables are the H-P and B-K filters. As mentioned in the introduction section, our study makes use of the Corbae and Oularis (2006) filter which yields superior filtering properties in comparison to other traditional filters found in the literature. The authors particular assume that a series, which is an I(1), has a first difference Wold representation with a spectral density $f_w(\vartheta) > 0$. In applying this to our unemployment and outgrowth series their Fourier transformations are given as:

$$w_{\vartheta}(X) = (1 - e^{\vartheta})^{-1} w_v(\vartheta) - e^{\vartheta}(1 - e^{\vartheta})^{-1} \frac{U_n - U_o}{\sqrt{n}} \quad (2)$$

$$w_{\vartheta}(X) = (1 - e^{\vartheta})^{-1} w_v(\vartheta) - e^{\vartheta}(1 - e^{\vartheta})^{-1} \frac{Y_n - Y_o}{\sqrt{n}} \quad (3)$$

Where $\vartheta = 2\pi s/n$, for s= 0,1,…, n-1 frequency components and an imposed restriction of $(U_n - U_1) = (U_n - U_0)$ and $(Y_n - Y_1) = (Y_n - Y_0)$, respectively.

In estimating regression (1), we firstly specify the Okun's regression as the following autoregressive distributive lag (ARDL) model specification:

$$\Delta(U - U^T)_t = \alpha_0 + \sum_{j=1}^{n} \alpha_1 \Delta(U - U^T)_{t-j} + \sum_{j=1}^{n} \alpha_{12} \Delta(Y - Y^T)_{t-j} + \beta_1 (U - U^T)_{t-1} + \beta_2 (Y - Y^T)_{t-1} + e_t \quad (4)$$

And by decomposing $(Y - Y^T)$ into its positive and negative partial sum processes results in the following N-ARDL model specifications:

$$\Delta(U-U^T)_t = \sum_{j=1}^{p}\psi_i(U-U^T)_{t-j} + \sum_{j=1}^{p}\left(\Phi_j^+(Y-Y^T)_{t-j}^+ + \Phi_j^-(Y-Y^T)_{t-j}^-\right) + \zeta_t \quad (5)$$

Where $(Y-Y^T)_t^+ = \sum_{j=1}^{i}\Delta(Y-Y^T)_j^+ = \sum_{j=1}^{i}\max(\Delta(Y-Y^T)_{,j}, 0)$ and $(Y-Y^T)_t^- = \sum_{j=1}^{i}\Delta(Y-Y^T)_j^- = \sum_{j=1}^{i}\min(\Delta(Y-Y^T)_j, 0)$. In continuing with our modelling process, the associated error correction representation can be denoted as:

$$\Delta(U-U^T)_t = \sum_{j=1}^{p}\rho_i(U-U^T)_{t-j} + \Phi_j^+(Y-Y^T)_{t-j}^+ + \Phi_j^-(Y-Y^T)_{t-j}^- + \sum_{j=1}^{p-1}\lambda_i\Delta(U-U^T)_{t-j} + \sum_{j=0}^{q-1}(\alpha_j^+\Delta(Y-Y^T)_{t-j}^+ + \alpha_j^-\Delta(Y-Y^T)_{t-j}^-) + \lambda ECT_{t-1} + \zeta_t \quad (6)$$

Where ECT_{t-1} is the error correction term. The traverse between short-run disequilibrium and the new long-run steady state of the system can be estimated through the following cumulative dynamic multipliers:

$$M_h^+ = \sum_{j=0}^{n}\frac{\partial y_{t+j}}{\partial x_i^+},\ M_h^- = \sum_{j=0}^{n}\frac{\partial y_{t+j}}{\partial x_i^-}, \qquad h = 0, 1, 2 \ldots. \quad (7)$$

Where M_h^+ and $M_h^+ \rightarrow \beta^+$ and β^-, respectively as $h\rightarrow\infty$, such that the long-run regression coefficients are computed as $\beta^+ = -(\Phi^+/\rho)$ and $\beta^- = -(\Phi^-/\rho)$. To validate N-ARDL cointegration effects Shin et al. (2014) propose the testing of three empirical hypotheses. The first hypothesis tests for asymmetric N-ARDL effects using the following null hypothesis, H_{00}: $\rho = \Phi^+ = \Phi^-$. The second hypothesis tested is that for no long-run asymmetric effects i.e. H_{01}: $\beta^- = \beta^+$. The third null hypothesis tested concerns no short-run asymmetries i.e. H_{02}: $\sum_{i=0}^{q-1}\alpha_j^+ = \sum_{i=0}^{q-1}\alpha_j^-$. Note that the first hypothesis is an extension of the non-standard bounds based F-test of Pesaran et al. (2001) whilst the the latter two null hypotheses of 'no long-run' and 'no short-run' asymmetric effects can be evaluated by relying on standard Wald tests.

4 DATA AND EMPIRICAL RESULTS

4.1 Data presentation/overview

Our empirical data is sourced from the World Bank online statistical database and consists of two empirical time series variables, namely, GDP growth (i.e. Y_t) and the unemployment as a percentage of total labour force (i.e. U_t). Our times series covers a period of 1991 to 2017 and our data is collected on an annual basis. From these time series we use the C-O filter to extract the gap variables $(U - U^T)$ and $(Y - Y^T)$ which we use for empirical analysis. Table 1 presents the basic descriptive statistics and the correlation matrix for the gap variables.

Table 1: Basic descriptive statistics and correlation matrix

Panel A: Descriptive statistics	$(U - U^T)$	$(Y - Y^T)$
Mean	-6.84E-16	-3.78E-16
Median	-0.068863	0.130603
Maximum	2.723538	1.925418
Minimum	-2.274175	-1.897172
Std. dev.	1.335438	1.088551
Skewness	0.311314	-0.035837
Kurtosis	2.652195	2.093512
Jarque-Bera	0.572213	0.930215
Probability	0.751183	0.628068
observations	27	27
Panel B: Correlation matrix		
$(U - U^T)$	1.00	-0.288363
$(Y - Y^T)$	-0.288363	1.00

Notes: Authors own computation on Eviews 10.

4.2 Unit root tests

One of the primary advantages of the ARDL/N-ARDL models is that unlike other cointegration frameworks like the Engle-Granger two-step procedure and the vector error correction (VECM) techniques, the time series are not required to be integrated of similar order for cointegration to occur. On condition that none the series are integrated of order I(2) or higher, the ARDL/N-ARDL models is compatible with a combination of I(0) and I(1) series. To ensure continuity in our argument of nonlinearity in cointegration effects, we compliment this framework by employing the ESTAR unit root testing procedure of Kapetanois et al. (2003) (hereafter KSS) to make certain that none of our time series is integrated of order I(2) or higher. KSS particularly propose the following exponential smooth transition autoregressive (ESTAR) the data generating process for a series, X_t:

$$\Delta X_t = \phi_i X_{t-1} + \gamma_i X_{t-1}[1 - \exp(-\theta X_{t-d}^2)] + e_t \tag{8}$$

Where $e_t \sim iid(0, \sigma^2)$ and θ is a smoothness parameter. KSS further assume (2003) that $\phi_i = 0$ and d=1 i.e.

$$\Delta X_t = \gamma_i X_{t-1}[1 - \exp(-\theta X_{t-1}^2)] + e_t \tag{9}$$

Since testing for a unit root is not directly feasible due to nuisance parameters under the unit root null hypothesis (i.e. $\theta_i = 0$), we apply a first-order approximation around $\theta_i = 0$ and obtain the following auxiliary regression:

$$\Delta X_t = \delta_i X_{t-i}^3 + \sum_{j=1}^{p} \rho_i \Delta X_{t-i} + e_t \tag{10}$$

Where the null hypothesis of a linear unit root process can be now tested as H_0: $\delta_i = 0$ against the alternative of stationary ESTAR process (i.e. H_1: $\delta_i = 0$) and the asymptotic critical value of the Kapetanios et al. (2003) unit root test is computed as:

$$t_{NL} = \frac{\hat{\delta}}{S.E.(\hat{\delta})} \tag{11}$$

Where $\hat{\delta}$ is the estimated value of δ and S.E.($\hat{\delta}$) is the standard error of $\hat{\delta}$. Since the t_{NL} statistic does not follow an asymptotic standard normal distribution, KSS derive critical values for the test statistics performed on raw time series, de-meaned data (i.e. $x_t = y_t - \bar{y}_t$) and de-trended data (i.e. $z_t = y_t - \widehat{\mu} - \widehat{\delta t}$) where $\bar{y}_t$ is the sample mean and $\widehat{\mu}$ and $\widehat{\delta t}$ are the OLS estimates of μ and δ, respectively. The results for the KSS unit root test are reported in Table 1 and all reported KSS test statistics exceed their 1% critical values except for the de-trended series of both ($U - U^T$) and ($Y - Y^T$) variables when the test is performed on their levels. Nonetheless, these results are collectively favourable for analytical use.

Table 2: KSS unit root test results

Series	Raw	De-meaned	De-trended
Panel A: Levels			
($U - U^T$)	-6.145942***	-6.145942***	-2.010862
	[1]	[1]	[1]
($Y - Y^T$)	-4.340919***	-4.340919***	-2.863638
	[1]	[1]	[1]
Panel B: First differences			
($U - U^T$)	-6.480010***	-6.480010***	-4.152667***
	[1]	[1]	[1]
($Y - Y^T$)	-8.196387***	-8.196387***	6.299008***
	[1]	[1]	[1]

Notes: "***", "**", "*" denote 1%, 5% and 10% significance levels, respectively. Critical values are derived from KSS for the raw series -2.82(1%), -2.22 (5%), -1.92(10%), for the de-meaned series -3.48(1%), -2.93(5%), -2.66(10%), for the de-trended series -3.93(1%), -3.40(5%), -3.13(10%). Optimal lags length as determined by the Schwarz criterion reported in [].

4.3 Empirical estimates/analysis

Before presenting our main N-ARDL estimates, we first estimate a conventional ARDL (p,q) with the results reported in Table 3. To determine the optimal lag length of the regression we set the maximum lags of p=4 and q=4 on the ARDL regression and by decreasing the number of lags sequentially on both p and q, we choose the regression which produces the lowest Schwarz criterion (SC) value, which in our case amounts to an ARDL(1,1) specification.

Panel A of Table 3 presents the long-run ARDL(1,1) coefficient estimates and as can be witnessed the $(Y - Y^T)$ coefficient produces a correct negative estimate of -0.38 yet is statically insignificant. Nevertheless, the short-run estimates presented in Panel B of Table 3, our results encouragingly produce coefficients which are statistical significant at all critical levels hence providing evidence of potential short-run effects. However, we are quick to note that the signs on the short-run coefficient estimates are mixed with the $\Delta(Y - Y^T)$ coefficient producing a negative estimate whilst the $\Delta(Y - Y^T)_{t-1}$ coefficient produces a positive coefficient. So even though the error correction term (ECT_{t-1}) produces a correct negative and statistically significant estimate of -0.20, these findings are futile in the absence of long-run effects and mixed short-run dynamics.

Table 3: ARDL(1,1) regression estimates

variable	coefficient	Std. error	t-statistic	Prob
Panel A: Long-run estimates				
C	-0.031015	0.132635	-0.233835	0.8176
$(Y - Y^T)$	-0.382557	0.267720	-1.428941	0.1693
Panel B: Short-run estimates				
$\Delta(U - U^T)$	0.991032	0.042114	23.532210	0.0000***
$\Delta (Y - Y^T)$	-0.615099	0.152064	-4.045008	0.0007***
$\Delta (Y - Y^T)_{t-1}$	0.467925	0.147952	3.162673	0.0051***
ECT_{t-1}	-0.199292	0.014209	-14.025588	0.0000***

Notes: "***", "**", "*" denote 1%, 5% and 10% significance levels, respectively.

In turning to our N-ARDL estimates, we similarly find that the optimal lag length as selected by the minimization of the SC information criterion points to a N-ARDL (1,1,1) model. However, the N-ARDL(1,1,1) estimates which are presented in Table 4, these results clearly paint a different picture compared to those obtained from the linear ARDL estimates. Judging on the long-run estimates reported in Panel A, one can notice how the long-run estimates produce highly significant values after accounting for asymmetries in the cointegration framework. The $(Y-Y^T)_t^-$ estimate of -0.57 implies a percentage increase in the output gap decreases the unemployment gap by 0.57 percent. Conversely, the $(Y-Y^T)_t^+$ estimate of -0.77 implies that a percentage increase in the output gap decreases the unemployment gap by 0.77 percent. On the other hand, the results obtained of the short-run Okun's estimates are mixed with the $\Delta(Y-Y^T)_{t-1}^+$ and $\Delta(Y-Y^T)_{t-1}^-$ coefficients producing a positive and statistically significant estimates whereas the $\Delta(Y-Y^T)_t^+$ and $\Delta(Y-Y^T)_t^-$ coefficients produces a significantly negative estimates. Collectively, these results imply different Okun's trade-off during various phase of the business cycle, with the trade-off being more prominent during recessionary phases and less so during expansionary phase

Table 4: N-ARDL(1,1,1) regression estimates

variable	coefficient	Std. error	t-statistic	Prob
Panel A: Long-run estimates				
C	0.353417	0.191132	1.849076	0.0843*
$(Y-Y^T)_t^+$	-0.570495	0.090018	-6.337592	0.0000***
$(Y-Y^T)_t^-$	-0.770009	0.093371	-8.246773	0.0000***
Panel B: Short-run estimates				
$\Delta(U-U^T)_{t-1}$	1.042078	0.014360	72.565858	0.0000***
$\Delta(Y-Y^T)_t^+$	-0.723521	0.039594	-18.273655	0.0000***
$\Delta(Y-Y^T)_{t-1}^+$	0.646555	0.045429	14.232225	0.0000***
$\Delta(Y-Y^T)_t^-$	-0.763550	0.040902	-18.667772	0.0000***
$\Delta(Y-Y^T)_{t-1}^-$	0.672683	0.049399	13.617298	0.0000***
ECT_{t-1}	-0.203032	0.002816	-72.094284	0.0000***

Notes: "***", "**", "*" denote 1%, 5% and 10% significance levels, respectively.

4.4 Model evaluation

In order to evaluate the reliability of our estimated ARDL and N-ARDL models, we present three pairs of diagnostic tests which are summarized in Table 5. Firstly, as found in Panel A, we report the linear and nonlinear bounds testing procedures for linear and nonlinear

ARDL effects and our produced F-statistics exceed their respective 1 percent critical values. Secondly, we report our test result for the residual diagnostics in Panel B of Table 5 and these test for normality, serial correlation, heteroscedasticity and functional form all indicate that both estimated regressions conform to the classical 'well-behaved' regression assumptions. We finally summarize the findings from the CUSM and CUSUM squares plots in Panel C of Table 5 of which we find that both ARDL and N-ARDL estimated regressions are stable within their 5 percent critical bounds.

Table 5: Model evaluation diagnostics

	ARDL specification	N-ARDL specification
Panel A: Cointegration tests		
Bounds test	119.5703***	1718.137***
Long-run asymmetries		78.137***
Short-run asymmetries		18.137***
Panel B: Diagnostic tests		
J-B	1.409817 (0.494154)	0.071557 (0.964854)
SC	1.78975 (0.265687)	2.855190 (0.1132)
Heter.	1.889278 (0.1478)	0.360301 (0.5548)
RESET	1.613362 (0.1241)	0.501817 (0.6236)
Panel C: Stability analysis		
CUSUM	Stable	Stable
CUSUMSQ	Stable	Stable

Notes: “***”, “**”, “*” denote 1%, 5% and 10% significance levels, respectively. p-values reported in parentheses ().

5 CONCLUSION

Against a backdrop if a deteriorating World economy caused by the global financial crisis and the global recession period, our study sought to investigate whether simultaneous increase in unemployment and decrease in economic growth observed for the Swazi economy are coincidental or incidental. To achieve this feat we investigate whether Okun’s law holds for Swazi data over a period of 1991 to 2017 using the recently introduced N-ARDL cointegration model of Shin et al. (2014). We also make use of the Corbae-Oularis filter to extract the gap variables required for estimation purposes. The prime novelty of our study is thus threefold in being the first to estimate Okun's relationship for Swaziland and in also being the first to estimate Okun’s law using the more favourable N-ARDL technique as well as being the first to use the powerful C-O filter to extract the gap variables.

Our empirical results are encouraging in the sense that Okun’s law is validated over the long-run for the N-ARDL model whereas no such effects are present when estimated with a linear ARDL specification. The results particularly indicate that Okun’s trade-off is more prominent during recessionary periods whilst during expansionary periods the trade-off is not as strong. In turn, this implies that the Swazi economy is very vulnerable towards a combination of high unemployment and low growth during recessionary cycles whilst during expansionary cycle improved growth is not so inclusive as to offset high unemployment rates. Henceforth Swazi policymakers should be concerned with implementing structural reforms aimed at strengthening the link between product and labour markets which would assist in boosting employment during upswings of the business cycle and preventing increased unemployment during downswings of the cycle. The nucleus of these reforms should be centred on the development of the private sector as a means of addressing the skills mismatch in labour markets as well as reducing fiscal dependence on SACU trade activities as a major source of government revenues.

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