A provincial perspective of nonlinear Okun's law for emerging markets: The case of South Africa

Kavese, Kambale and Phiri, Andrew

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A PROVINCIAL PERPSECTIVE OF NONLINEAR OKUN'S LAW FOR EMERGING MARKETS: THE CASE OF SOUTH AFRICA

Kambale Kavese
Eastern Cape Socio Economic Consultation Council,
East London, South Africa, 5217

And

Andrew Phiri
Department of Economics, Faculty of Business and Economic Studies, Nelson Mandela University, Port Elizabeth, South Africa, 6031.

ABSTRACT: A provincial analysis of Okun's law in South Africa is provided in this article over a period of 1996 to 2016. Empirically, we rely on the nonlinear autoregressive distributive lag (N-ARDL) model whilst the Corbae-Ouliaris filter is used to extract the 'gap' variables required for our regression estimates. Okun's law is found to be significant hold in the long-run exclusively for the Western Cape and Kwa-Zulu Natal provinces whereas the remaining provinces partially display significant short-run effects. Our sensitivity analysis in which panel N-ARDL estimations for all provinces finds insignificant long-run Okun effects for the country as a whole, whilst validating the relationship only in the short-run. Our study hence implies that/advices that the epicentre of policy efforts in addressing the country's high unemployment and low economic growth dilemma should be concentrated at a provincial level.

Keywords: Economic growth; unemployment; Okun's law; Provincial analysis; nonlinear ARDL model; Corbae-Ouliaris filter; South Africa; Emerging economies.

JEL Classification Code: C13; C32; H61; H72.

1 INTRODUCTION

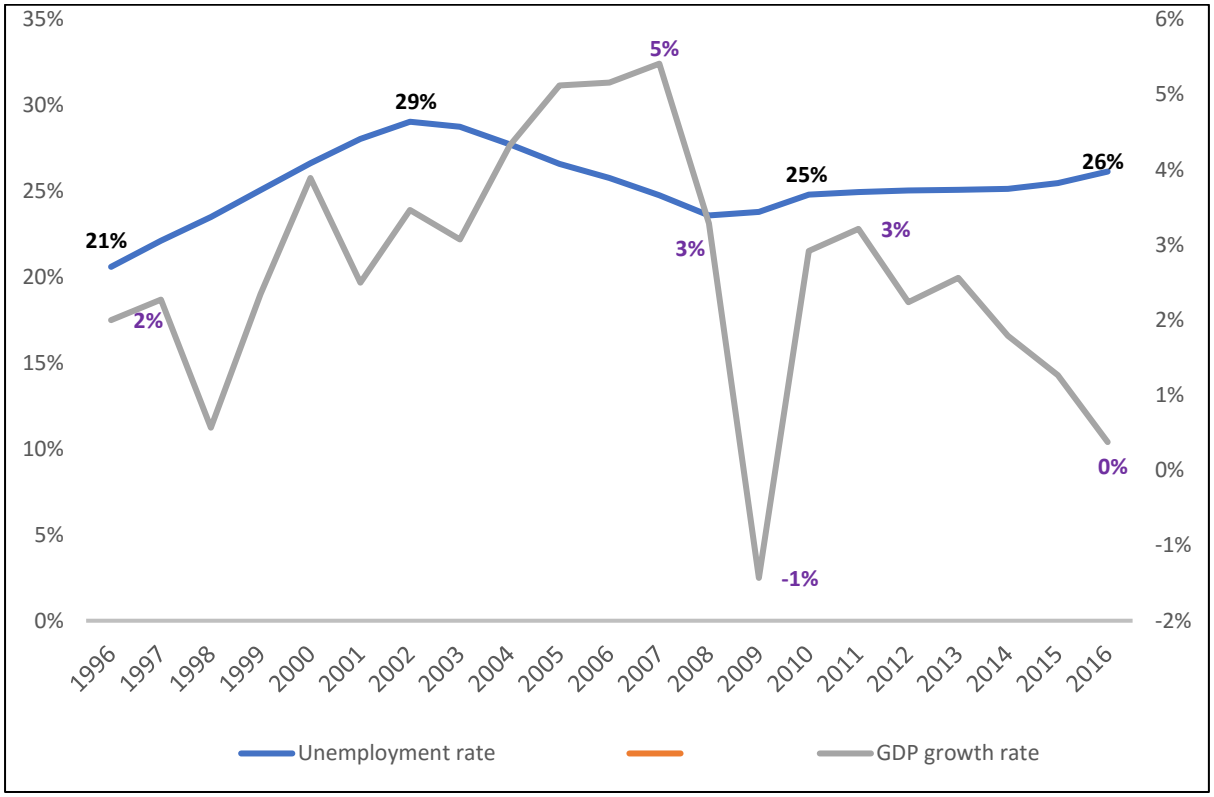
According to the International Labour Organization (ILO, 2016), the current unemployment rate in South Africa stands at 26 percent, which is a figure more than four-fold higher than the global average of 6 percent. For this reason South African policymakers have prioritized the mandate of job creation through strategic fiscal spending and investment. On a philosophical forefront, Okun's law could be used as a yardstick in informing policymakers of how much economic unemployment can be gained or lost when economic is below or above its natural rate. However, it is not very clear whether the persisting low growth path and chronic high unemployment in South Africa are being affected by Okun's law or whether this occurrence is purely coincidental? This question remains pertinent today as measures to boost growth and reduce unemployment in the country continue to be futile.

Over the past two decades or so, South Africa's government has developed five strategic policy programs, namely, the Reconstruction and Development Program (RDP) in 1994; the Growth, Employment and Redistribution strategy (GEAR) in 1998; the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) in 2004, the New Growth Path (NGP) in 2010 and most recently, the National Development Plan (NDP) in 2014. These five strategies have had one objective in common, to stimulate economic growth, reduce the continuing challenge of poverty and unemployment. For example, the most recent NDP strategy envisaged to create 11 million jobs by 2030 and to reduce the unemployment rate from 25% in 2010 to 6% in 2030. The outcome of effort made for the past two decades reveal that, despite the implementation of the above five policies, the desired growth target of 6% and the unemployment rate below 20% were never achieved.

The historical evolution between unemployment and economic growth in South Africa in the post-Apartheid period of 1994 to 2016 is depicted in Figure 1. As can be observed the time series plot is marked by three distinct eras. During the first era (1994 to 2003), both unemployment and GDP variables rose. Unemployment rate increased by eight percentage points from 21% to 29% between 1994 and 2003 and GDP rose by one percentage point from

2% to 3% over the same period. During the second era (2003–2008), unemployment declined but GDP rose. Unemployment declined by four percentage points from 29% to 25% between 2003 and 2008 while over the same time frame, GDP rose by two percentage point, reaching its highest level of 5% in 2008. During the third era, which corresponds to the post-recession era of 2010 to 2016, unemployment rose but GDP declined. Unemployment increased by one percentage point but GDP decline by three percentage points. Such inconsistency in the relationship between unemployment and GDP makes Okun's law questionable for South Africa in the post-Apartheid era.

Figure 1: Unemployment rate and economic growth in South Africa (1996 – 2016)



Source: Statistics South Africa (2017)

Our study argues that the problems observed so far do not end here. In particular, the aggregation of the unemployment and economic growth rates at national level consequentially neglects provincial specifics. In considering South Africa's high level of inequality amongst various provinces, the omission of regional variances could lead to inappropriate policy interventions. Our study measure Okun's coefficient at provincial level for South Africa using

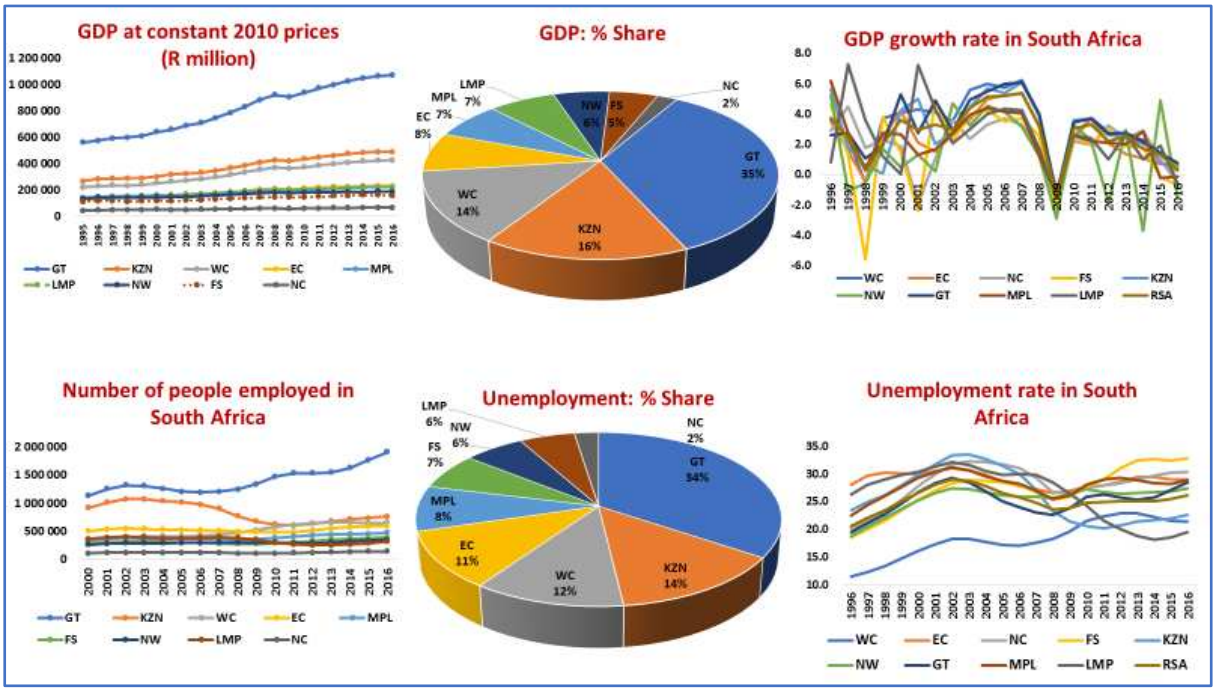
annual data collected over the post-Apartheid period of 1996 to 2016. To the best of our knowledge, our study is the very first study to take this empirical approach and in doing so, our empirical analysis could be used to inform provincial governments in their development aspirations. In realizing the short time span of the available empirical data, we employ the recently developed nonlinear autoregressive distributive lag (N-ARDL) model of Shin et al. (2014), which produces strong asymptotic properties even with a relatively small sample size. In also differing from other cointegration models found in the literature, the framework permits the modelling of nonlinear long-run and short-run cointegration relations amongst a combination of I(0) and I(1) time series variables. This is important for our study since the different series for different provinces possibly have differing integration properties.

Having provided background to our study we organize the rest of the paper as follows. The next section presents the evolution of output and unemployment for the different South African provinces. The third section presents a review of the related literature whereas our empirical methodology is outlined in the fourth section of the paper. The presentation of the data and the general empirical analysis is conducted in section five and conclusions are drawn in the sixth section.

2 HISTORIC AND CURRENT TRENDS IN SOUTH AFRICAN GDP AND UNEMPLOYMENT AT PROVINCIAL LEVEL

The South African economy comprises of 9 provinces which in descending order from the largest to the smallest in terms of geographical size are the Northern Cape (NC), Eastern Cape (EC), Free State (FS), Western Cape (WC), Limpopo (LIM), North West (NW), Mpumalanga, KwaZulu Natal (KZN) and Gauteng (GP). Nonetheless the most populous provinces are the smaller Gauteng and KZN provinces which account for approximately 40% of the total population followed by the Eastern Cape, Western Cape, Limpopo, Mpumalanga, North West, Free State and the Northern Cape (StatsSA, 2017). The size, distribution and historical trends for unemployment and GDP for all nine provinces in South Africa are shown in Figure 1 below for the period 1996 to 2016.

Figure 1: Performance, development and trends in South Africa's GDP and unemployment (1995-2016)



Source: Statistics South Africa, 2017

With regards to economic growth trends, soon after the democratic election in 1994 and the launch of the RDP and GEAR policies, economic growth in all South African provinces declined in 1998, mainly due to Asian crisis with the Free State being the province most affected by this crisis. While a mixed recovery occurred in most provinces until 2001, due to episodes of drought and the severe oil price hikes experienced in 2002/2003, the GDP dropped for a while in most provinces. Nevertheless, this was followed by a prosperous period of high growth until 2007 mainly due to a strong global economy and favourable Southern African Customs Union (SACU) trade activity. As the recession kicked in, economic activities and GDP declined sharply in all South African provinces reaching a bottom in 2009, especially in the North West and Northern Cape provinces, and thereafter economic growth slowly recovered in 2010 in all provinces. To accelerate economic activities, the New Growth Path was introduced in 2010. However, between 2010 and 2016, despite the reliance on the NGP policy framework, a low growth path averaging 1.6% per annum has persisted. Nevertheless,

domestic policymakers have remained optimistic as it is anticipated that South Africa's National Development Plan (NDP) and vision 2030 will bring a radical change to the economy.

In terms of historic unemployment trends, Figure 1 shows that unemployment rates in all provinces have followed a trajectory that is different to that of Gross Domestic Product (GDP). For the period under review (1996 – 2016), unemployment in South Africa has been marked by three distinct eras. Despite the RDP and GEAR policies that aimed at boosting employment growth above the increase in the economically active population, during the first period (1996 to 2003), unemployment rate increased, more specifically in KwaZulu-Natal. After 2003, with the introduction of ASGISA, South Africa experienced a period of slight decline in unemployment throughout all provinces and yet these positive developments were not sustained due to the recession in 2008. The third period of post-recession was marked with a rise in unemployment rate, especially in Free State province. However, unemployment in Limpopo has being an exception to this trajectory.

In terms of current trends, Figure 1 further shows that % share in GDP and % share in number of people unemployed is unevenly distributed across the nine provinces. In particular, Gauteng (35%), KwaZulu-Natal (16%) and the Western Cape (14%) have kept the leading position in terms of % share of total GDP in which these provinces alone account for more than two thirds of South Africa's GDP and at the same time these three provinces together generate approximately 60 percent of total unemployment in South Africa. On the other hand, for the remaining provinces collectively account for 35% in the share of GDP (i.e. Northern Cape (2%), Free State (5%), North West (6%), Limpopo (7%), Mpumalanga (7%), Eastern Cape (8%)) whilst also accounting for about 40% of unemployment (i.e. Northern Cape (2%), Limpopo (6%), North West (6%), Free State (7%), Mpumalanga (8%) and Eastern Cape (11%)).

3 A BRIEF OVERVIEW OF THE ASSOCAITED LITERATURE

Okun's law assumes the existence of an inverse relationship exists between cyclical output and cyclical unemployment. In his original manuscript Okun (1962) discovered that a 1% increase in the GDP growth above it's natural rate leads to a 3% in reduction of unemployment below it's potential. However, a percentage increase in unemployment implies approximately an excess of 3% loss in GDP growth. Although Okun's law was originally introduced in 1962 (Okun 1962) strictly for US data, many recent studies still base their research on this law. Recent empirical contributions include those of Malley and Molana (2008) and Pierdzioch et al. (2011) for G7 countries; Moazzami and Dadgostar (2009); Zanin (2014); Dixon et al., (2016) for OECD countries as well as Grant (2017) for the US. Despite the discrepancies in their results, these studies commonly reveal that the relationship between growth and unemployment has a permanent and stable character and it also confirms that Okun's law is still recognized as one of the fundamental macroeconomic laws.

Even though a bulk majority of literature is dedicated to industrialized economies, there have been a handful previous empirical works conducted for the South African economy (i.e. Geldenhuys and Marinkov (2007); Moroke et al. (2014); Phiri (2015); Madito and Khumalo (2014); and Banda et al. (2016)). In general, these previous South African studies have applied different empirical methodologies such as the piece-wise OLS estimates (Geldenhuys and Marinkov (2007)), VECM model (Moroke et al. (2014), Madito and Khumalo (2014) and Banda et al. (2016)) and momentum threshold autoregressive model (Phiri (2015)), which have been employed to different sample periods using different measures of the unemployment and GDP gap variables. Unsurprisingly, the obtained empirical results of these studies have been mixed, controversial and inconsistent.

In using the most recent developments in the literature as a guide in rectifying these inconsistencies observed in these previous South African studies we follow two routes. Firstly, there has emerged a number of studies which have argued for provincial level analysis providing a better picture of Okuns law (see Apergis and Rezitis (2003) For Greek regions; Adanu (2005) for Canadian provinces, Villaverde and Maza (2007, 2009) for Spanish provinces, Huang and Yeh (2013) for 8 US regions; Durech et al. (2014) for provinces in the

Czech Republic and Slovakia, Melguizo (2017) for Spanish provinces, and Guisinger et al. (2018) for US states). A majority of these studies confirm an aggregation bias for Okun's coefficient for the countries investigated.

Secondly, we follow a host of more recent studies that advocates for nonlinearity in Okun's relationship (see 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). These 'nonlinear' studies tend to provide more powerful inferences on the unemployment-growth relationship compared to the linear-based econometric studies by implying that Okun's law applies differently depending on which phase of the business cycle the economy is at. Notably, a majority of these nonlinear studies rely on the momentum threshold autoregressive (MTAR) model of Enders and Silkos (2001) to establish dynamic asymmetries over the short-run yet retaining linearity in the long-run regression. As previously mentioned in the introduction, our study employs the N-ARDL model of Shin et al. (2014) which allows for modelling of both short-run and long-run cointegration relations between unemployment and economic growth. To the best of our knowledge, this model has not been used in previous literature despite its technical superiority over other competing nonlinear cointegration frameworks.

4 EMPIRICAL SPECIFICATIONS

From an empirical perspective there are two function specifications of Okun's law. The first is the 'first differences model0 i.e.

$$\Delta U = \alpha + \beta \Delta Y + e_t \quad (1)$$

Where $\Delta U = (U_t - U_{t-1})$, $\Delta Y = (Y_t - Y_{t-1})$ and e_t is a well-behaved error term. The second specification in the literature is the 'gap model' which can be expressed as:

$$U_{gap} = \alpha + \beta Y_{gap} + e_t \quad (2)$$

Where $U_{gap} = (U - U^T)$, $Y_{gap} = (Y - Y^T)$, U^T is the natural rate of unemployment and Y^T is the natural rate of output which are both unobservable variables. In regressions (1) and (2), the value of the β, which is defined as Okun's coefficient, is expected to be negative and significant (i.e. $\beta < 0$). Knotek (2007) points out that the original versions of Okuns law were problematic since they both ignored important dynamics in which both past and current output can impact the current level of unemployment. This has led more recent researchers, such as Huang and Yeh (2013) and Amor and Hassine (2017), to rely on the autoregressive distributive lag (ARDL) model of Pesaran et al. (2001) to model both short-run and long-run dynamic versions of Okun's specification. The typically dynamic ARDL regression model of Okun's law takes the following form:

$$\Delta U_{gap,t} = \alpha_0 + \sum_{j=1}^{n} \alpha_1 \Delta U_{gap,t-j} + \sum_{j=1}^{n} \alpha_1 \Delta Y_{gap,t-j} + \beta_1 U_{gap,t-1} + \beta_2 Y_{gap,t-1} + e_t \quad (3)$$

Where Δ denotes a first difference operator, α_1 and α_2 are the short-run coefficient parameters, β_2 is the long run regression coefficient which is normalized on β_1 and e_t is a normally distributed residual term. The unrestricted error correction model (UECM) formed from regression (3) can be specified as:

$$\Delta U_{gap,t} = \alpha_0 + \sum_{j=1}^{n} \alpha_1 \Delta U_{gap,t-j} + \sum_{j=1}^{n} \alpha_1 \Delta Y_{gap,t-j} + \lambda ECT_{t-1} + u_t \quad (4)$$

With ECT_{t-1} being the error correction term which measure the speed of adjustment back to steady-state equilibrium following a shock to the system and $u_t \sim N(0, \sigma^2)$. Note that the above framework is a linear one which presupposes that Okun's coefficient remains the constant during recessions and expansion phases of the business cycle. However, as was first noted by Keynes (1936) and later theoretically refined by Courtney (1991), Palley (1993) and more recently Lang and de Perretti (2009), variations in unemployment and output differ along

different phases of the business cycle hence exhibiting nonlinearities. Shin et al (2014) provide a method of capturing such asymmetries which involves decomposing the ΔY_{gap} variable into positive and negative partial sum processes i.e. $Y_{gap,t}^{+} = \sum_{j=1}^{i} \Delta Y_{gap,j}^{+} = \sum_{j=1}^{i} \max(\Delta Y_{gap,j}, 0)$ and $Y_{gap,t}^{-} = \sum_{j=1}^{i} \Delta Y_{gap,j}^{-} = \sum_{j=1}^{i} \min(\Delta Y_{gap,j}, 0)$. Therefore equation (4) can be re-specified as the following nonlinear ARDL (N-ARDL) (p, q) regression:

$$\Delta U_{gap,t} = \sum_{j=1}^{p} \psi_i U_{gap,t-j} + \sum_{j=1}^{p} \left(\Phi_j^{+} Y_{gap,t-j}^{+} + \Phi_j^{-} Y_{gap,t-j}^{-} \right) + \zeta_t \quad (5)$$

Whereas the associated error correction representation can be denoted as:

$$\Delta U_{gap,t} = \sum_{j=1}^{p} \rho_i U_{gap,t-j} + \Phi_j^{+} Y_{gap,t-j}^{+} + \Phi_j^{-} Y_{gap,t-j}^{-} + \sum_{j=1}^{p-1} \lambda_i \Delta U_{gap,t-j} + \sum_{j=0}^{q-1} (\alpha_j^{+} \Delta Y_{gap,t-j}^{+} + \alpha_j^{-} \Delta Y_{gap,t-j}^{-}) + \lambda ECT_{t-1} + \zeta_t \quad (6)$$

Where the long-run regression coefficients are computed as $\beta^{+} = -(\Phi^{+}/\rho)$ and $\beta^{-} = -(\Phi^{-}/\rho)$. From the N-ARDL model encompassed in regressions (5) and (6), the following three empirical hypotheses are tested. The first hypothesis tests for asymmetric N-ARDL effects using the following null hypothesis:

H_{00}: $\rho = \Phi^{+} = \Phi^{-}$. (7)

The second hypothesis tested is that for no long-run asymmetric effects i.e.

H_{01}: $\beta^{-} = \beta^{+}$ (8)

The third null hypothesis tested concerns no short-run asymmetries i.e.

H_{02}: $\sum_{i=0}^{q-1} \alpha_j^{+} = \sum_{i=0}^{q-1} \alpha_j^{-}$ (9)

5 DATA AND EMPIRICAL RESULTS

5.1 Data description and unit root tests

We collected annual data of total unemployment and real GDP growth rates for all 9 South African provinces on an annual frequency ranging from 1996 and 2016. All data has been sourced from the Statistics South Africa online database. Our first element of complexity is approximating the potential unemployment (U_{gap}) and potential GDP (Y_{gap}) variables. We employ the filter of Corbae and Ouliaris (2006), which assumes that a time series X_t is nonstationary such that its first difference has a Wold representation with a spectral density f_w (ϑ) > 0. In denoting $\vartheta = 2\pi s/n$ as a Fourier transformation of X_t is given by:

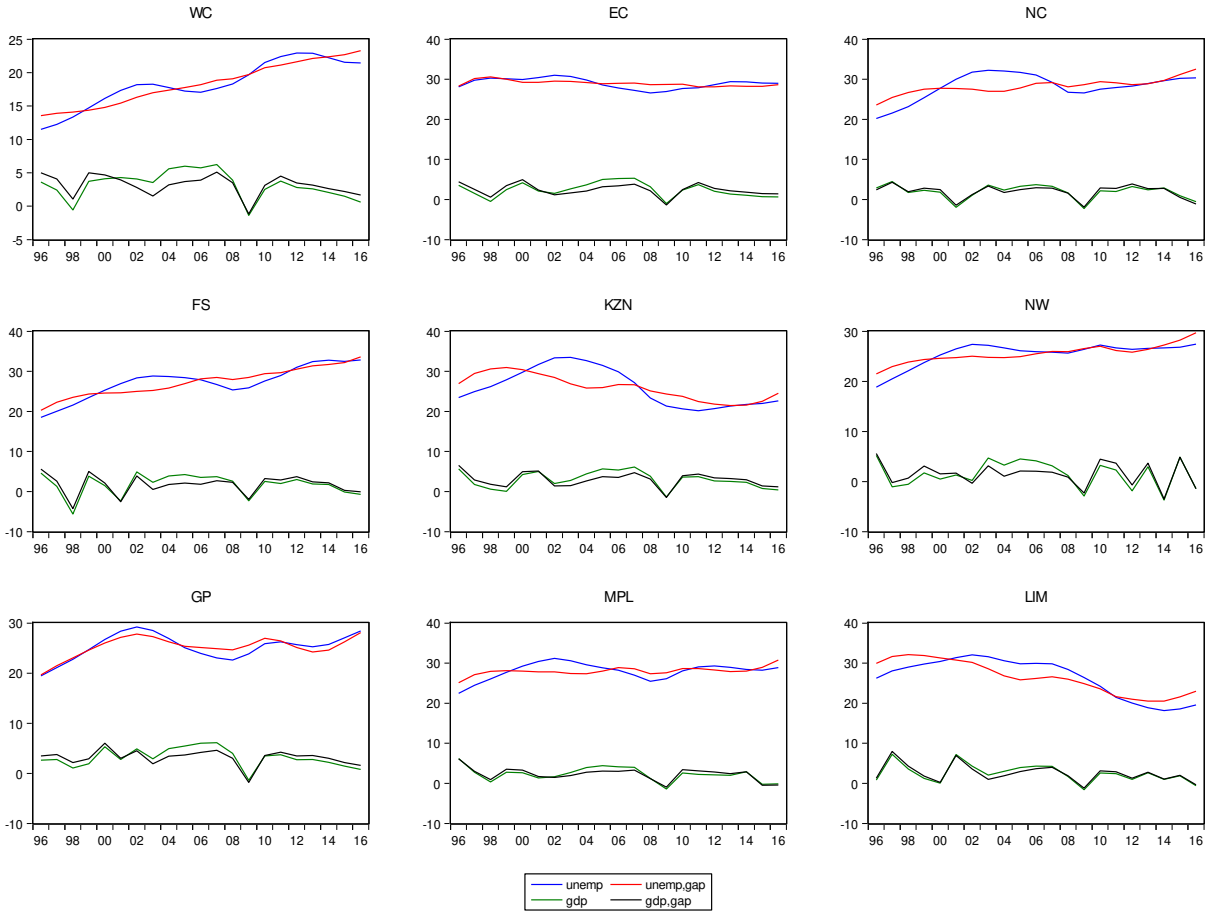
$$w_{\vartheta}(X) = (1 - e^{\vartheta})^{-1} w_v(\vartheta) - e^{\vartheta}(1 - e^{\vartheta})^{-1} \frac{X_n - X_o}{\sqrt{n}} \qquad (10)$$

For s= 0,1,…, n-1 frequency components. Corbae and Ouliaris (2006) demonstrate that imposing restrictions ($X_n - X_1$) = ($X_n - X_0$) will yield superior filtering properties in comparison to traditional filters such as the Hoddrick-Prescott and the Baxter-King filters and its compatibility with stationary or first differenced time series. We therefore apply the Corbae-Ouliaris (2006) filter to our empirical time series and extract the unemployment gap and GDP gap variables for the 9 provinces. The summary statistics of the extract variables are reported in Table 1.

Table 1: Summary statistics of time series variables

Province	variable	mean	median	maximum	minimum	Std. dev.	Jb (p-value)
WC	U_{gap}	18.30	18.18	23.29	13.55	3.20	0.47
	Y_{gap}	3.19	3.48	5.11	-1.15	1.52	0.06
EC	U_{gap}	28.98	28.88	30.61	28.10	0.70	0.40
	Y_{gap}	2.42	2.34	4.92	-1.39	1.43	0.46
NC	U_{gap}	28.22	28.13	32.57	23.57	1.87	0.54
	Y_{gap}	1.96	2.48	4.31	-1.88	1.67	0.10
FS	U_{gap}	27.34	27.96	33.60	20.26	3.52	0.76
	Y_{gap}	1.73	2.18	5.58	-4.22	2.39	0.24
KZN	U_{gap}	25.99	25.93	30.96	21.46	3.09	0.56
	Y_{gap}	2.95	3.10	6.54	-1.48	1.78	0.78
NW	U_{gap}	25.52	25.49	29.67	21.49	1.77	0.80
	Y_{gap}	1.51	1.68	5.57	-3.45	2.37	0.77
GP	U_{gap}	25.26	25.34	28.09	19.64	2.03	0.05
	Y_{gap}	3.16	3.44	6.03	-1.79	1.52	0.00
MPL	U_{gap}	28.01	27.99	30.76	25.11	1.03	0.01
	Y_{gap}	2.29	2.83	6.11	-0.95	1.62	0.87
LIM	U_{gap}	26.40	26.15	32.10	20.50	4.08	0.44
	Y_{gap}	2.53	2.00	7.96	-1.17	2.17	0.25

Figure 1: Extracted unemployment and output gap variables vs original time series



Even though our empirical model the N-ARDL model does not require any formal testing of unit roots in the time series, it is important that the variables are not integrated of an order higher than I(1). Therefore, as a precaution, we test the unit roots on the time series variables use the ADF and DF-GLS test, and the results of this empirical exercise are reported in Table 1 below. As can be clearly observed, the time series for a majority of the provinces unanimously rejects the unit root null hypothesis regardless of whether the tests are performed with a drift or whether a trend is included.

Table 2: Unit root tests on first differences of time series

Time series	Unit root test	Province								
		WC	EC	NC	FS	KZN	NW	GP	MPL	LIM
ΔUgap	ADF (intercept)	-6.01***	-1.77	-2.61	-2.66*	-1.97	-2.86*	-3.40**	-3.22**	-2.16
	ADF (trend)	-5.80***	-1.68	-2.57	-2.58	-1.30	-1.92	-3.25	-3.03	-1.98
	DF-GLS (intercept)	-6.07***	-2.43**	-2.70***	-2.75***	-2.05**	-2.09**	-3.34***	-3.07***	-1.63*
	DF-GLS (trend)	-4.54***	-2.96*	-2.73	-2.72	-2.04	-2.12	-3.49***	-3.23**	-2.20
ΔYgap	ADF (intercept)	-5.39***	-6.22***	-5.65***	-6.95***	-4.97***	-9.78***	-6.14***	-4.87***	-6.02***
	ADF (trend)	-5.29***	-6.06***	-5.49***	-6.73***	-4.79***	-9.38***	-5.96***	-4.69***	-4.15***
	DF-GLS (intercept)	-4.96***	-4.11***	-5.62***	-6.71***	-4.39***	-9.19***	-6.32***	-4.30***	-6.42***
	DF-GLS (trend)	-5.18***	-5.68***	-5.69***	-7.03***	-4.46***	-9.24***	-6.33***	-4.70***	-5.36***

Notes: “***”, “**”, “*” represent the 1%, 5% and 10% critical levels respectively.

5.2 Empirical estimates

Having ruled out the possibility of our time series being integrated of an order higher than I(1), we confidently proceed towards modelling Okun’s relationship for the nine South African provinces using the N-RADL model. Table 2, presents the three tests for nonlinear cointegration effects, which if one is to recall are tests for i) general N-ARDL effects ii) long-run asymmetries and iii) short-run asymmetries. Note that the optimal lag length chosen for each regression was determined through a minimization of the AIC and SC. As can be generally observed, the reported statistics unanimously reject all associated null hypotheses for all provinces at all critical levels.

Table 2: N-ARDL cointegration test results

Province	ARDL specifications	H_{00}: $\rho = \Phi^+ = \Phi^-$.	H_{01}: $\beta^- = \beta^+$	H_{02}: $\sum_{i=0}^{q-1} \alpha_j^+ = \sum_{i=0}^{q-1} \alpha_j^-$
Western Cape	ARDL(1,0,0)	6.09***	6.09***	9.51***
Eastern Cape	ARDL(1,0,0)	7.05***	9.02***	7.35***
Northern Cape	ARDL(1,0,0)	3.79***	4.01***	6.07***
Free State	ARDL(1,0,0)	11.53***	5.27***	8.85***
Kwazulu-Natal	ARDL(1,0,0)	13.58***	12.69***	15.23***
North West	ARDL(1,0,0)	4.57***	12.09***	15.72***
Gauteng	ARDL(1,0,0)	4.02***	4.20***	3.36***
Mpumalanga	ARDL(1,0,0)	8.34***	5.82***	7.56***
Limpopo	ARDL(1,0,0)	8.09***	4.15***	4.98***

Notes: "***", "**", "*" represent the 1%, 5% and 10% critical levels respectively.

The long-run and short-run asymmetric coefficients highlight the discrepancies in Okun's law for the different South African provinces. For instance, we find insignificant long-run asymmetric coefficients for two-thirds of the country's provinces (i.e. Eastern Cape, Northern Cape, North West, Gauteng, Mpumalanga and Limpopo) and this finding is in line with that of Madito and Khumalo (2014) and Banda et al. (2016) for similar South African data. On the other hand, we find statistically significant coefficients for the Western Cape, Free State and KZN provinces although the obtained coefficients are negative for Western Cape and KZN as in Phiri (2015) and yet being positive for the Free State province as in Geldenhuys and Marinkov (2007) and Moroke et al. (2014).

However, in differing from previous studies, our findings point to asymmetric long-run effects for the three provinces in which the impact of recessionary periods (positive output gap) or expansionary periods (negative output gap) on unemployment are not uniform. For instance, a percentage increase in the output gap decreases the unemployment gap by 0.51 percent for the Western Cape and 1.91 for the KZN, with these coefficients being statistically significant

at a 10 percent critical level. Conversely, a percentage decrease in the output gap increases unemployment gap by 0.51 percent for the Western Cape and 1.12 for KZN and yet causing a decrease of 1.66 in the Free State.

The short-run estimates are more encouraging as all provinces, with the sole exception of the Free State province, have a correct negative and statistically significant for either one of the Y^{+}_{gap} or Y^{-}_{gap} coefficients. In particular we note that short-run Okun effects are most prominent for the Western Cape, Kwa-Zulu Natal and Eastern Cape provinces whereas short-run effects are partial (i.e. Okun's relationship either exists in the upswings or downswings but not throughout all cycles) for the Northern Cape, North West, Gauteng, Mpumalanga and Limpopo provinces. Note that no significant short-run estimates are established for the Free State province. In turning our attention to the error correction estimates, we find that reversions back to equilibrium after a shock differs between South African provinces, with Limpopo have the highest equilibrium reversion (-1.70), followed by the Western Cape (-1.07), Eastern Cape (-1.02), Free State (-0.72), North West (-0.72), Mpumalanga (-0.69), Northern Cape (-0.22), Gauteng (-0.18) and KZN (-0.17).

Table 2: N-ARDL long-run, short-run and diagnostic tests

Province	Model specification	Long-run estimates		Short-run estimates			Diagnostics (p-values)			
		$Y_{gap}+$	$Y_{gap}-$	$\Delta Y_{gap}+$	$\Delta Y_{gap}-$	ECT	Nor	SC	HET	FF
Western Cape	ARDL(1,0,0)	-0.51 (0.06)*	-0.50 (0.07)*	-0.47 (0.00)***	0.44 (0.00)***	-1.29 (0.00)***	0.83	0.67	0.21	0.18
Eastern Cape	ARDL(1,0,0)	-0.15 (0.19)	-0.01 (0.87)	0.23 (0.06)*	-0.91 (0.02)**	-1.02 (0.02)**	0.27	0.92	0.77	0.46
Northern Cape	ARDL(1,0,0)	-0.76 (0.16)	-0.71 (0.20)	-0.03 (0.74)	-0.15 (0.06)*	-0.22 (0.00)***	0.30	0.18	0.23	0.74
Free State	ARDL(1,0,0)	1.91 (0.06)*	1.66 (0.06)*	-0.03 (0.42)	-0.05 (0.11)	-0.72 (0.01)**	0.60	0.89	0.35	0.46
Kwazulu-Natal	ARDL(1,0,0)	-1.91 (0.02)**	-1.12 (0.02)*	-0.89 (0.00)***	-0.18 (0.00)***	-0.17 (0.00)***	0.32	0.65	0.13	0.45
North West	ARDL(1,0,0)	0.22 (0.70)	0.89 (0.36)	0.06 (0.43)	-0.73 (0.07)*	-0.72 (0.07)*	0.83	0.11	0.13	0.47
Gauteng	ARDL(1,0,0)	-3.76 (0.21)	-3.48 (0.24)	-0.29 (0.13)	-0.14 (0.02)**	-0.18 (0.00)***	0.77	0.65	0.48	0.97
Mpumalanga	ARDL(1,0,0)	-4.01 (0.17)	-4.31 (0.18)	-0.73 (0.06)*	-0.08 (0.23)	-0.69 (0.05)*	0.78	0.66	0.50	0.47
Limpopo	ARDL(1,0,0)	-1.24 (0.17)	-1.07 (0.19)	-0.62 (0.07)*	0.48 (0.11)	-1.70 (0.05)*	0.40	0.99	0.66	0.52

Notes: "***", "**", "*" represent the 1%, 5% and 10% critical levels respectively. p-values reported in (). The Jarque Bera (J-B) statistic, the Breusch-Godfrey (B-G) test, the Autoregressive Conditional Heteroscedasticity (ARCH) tests and the Ramsey RESET test indicate that all estimated regressions are devoid of normal errors, serial correlation, heteroscedasticity and incorrect functional form.

5.3 *Sensitivity analysis: Is there an aggregation bias in Okun's law*

In this section of the paper, we explore the possibility of an aggregation bias by re-estimating Okun's law using an aggregated approach to the analysis. To achieve this, we follow estimate two aggregated regressions; the first being a panel N-ARDL model estimates to pooled data of the nine provinces; and the second being a conventional N-ARDL estimates of 'aggregated' national time series data. The findings from this empirical exercise are reported in Table 4. As was the case for the individual provinces, Panel A of Table 4 indicates that the null hypothesis of no N-ARDL effects, no long-run asymmetries and no short-run asymmetries are mutually rejected for both estimate 'aggregate' models at all levels of significance.

Nevertheless, the same optimism is unobserved for the long-run Okun coefficients as only one of the produced long-run estimates reported in Panel B of Table 4 is significant, that being the Y^{+}_{gap} for the N-ARDL estimates of national data which produces the correct negative estimate. Similarly, the short-run estimates reported in Panel B provide very mild evidence of any significant short-run Okun effects, with the Y^{+}_{gap} variable producing the only coefficient with a correct negative and statistically significant coefficient. The error terms further provide evidence on the disequilibrium correction behaviour in both regressions, even though the speeds of adjustment widely differ between the two estimated panel regressions. Collectively our sensitivity analysis leads to a conclusion of an aggregation bias in Okun's law for South Africa in the post-democratic era.

Table 4: Panel N-ARDL Okun estimates for South Africa

	Panel N-ARDL (1,0,0) estimates for all provinces		**N-ARDL (1,0,0) estimates of aggregated data**	
	Coefficient	p-value	Coefficient	p-value
Panel A: Cointegration tests				
H_{00}: $\rho = \Phi^+ = \Phi^-$.	6.19	0.00	6.19	0.00
H_{01}: $\beta^- = \beta^+$	6.57	0.00	6.57	0.00
H_{02}: $\sum_{i=0}^{q-1} \alpha_j^+ = \sum_{i=0}^{q-1} \alpha_j^-$	7.19	0.00	7.19	0.00
Panel B: Long-run estimates				
$Y_{gap}+$	-3.87	0.54	-0.40	0.02**
$Y_{gap}-$	-2.60	0.48	-0.16	0.56
Panel C: Short-run estimates				
$\Delta Y_{gap}+$	-0.02	0.32	-0.61	0.28
$\Delta Y_{gap}-$	-0.41	0.00***	-0.49	0.68
ECT	-0.04	0.00***	-1.05	0.00***
Panel D: Diagnostic tests				
Nor	0.37	0.83	3.76	0.15
SC	0.97	0.43	0.94	0.45
Het	2.43	0.11	0.28	0.96
FF	1.63	0.15	0.43	0.68

Notes: "***", "**", "*" represent the 1%, 5% and 10% critical levels respectively. The Jarque Bera (J-B) statistic, the Breusch-Godfrey (B-G) test, the Autoregressive Conditional Heteroscedasticity (ARCH) tests and the Ramsey RESET test indicate that all estimated

regressions are devoid of normal errors, serial correlation, heteroscedasticity and incorrect functional form. Optimal lag length for both models is determined through the minimization of the AIC and SC.

6 CONCLUSIONS

In focusing on a 20-year post-Apartheid period dating from 1996 to 2016, our study sought to contribute to the on-going debate on Okun's law for South Africa based on three modifications over the previous domestic literature. Firstly, we provide an analysis of the relationship from a provincial level henceforth addressing the issue of an aggregation bias commonly highlighted in the fore-going international literature. Indeed, our sensitivity analysis confirms this phenomenon for South Africa as our panel estimates of Okun's law for all domestic provinces produces insignificant long-run estimates. Secondly, we employ a nonlinear ARDL cointegration model to estimate both long-run and short-run equilibrium relations for each province. In contrast to other linear cointegration frameworks employed in previous studies, the N-ARDL model assumes differing equilibrium dynamics dependent on whether the economy is in an expansionary or recessionary phase of the business cycle. Moreover, the model is compatible with a combination of time series data integrated of order I(0) or I(1). Lastly, we employ the Corbae-Ouliaris filter, which is superior to preceding filters commonly used in previous studies and can efficiently segregate cyclical and trend patterns in the unemployment and GDP series, regardless of whether the raw data is levels stationary or first difference stationary.

Our obtained empirical results point to a couple of interesting realizations. For starters, a negative and significant long-run relationship, in lieu of Okun's original finding, is only established for two provinces i.e. Western Cape and Kaw-Zulu Natal. We also find significant long-run asymmetric relationships for the Free-state province, albeit these estimates being positive, On the other hand, over the short-run we observe significant asymmetric Okun estimates, with the sole exception of the Free-State province in which no significant short-run effects are identified. As indicated by the error correction estimates, Limpopo, Western Cape

and the Eastern Cape provinces adjusts the quickest back to steady-state equilibrium in the face of exogenous shocks to the economy, and this/which is lagged by other provinces. Collectively, our empirical results imply that in most provinces over the short-run, economic growth assists in reducing unemployment more prominently during upswings of the economic cycle and recovering from vulnerabilities presented during the down-swings of the business cycles. Reserve dynamics apply to the Free State province over the long-run.

From a policy viewpoint, our results indicate that the Western Cape and Kwa-Zulu Natal are the most efficient provinces in translating increased economic activity into reduced unemployment rate over both the long-run ad short-run. Most of the remaining provinces, and in particular the Eastern Cape, North West, Mpumalanga, Northern Cape, Gauteng and Limpopo provinces, economic growth is partially translated into reduced unemployment over the short-run. Meanwhile, a controversial province is the Free-State on which provincial governments efforts to influence unemployment through increased economic activity in the short-run appears to be futile and this has resulted in both economic growth and unemployment increases during expansionary periods yet both variables are decreased during recessions. Authorities in the Free-State province are thus encouraged to develop more finesse short-to-medium policy plans which addresses issue of irregular government spending which increases provincial activity and yet is redundant in reducing unemployment.

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