

The Nexus between Unemployment and Economic Growth: An Empirical Enquiry into Okun's Law on South Africa's Provinces (2008-2024)

By Ngonidzashe Chiranga*, Samuel Chingoiro[±] & Stephen Zhanje[°]

South Africa (SA)'s economic growth has largely been less than 1% which is relatively lower than the 3% average in the Sub-Saharan Africa region. On the other hand, unemployment has been over 28% over the 2013 to 2023 period. Questions emerge on the nexus between unemployment and economic growth, whether it still follows Okun's law at the SA provincial level. This study departs from the existing academic discourse by novelly contributing to academic scholarship through the following frontiers. Firstly, the study seeks to test using SA provincial data if a significant relationship exists in both the short-run and long-run, the unemployment - economic growth nexus still follows Okun's law and explore the underlying factors contributing to SA's unemployment crisis. The paper aims to achieve this through a panel of 9 SA provincial data empirically tested by employing three baseline models which include the Dynamic Fixed Effects (DFE) model, the Dynamic Fixed Effects with Mean Group (MG), and the Pooled Mean Group (PMG) mode utilising provincial quarterly data on unemployment rates and output in South Africa from 2008 to 2024. In the subsequent analysis, we refine the models by incorporating two additional techniques, the Panel-Corrected Standard Errors (PCSE) estimator, and the Fully Generalised Least Squares (FGLS) estimator. Overall, the results suggest that, while the short-run impact of unemployment on GDP is less clear, the long-run effects indicate a positive and significant relationship, debunking the relevance of Okun's Law in understanding the dynamics between unemployment and economic output. This study aims to contribute to policymaking and broaden the understanding from an emerging country perspective.

Keywords: *Economic growth, Okun's law, South Africa, Unemployment, Panel Autoregressive Distributed Lag method.*

Introduction and Background

South Africa's (SA) economic growth from 2015 has been largely lower than 1% compared to the 3% average in the Sub-Saharan region. On the other hand, unemployment has averaged over 28% since 2015. Slow economic growth has been singled out by different scholars as one of the chief causes of unemployment.

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Following Okun's law¹, is there a scientific basis to question the efficacy of this law using SA provincial data? Single-country studies by Priambodo (2021), Tabash, Farooq, Safi, Shafiq, and Drachal (2022) and Gonese, Sibanda, and Ngonisa (2023), contributed to the debate on Okun's law for single countries. Yet, when considering panel cross-country studies, mixed results on the nexus occur. Much of the scholarship debates emanate from the non-agreement of results in the short and long run.

However, there have been few country-specific studies conducted on Okun's law that considered sub-regions within the country. For instance, Christopoulos (2004), did a study in Greece using unit roots in which 6 of the 13 regions found consistent results with Okun's specification. Also, Villaverde and Maza (2009), did a study in Spanish provinces using data from 1980 to 2004, in which the majority of areas found an inverse relationship between unemployment and economic growth. In this respect, the novelty of this study stems from a scholarship contribution in addressing the following research question:

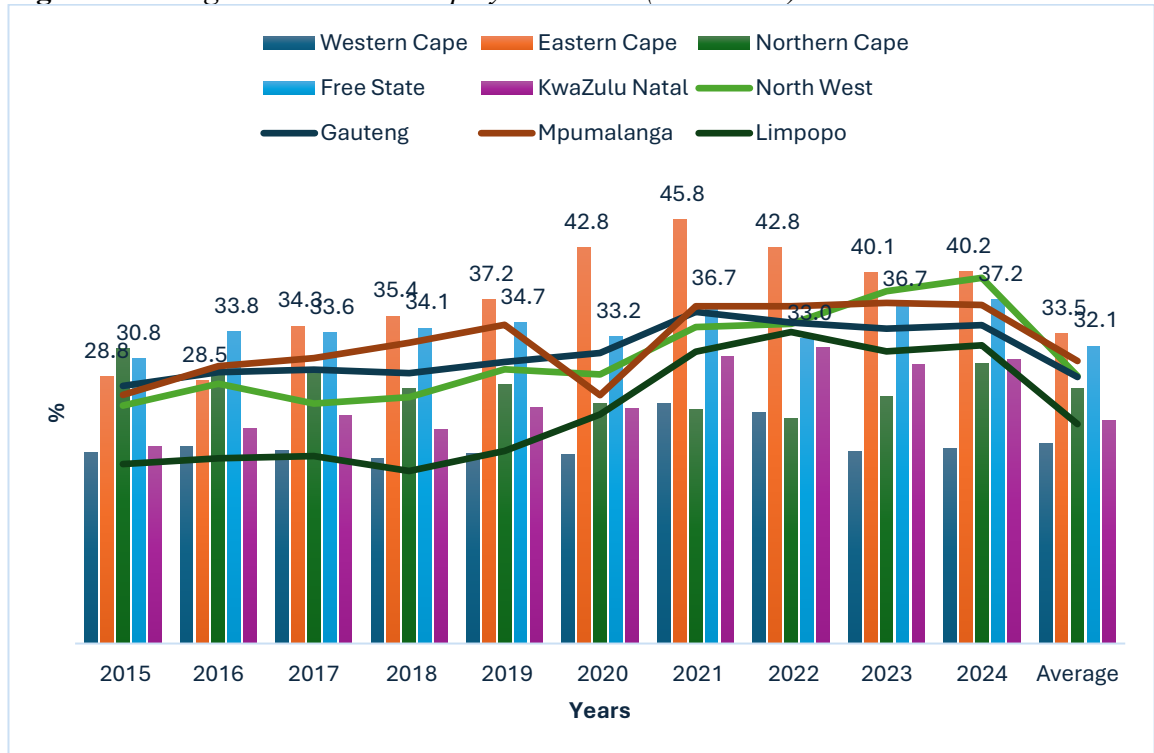
What is the short and long-run impact of Unemployment (U) on economic growth (EG) in South Africa at the provincial levels? The study aims to solve these research questions using three baseline equations namely, the DFE, MG and PMG. Additionally, two techniques are applied namely PCSE and the FGLS to improve the robustness of the results. The rest of the paper is as follows: Section 2 is a presentation of the stylised SA unemployment and GDP data. Afterwards, section 3 is a Review of related literature, which is followed by Research methods and a discussion of results. Finally, the paper presents a conclusion and policy implications.

Unemployment and Economic Growth Trends in SA Provinces (2013-2023).

Figure 1 presents the average unemployment statistics for SA's 9 provinces, of which Eastern Cape, KwaZulu Natal and Limpopo Provinces are considered rural. On the other hand, the Northern Cape, Western Cape, Eastern Cape, and KwaZulu-Natal have a coastline. Does it imply this has any added benefits to lowering average provincial unemployment rates? What is striking is that the Eastern Cape registered the highest unemployment of 45.8% in 2021; this may be attributed to the fact that it is a rural-based province. This is followed by the Free State Province, with farms also surround. Does it follow then that most people working on farms are not recorded, or do they consider themselves unemployed? Those discussions make the official unemployment rate from STATS SA the subject of scrutiny. However, for purposes of this study, the strict definition² of unemployment is followed. On the other hand, the Western Cape, Gauteng, and KwaZulu Natal have repeatedly registered lower unemployment rates.

¹When the economy is growing strongly it follows that unemployment will decrease but a non-growing economy has an increase in unemployment (Hjazeen, Seraj, & Ozdeser, 2021)

²Following international standards, a person should meet three criteria to be considered unemployed. First, they (a) did not work in the reference period; (b) were available to take up a job had one been offered in the week before the reference period and (c) actively sought work within the past month

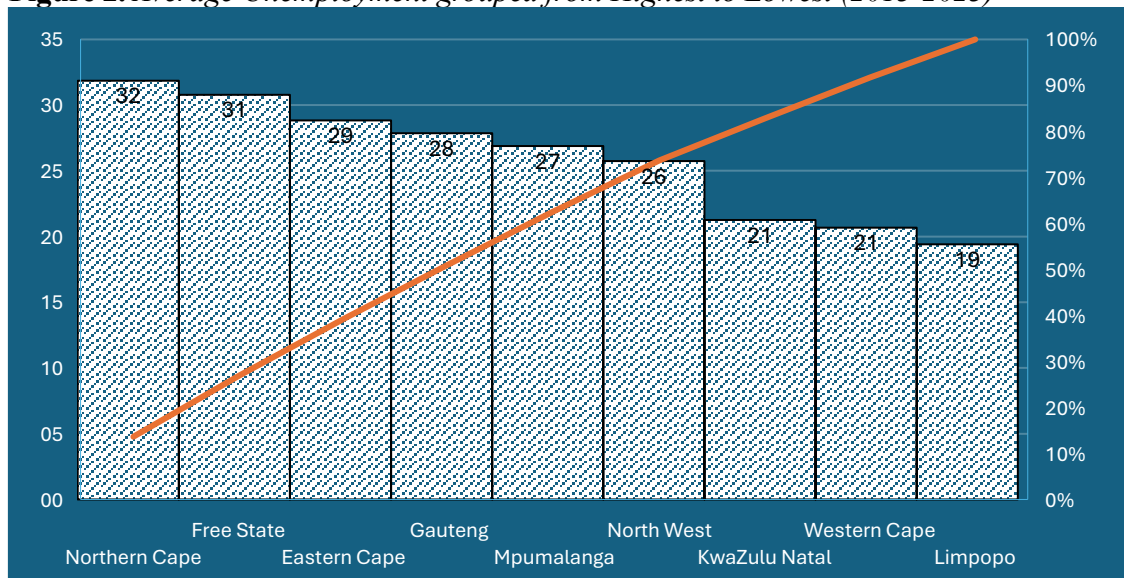
Figure 1. Average Provincial Unemployment in SA (2008-2024)

Source: STATS SA (2008-2024)

Is there enough scientific evidence to justify the claim that unemployment is related to being in a rural or urban province? The stylised facts, on the contrary, show that the Northern Cape, which cannot be classified as not rural, had the highest average unemployment rate of 31.9% followed by the Free State, also another not-so-rural province. However, the Eastern Cape (a rural province) is one of the top 3 highest provinces with unemployment. In a way, Limpopo is a rural province but has the lowest average unemployment of 19.4% just below the Western Cape at 20.7%. Does this imply that in a rural province, people are employed in subsistence farming, yet they don't derive any form of compensation? What is striking are the many cars that trek back via N1 North³ to Limpopo province from Gauteng province every month, indicative that most Limpopo economically active population do not reside in the province but rather remit back to the province. Hence, there is little evidence to justify that unemployment can be traced to a province being either rural-based or urban-based or based on having a coastline or being landlocked unless this is subjected to econometric estimation to measure impact elasticities.

³The N1 National Route emanates from Cape Town (Western Cape) and goes through Bloemfontein (Free State), Johannesburg, Pretoria (Gauteng), and Polokwane (Limpopo) to Beit Bridge on the border with Zimbabwe.

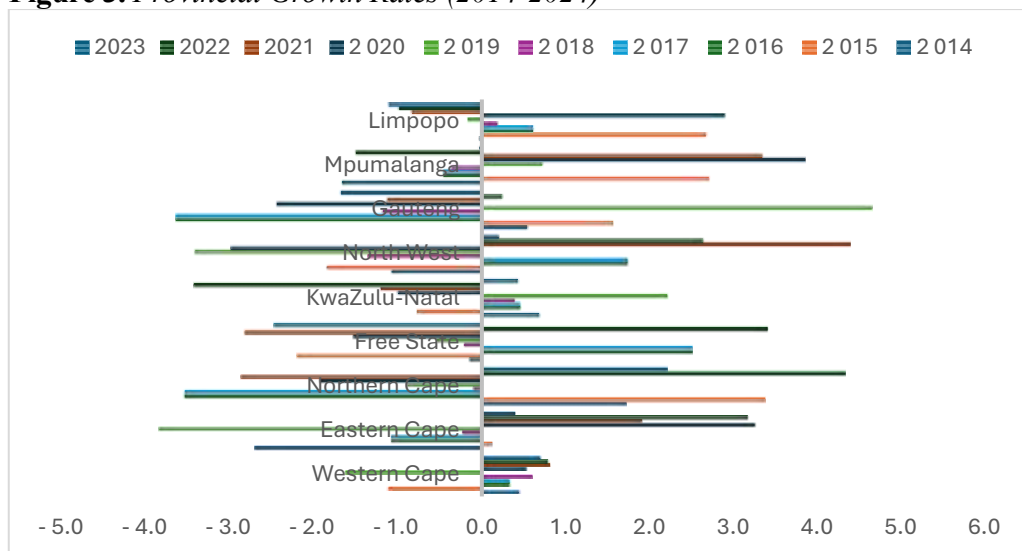
Figure 2. Average Unemployment grouped from Highest to Lowest (2013-2023)



Source: STATS SA (2024)

Furthermore, from Figure 3, the Northern Cape province registered the highest GDP growth rate of 2.2%. That is rather surprising given there are not many companies situated in the province or perhaps a bigger company relocated there and hence the multiplier effect caused a lot of economic activity resulting in GDP growth. The irony is it is the province registering the highest unemployment. Could it be a capital-intensive company relocated to the Northern Cape that does not translate to employment growth?

Figure 3. Provincial Growth Rates (2014-2024)



Source: STATS SA (2014-2024)

However, from Table 1, the contributions from the different economic provincial sectors in the Northern Cape province are provided. Community services have dominated the contributions at the provincial level, from 28.4% in 2021 to 27.5% in

2022. Still, it does not justify why unemployment is still high in this province. Furthermore, the mining sector follows, which is a capital-intensive industry. Is there scope to speculate that mines are adopting Artificial Intelligence (AI) as a factor of production in replacing workers? This may require further scrutiny, but at face value, South African mines are deep and are increasingly becoming dangerous for humans to go underground. So, from a profit motive and safety motive, mining has drifted towards robotic mining as it saves costs and reduces the headache of mining fatalities. All in all, unemployment will increase despite an economic growth increase, a possible explanation of this puzzle.

Table 1. Economic Contributions in the Northern Cape Province (2021-2022)

Sector	Contributions from different industries in the Northern Cape Province (%)	
	2021	2022
Primary Sector	30.6	30.8
Agriculture	7.5	8.4
Mining	23.1	22.4
Secondary Sector	8.5	8.6
Manufacturing	3.8	3.7
Electricity	3.1	3.2
Construction	1.7	1.7
Tertiary Sector	60.9	60.5
Trade	10.8	10.9
Transport	7.5	8.1
Finance	14.1	14.0
Community Services	28.4	27.5
Total	100.0	100.0

Source: Northern Cape Socio-economic Review (2024)

In a way, the stylized facts from Northern Cape province are at variance with Okun's law postulations. Does it imply Okun's validity only applies when there is GDP growth associated with expanding a labour-intensive industry, which is not the case with the advent of artificial intelligence (AI)? GDP can indeed increase, yet people are unemployed. This is the quagmire most developing countries find themselves in when they overly and excitedly adopt AI into their production systems in environments with vast available economically active populations, resulting in agitations from the voting youths and protestant voting patterns that usually take ruling parties by surprise.

From Table 2, the Eastern Cape registered the lowest GDP growth rate in 2014 at 2.7% followed by Mpumalanga province at -1.7%. On the other hand, Gauteng province has, over the years positive GDP growth rates, but somehow in 2023, there was a lower negative growth of -1.7%. Could the province be in a technical recession? That remains unclear.

Table 2. SA Provincial GDP Growth Rates (2014-2023)

Province	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Western Cape	0,4	-1,1	0,3	0,3	0,6	-1,6	0,5	0,8	0,8	0,7
Eastern Cape	-2,7	0,1	-1,1	-1,1	-0,2	-3,9	3,3	1,9	3,2	0,4
Northern Cape	1,7	3,4	-3,6	-3,6	-0,1	-0,9	-1,9	-2,9	4,3	2,2
Free State	-0,2	-2,2	2,5	2,5	-0,2	-0,5	-1,5	-2,8	3,4	-2,5
KwaZulu-Natal	0,7	-0,8	0,5	0,5	0,4	2,2	-1,0	-1,2	-3,4	0,4
North West	-1,1	-1,8	1,7	1,7	-1,4	-3,4	-3,0	4,4	2,6	0,2
Gauteng	0,5	1,6	-3,7	-3,7	-1,2	4,7	-2,4	-1,1	0,2	-1,7
Mpumalanga	-1,7	2,7	-0,5	-0,5	-0,4	0,7	3,9	3,3	-1,5	0,0
Limpopo	0,0	2,7	0,6	0,6	0,2	-0,2	2,9	-0,8	-1,0	-1,1

Source: STATS SA (2014-2023)

Review of Literature

The literature on Okun's law can be traced to the scholarship by Priambodo (2021), Aaronson, Daly, Wascher, and Wilcox (2019), Banda, Ngirande, and Hogwe (2016) and Ali, Osman, Hassan, and Osman (2022) where they consider the Keynesian economic view on the macroeconomy. More specifically, the economy is made up of consumers (C), investors (I), government (G), and net exports(X-M). Put simply, aggregate demand, $Y=C+I+G+X-M$. On the other hand, a low-investment climate has been prevalent in SA, and why this is so may be due to several factors. This follows that investment by nature depends on expectations, which depend on a quantum of factors, some of which include respect for property rights, favourable investment government policies, the tax regime in the country, and inflation and interest rate expectations, to mention just a few. Investors follow the country trends and are guided, unfortunately, by recommendations from rating agencies like Moody's, which, with their grading, can magnify the unemployment crisis even further, as investors hold back on long-term investments in line with rating agencies' recommendations.

On the other hand, SA's export basket is largely dominated by base metals that suffer volatility from world prices, coupled with high labour costs, which makes SA goods on the world market price uncompetitive. Further, import demand for non-essentials has largely been driven by external aggressive persuasive advertisements on social media platforms from foreign companies, and with a high internet penetration ratio, the unsuspecting consumer imports goods that otherwise could have been bought in a store next door. It is equally worth noting that the world has become one big global village that somehow seems to punish losers and reward winners. Is SA losing in this game of trade where they are exporting what the world essentially has more substitutes for but importing essential goods that are relatively price inelastic like crude oil? Equally, SA is importing non-essentials that are also available locally, which results in the perennial unemployment problem. But in a free world, can you control what people do with their money, or can you only put a cap on how much they can spend outside? The question that remains unclear is, this is working for or against SA's fight against youth unemployment. Interestingly, Oner (2020) maintains that unemployment of skilled workers is pricing them out of the

labour market by demanding higher reservation wages than what the employers can pay. Another possibility is that workers earn below minimum wage salaries than the gazetted minimum wage, a phenomenon prevalent in the farming industry. In this respect, does it follow thereafter that unemployment registered in the Free State Province, a predominantly commercial farming area, is underreported, as those employed are not registered, as employers fear being caught paying below minimum wage? Similarly, Suma (2017) saw that unemployment may increase the moment wages rise above realistic break-even levels that trigger the attractiveness of AI as an alternative to labour.

Theoretical Framework on Okun's Law

This paper is based on Okun's foundational work (1962), which predicts an inverse relationship between output and unemployment. A substantial body of literature has shown that there are two versions of models that can be used to project this relationship (Christopoulos, 2004; Dajcman, 2018; Gonese, Sibanda and Ngomisa, 2023; Ibourk and Elaynaoui, 2024). In the gap model version, the relationship is expressed as follows:

$$U_t - U^* = \varphi(Y_t - Y^*) + \varepsilon_{it} \quad (1)$$

where; U_t is the unemployment rate in period t and U^* is the natural unemployment rate. The right-hand side depicts the output gap, where Y_t is the real output in period t and Y^* is the potential output of the country. Researchers who estimated the relationships of this version are all premised on the principle that when an economy produces output above its potential, the unemployment rate must generally fall (Ibourk and Elaynaoui, 2024). Thus, increases in real output improve the prospects of reducing unemployment rates. However, the downside of estimating U^* and Y^* is that they are unobservable variables and hence, may lack predictive power (Lancaster and Tulip, 2015). Advanced approaches to estimating the unobservable variables still have limitations for oversimplification and cannot fully address institutional factors such as unionism and minimum wages (Jacob and Wong, 2018). Okun's law can also be expressed using the differences version.

$$U_t - U_{t-1} = \beta(Y_t - Y_{t-1}) + \varepsilon_{it} \quad (2)$$

where the left-hand side represents the change in unemployment rate between two periods, and the right-hand side represents the change in GDP expressed in logs. The difference in (2) can be derived from the gap version in (1). However, researchers usually use the differences version as a simpler and separate version of modelling Okun's law (Jacob and Wong, 2018). The current study adopts the differences version of the conceptual approach for Okun's law to circumvent the limitations associated with estimating the unobservable variables in (1).

Empirical Review

The nexus between unemployment and economic growth has attracted many outcomes. There is generally a lack of consensus, which has attracted a variety of outcomes even currently. For instance, a country-specific study was done in Jordan using panel data from 1991 to 2019 using ARDL by Hjazeen et al. (2021) and found a negative relationship between economic growth and unemployment. In agreement, Khan, Xue, Zaman, and Mehmood (2023), did a study in Pakistan using the ARDL bounds test with data from 1990 to 2019 also confirmed a significant negative relationship between unemployment and economic growth, in agreement with Okun's law findings. Furthermore, Conteh (2021), did a panel study applying an ARDL bounds test on Liberia from 2001 to 2019, but found no long-run relationship between unemployment and economic growth.

However, Ibourk and Elaynaoui (2024)'s study from 39 African countries applied a first differences Hodrick-Prescott (HP) filter. The findings suggest that most African countries have a weak and non-existent relationship between unemployment and economic growth. Furthermore, when you consider the Southern African Development Community (SADC) region, Gonese et al. (2023), used ARDL and the Pooled Mean Group (PMG) estimation technique on a sample from 1980 to 2019 and found that there was a long-run positive relationship between unemployment and economic growth.

On the other hand, for country-specific studies from South Africa, a study by Marinkov and Geldenhuys (2007), found Okun's law to be valid. However, a study by Banda et al. (2016), also from South Africa, found a positive relationship between economic growth and unemployment in direct contrast with other empirical findings by other authors. Could it be because Banda did not apply ARDL like most authors, but instead used Johansen's cointegration from SA's time series data from 1994 to 2013?

In another study, Christopoulos (2004), did a study in Greece and considered Spanish provinces using data from 1980 to 2004 and found similar results, which indicated that most regions follow Okun's law. The panel set up for a country-specific study used in this study shall be adopted in this study by considering SA's 9 provinces as a micro panel from 2015 to 2023, a clear departure from most studies that usually applied ARDL over long periods. The absence of a panel study using a country's provinces from a developing and emerging country perspective makes this study unique, and the novelty contributes to the academic scholarship.

Evans (1989), panel data from single-country studies found an inverse relationship between economic growth and unemployment. However, Al-Habees and Rumman (2012) used VECM, and the findings suggested a negative and significant relationship between economic growth and unemployment in the long run. But in the short term, the economic growth and unemployment nexus had an insignificant positive effect, even though the population growth variable had a contrasting effect on economic growth.

Materials and Methods

This paper utilises provincial quarterly data on unemployment rates and output in South Africa from 2008 to 2024 to estimate Okun's coefficients for each of its nine regions. Both versions of Okun's models in (1) and (2) can be nested into several econometric models. Therefore, to provide a more comprehensive understanding of the underlying relationship between the unemployment rate and GDP growth, and ensure the robustness of the findings, this study embraced several panel models of the differences-version in (2). Since each model is shaped by different assumptions, reporting results across the models helps to evaluate the robustness of the findings and to verify whether the Okun's law holds under the different assumptions.

We employ three baseline models, which include the Dynamic Fixed Effects (DFE) model, the Dynamic Fixed Effects with Mean Group (MG), and the Pooled Mean Group (PMG) model. These models provide a solid foundation for capturing both cross-sectional and time-series variations within the data. In the subsequent analysis, we refine the models by incorporating two additional techniques, the Panel-Corrected Standard Errors (PCSE) estimator, which adjusts for potential heteroscedasticity and contemporaneous correlation, and the Fully Generalised Least Squares (FGLS) estimator, which is designed to address issues of endogeneity and serial correlation in the panel data.

Dynamic Fixed Effects (DFE) Model

The DFE model is useful for controlling for unobserved, time-invariant heterogeneity across the nine regions of South Africa. A Hausman test was first applied to choose between the Random Effects (RE) model and the FE model. It is employed in the analysis for capturing time-dependent effects of the unemployment rate and GDP output, where the past behaviour of the dependent variable influences the current value (Baltagi, 2008). The estimated DFE model for this study is specified in (3):

$$\ln(\Delta GDP_{it}) = \alpha_i + \beta \Delta U_{it} + \gamma \ln(\Delta GDP_{i,t-1}) + \varepsilon_{it} \quad (3)$$

where $\ln(\Delta GDP_{it})$ is the natural logarithm of the change in GDP for the province i in period t , and ΔU_{it} is the change in the unemployment rate for the province i and time t . The fixed effects intercept α_i represent province-specific, time-invariant factors that could influence GDP growth but are not included in the model, such as geographic factors (i.e coastal or non-coastal, and urban or rural province), and economic structure (for example, agrarian-based or industry-based province). $\ln(\Delta GDP_{i,t-1})$ is the lagged change in GDP, i.e., the growth rate of GDP in the previous period ($t-1$). The coefficient for the lagged change in GDP (γ) captures the persistence or momentum in GDP growth from the previous period ($t-1$).

The key goal of this model is to investigate the relationship between changes in the unemployment rate and the rate of growth in GDP in the nine provinces of South Africa. A negative in the Okun's coefficient (β) would suggest that an increase in the unemployment rate is associated with slower GDP growth or potentially negative GDP growth, which aligns with the idea behind Okun's Law.

Dynamic Fixed Effects with Mean Group (MG) Model

We introduce the MG model in the analysis to account for heterogeneous coefficients across the nine regions (Wooldridge, 2009). The estimated MG model for this study is specified in (4) below:

$$\text{Ln}(\Delta\text{GDP}_{it}) = \alpha_i + \beta_i\Delta U_{it} + \gamma\text{Ln}(\Delta\text{GDP}_{i,t-1}) + \varepsilon_{it} \quad (4)$$

where β_i is the province-specific coefficient for the change unemployment rate in period t. After estimating β_i for each province, the Mean Group (MG) estimator computes the average of the β_i 's to get a single estimate for the effect of change in the unemployment rate on change in GDP across all provinces.

Pooled Mean Group (PMG) MODEL

We used the PMG to allow for the estimation of both long-term and short-term relationships in panel data while accommodating potential heterogeneity across individual cross-sections. The PMG estimator assumes that the long-run coefficients are the same across cross-sectional units, while the short-run dynamics may differ (Pesaran, Shin, and Smith, 1999; Pesaran and Smith, 1995). The estimated model is specified in (5) as follows:

$$\text{Ln}(\Delta\text{GDP}_{it}) = \alpha_i + \lambda_t + \varphi\Delta U_{it} + \gamma\text{Ln}(\Delta\text{GDP}_{i,t-1}) + \varepsilon_{it} \quad (5)$$

where λ_t represents time-specific effects, and φ is the vector of long-run coefficients (assumed to be common across cross-sections).

Panel Corrected Standard Errors (PCSE)

We introduced the PCSE model to ameliorate the risks associated with heteroscedasticity and autocorrelation within the panel data (Baltagi, 2008). The model adjusts the standard errors of the coefficient estimates to account for the potential correlation between cross-sectional units and heteroscedasticity. The estimated static FE model for this study is as already specified in 2(a). However, the static fixed effects model with PCSE adjusts for unobserved heterogeneity (captured by α_i) and corrects for heteroscedasticity and serial correlation in the panel data, ensuring robust standard errors.

Feasible Generalised Least Squares (FGLS) Model

The FGLS arguably has a more efficient estimator in the presence of heteroscedasticity and autocorrelation, and helps to determine if the results are sensitive to the assumptions of error structures (Miller and Startz, 2018). The first step in the procedure to estimate the FGLS began by estimating the baseline model in (2a) to obtain the residuals. These were used to capture the error structure that is not explained by the DFE model (2a). The errors are modelled in (6) below:

$$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + \mu_{it} \quad (6)$$

where ρ is the coefficient capturing the serial correlation and μ_{it} is the idiosyncratic error.

Variables of Interest and Proxies

The variables of interest in this study and their proxies are as follows:

- (i) *Unemployment rate (Unemp_{it})*: The provincial quarterly data for unemployment rate was obtained from STATS SA
- (ii) *Natural log of the change in real GDP Ln(ΔGDP_{it})*: Real GDP for each quarter in each year sourced from STATS SA... It is computed by applying the Harmonised Index of Consumer Prices (HICP) on nominal GDP, with 2015 used as the base year.

Discussion of Results

Correlation Analysis Results

Table 3 shows the correlation analysis results of the model variables, and the correlation coefficients range from 0.0328 to 0.2263. Such values depicted in Table 3 show that there is a low correlation between the variables which indicates that the model under consideration is bereft of the problem of multicollinearity.

Table 3. *Correlation Matrix*

Variable	ln ΔGDP	lnGDP	Diffunemp _{it}	Unemp _{it}
ln ΔGDP	1.0000			
lnGDP	0.0494 (0.2264)	1.0000		
Diffunemp _{it}	0.1660*** (0.0000)	0.0389 (0.3408)	1.0000	
Unemp _{it}	0.0328 (0.4224)	0.0383 (0.3481)	0.2263*** (0.0000)	1.0000

Authors' computations

Cross-sectional Dependence and Homogeneity Tests

The utilisation of provinces in this panel study evokes the need to determine whether cross-sectional dependence or independence exists across cross-sections. The results in Table 4 show that the null hypothesis of cross-sectional independence is rejected at a 5% level of significance and even at a 1% level. Such an outcome signifies that there is cross-sectional dependence among cross sections, which calls for the utilisation of models that accommodate such a violation.

Table 4. Cross-sectional Dependence Test Results

Variable	CD-test	P-value	Average joint T	Mean ρ	Mean abs(ρ)
ln Δ GDP	24.988	0.000	66.78	0.51	0.70
LnGDP	48.904	0.000	67.00	1.00	1.00
Diffunemp _{prt}	19.008	0.000	66.78	0.39	0.39
Unemp _{prt}	22.701	0.000	67.00	0.46	0.51

Authors' computations

The null hypothesis, indicating the existence of homogeneity in the model, was tested in this study. Table 5 shows the homogeneity/heterogeneity results, which indicate that the null hypothesis of homogeneity among cross-sections is not rejected at 5% level. This result justifies the existence of homogeneity among South African provinces, which is a surprising result.

Table 5. Homogeneity/Heterogeneity Test

$ln_diffgdpr_{it} = \beta_0 + \beta_1 diffunemp_{prt}_{it} + \varepsilon_{it}$	Statistic	P-Value
Delta_tilde	1.896	0.058
Delta_tilde_adj	1.940	0.052

Source: Authors' estimations

Stationarity Testing of the Variables

Given that the null hypothesis of cross-sectional independence was rejected at a 5% level of significance justified the use of the second-generation panel unit root test (CIPS) to augment the first-generation panel unit root (IPS) to enhance the robustness of regression results. To ensure that the above panel models produce valid, reliable, and interpretable results, the econometric procedures followed in this study began by testing for and addressing the panel unit root issues. The results summarised in Table 6 indicate that the null hypothesis of the existence of a unit root for the LNGDP variable is not rejected at 5% in level but at 1st difference when IPS without trend is employed. However, with IPS with the trend, the null hypothesis of the existence is rejected at the level on the onset. Thus, stationarity is realised at first difference and at level concerning the LNGDP variable when the IPS panel unit root technique without or with trend is applied, respectively. On the other hand, the second-generation panel unit root (CIPS) without or with trend rejects the null hypothesis of the existence of a unit root at the first difference at the 5% level, which justifies stationarity at the first difference for the LNGDP variable.

The panel unit root results when IPS with trend, CIPS without trend and CIPS with trend panels are considered, the null hypothesis of the existence of a unit root is rejected at the level for the Unemp_{prt} variable. Whereas the panel unit root results of IPS without trend results for the Unemp_{prt} variable show that the null hypothesis of the existence of a unit root is rejected at the first difference at a 5% level of significance. Overwhelmingly, stationarity is realised at a level concerning the Unemp_{prt} variable. The realisation of stationarity not beyond 1st difference justifies the determination of cointegration among model variables.

Table 6. First- and Second-generation Panel Unit Root Test Results

Variables/Unit root tests	1 st Generation		2 nd Generation	
	IPS w/o trend	IPS w trend	CIPS w/o trend	CIPS w trend
GDP	1.3249 <i>I</i> (0)	-3.1701*** <i>I</i> (0)	-2.236* <i>I</i> (0)	-2.656 <i>I</i> (0)
	-22.0535*** <i>I</i> (1)	-21.9606*** <i>I</i> (1)	-6.080*** <i>I</i> (1)	-6.285*** <i>I</i> (1)
LNGDP	-1.2718 <i>I</i> (0)	-3.1313*** <i>I</i> (0)	-2.901*** <i>I</i> (0)	-3.299*** <i>I</i> (0)
	-20.3018*** <i>I</i> (1)	-19.9323*** <i>I</i> (1)	-6.190*** <i>I</i> (1)	-6.420*** <i>I</i> (1)

Authors' computations *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Cointegration Test Results

Pedroni's cointegration tests and the Westerlund (2007) ECM panel cointegration test results are depicted in Tables 7 and 8, respectively. Both panel unit root methodologies tested the null hypothesis of the existence of a long-run relationship among model variables. The results in Tables 7 and 8 show that the null hypothesis of no cointegration is rejected at a 5% level of significance, indicating that model variables are cointegrated in the long run, and this calls for the estimation of the regression model in the study.

Table 7. Pedroni's Cointegration Tests

Test Statistics	Panel	Group
V	18.57	
Rho	-36.33	-30.62
T	-43.96	-76.97
Adf	-36.66	-61.09

Authors' computations

Table 8. Westerlund (2007) ECM Panel Cointegration Test Results

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-8.762	-23.613	0.000	0.000
Ga	-2600	-1100	0.000	0.000
Pt	-6.471	-0.153	0.439	0.900
Pa	-915.798	-443.711	0.000	0.000

Authors' computations

Discussion of Empirical Results

In this section, we present the empirical results derived from the econometric modelling of Okun's Law, specifically focusing on the relationship between the change in GDP and the change in the unemployment rate. The natural logarithm of the change in GDP is modelled as a function of the change in the unemployment rate, using panel data across multiple quarterly periods for nine South African provinces.

This section aims to provide a comprehensive understanding of how these models contribute to estimating the dynamic relationship between unemployment and GDP growth changes, ultimately testing the validity of Okun's Law across different specifications and accounting for various econometric challenges. Table 9 presents the results for the three baseline models, highlighting the estimated coefficients and statistical significance for the relationship between the change in unemployment rate and the change in GDP. Table 4 also shows the results of the Mean Group (MG), Differenced Fixed Effects (DFE) and the Pooled Mean Group (PMG) models. Also, the results in Table 9 show that in the long run (LR), the three models oppose Okun's law. The coefficient of 0.00243 represents a change in GDP as influenced by the change in the unemployment rate in the MG long-run model. That is, on average, a one per cent increase in the unemployment rate is associated with a 0.00243 per cent increase in GDP over the long run. Similarly, the coefficients of the change in the unemployment rate in the DFE and PMG bring about a 0.00173 and 0.000636 per cent increase in GDP over the long run, respectively. Such an outcome is in line with findings by other scholars that contradict Okun's law (Banda et al., 2016; Gonese et al., 2023)

Table 9. Empirical Results of the Baseline Models

VARIABLES	MG Model (1)		DFE Model (2)		PMG Model (3)	
	LR	SR	LR	SR	LR	SR
Short-Run (SR)						
$Ln(\Delta GDP_{t,t-1})$		-1.049*** (-38.17)		-1.000*** (-1,330)		-1.071*** (-38.76)
D.diffunemprt		-0.0001 (-0.823)		-0.00004 (-0.227)		0.000586** (2.040)
Long-Run (LR)						
diffunemprt	0.00243** (2.326)		0.00173*** (6.470)		0.000636*** (6.426)	
Constant		15.35*** (38.16)		14.64*** (1,332)		15.68*** (38.70)
Observations		593		593		593
Hausman Test	MG vs PMG		MG vs DFE		DFE vs PMG	
	Chi2(2)=2		Chi2(1)=0.00		Chi2(2)=-122.92	
	Prob>chi2=0.1570		Prob>chi2=0.9964		Prob>chi2=0.0000	

Furthermore, the MG, DFE and the PMG appear to converge in the long run as the speed of adjustments of -1.049, -1 and -1.071, respectively, are within acceptable limits. Although statistically insignificant, the MG and DFE short-run models seem to sympathetically move in the direction of Okun's unemployment coefficient. A coefficient of -0.0001 for the change in the unemployment rate in the MG short-run model suggests that a one percent increase in the unemployment rate is associated with a very small decrease in GDP (by 0.0001 per cent) in the short-run. However, since this coefficient is statistically insignificant at the 5 per cent level, we cannot confidently infer that this relationship holds in the short run. The lack of statistical

significance implies that, based on the current data, the short-run effect of changes in the unemployment rate on GDP growth is not robust enough to make a definitive conclusion. The same conclusion is inferred from the DFE coefficient of 0.00004. In contrast, the PMG short-run coefficient of 0.000586 for the change in the unemployment rate indicates that a one percent increase in the unemployment rate is associated with a 0.000586 per cent increase in GDP in the short-run, which opposes Okun's directional effect. Since this coefficient is statistically significant at the 1 per cent level, we can conclude that there is a meaningful relationship between the change in unemployment and GDP growth in the short run. This suggests that, in the short term, an increase in unemployment is positively related to economic output, although the magnitude of the effect is extremely small.

To ensure the robustness and reliability of the model estimates in Tables 10 and 11, we employ the PCSE and the FGLS models, which cater to cross-sectional dependence among the cross sections. Such models also control for potential issues such as heteroscedasticity, serial correlation, and endogeneity, which could undermine the validity of the model results. That is, the PCSE adjusts for heteroscedasticity and contemporaneous correlation, while the FGLS accounts for endogeneity and serial correlation, ensuring more reliable and consistent parameter estimates. Tables 10 and 11 show the results of the PCSE and the FGLS, respectively, along with their diagnostic test results.

Table 10 shows the results of the PCSE Model under three error structures across the panels by assuming the existence of panel-level heteroscedasticity and correlated panels, panel-level heteroscedasticity only and independence across panels. The Okun's coefficient under all the error structures is tightly closed and only ranges from 0.0333 and 0.0358 and is all significant at a 5% level. In all conditions, the data does not support Okun's prediction, which synchronises with the findings of other scholars like Priambodo (2021) and Ali, Osman, Hassan, and Osman (2022). For instance, a coefficient of 0.0358 for the change in the unemployment rate in the PCSE model indicates that, after accounting for heteroscedasticity and contemporaneous correlation, a one per cent increase in the unemployment rate is associated with a 0.0358 per cent increase in GDP. The findings are consistent with the results under the FGLS in Table 11, with Okun's coefficient ranging from 0.00278 to 0.0358.

Table 10. Empirical Results for the PCSE Model

Error structure across the panels	Panel level heteroscedastic and correlated across panels			Panel level heteroscedastic			Independent across panels		
	No Auto	AR (1)	Panel specific AR (1)	No Auto	AR (1)	Panel specific AR (1)	No Auto	AR (1)	Panel specific AR (1)
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp	ln_diffgdp
diffunempt	0.0333*** (17.12)	0.0349*** (14.60)	0.0358*** (17.94)	0.0333*** (3.085)	0.0349*** (3.132)	0.0358*** (3.100)	0.0333*** (4.130)	0.0349*** (4.205)	0.0358*** (4.289)
Constant	14.62*** (2,287)	14.62*** (2,438)	14.62*** (2,616)	14.62*** (662.0)	14.62*** (746.4)	14.62*** (855.4)	14.62*** (662.0)	14.62*** (746.4)	14.62*** (755.2)
Observations	602	602	602	602	602	602	602	602	602
R-squared	0.028	0.359	0.956	0.028	0.359	0.956	0.028	0.359	0.956
Number of provinces	9	9	9	9	9	9	9	9	9
chi2 (Wald test)	293.1***	213.2***	321.9***	9.520***	9.810***	9.612***	17.05***	17.69***	18.40***
z-stats in parentheses									
*** p<0.01, ** p<0.05, * p<0.1									

From Table 11, a coefficient of 0.0333, which shows the change in the unemployment rate in the FLGS model, suggests that, after accounting for endogeneity and serial correlation, a one per cent increase in the unemployment rate is associated with a 0.0333 per cent increase in GDP. This result is statistically significant at the 1 per cent level, indicating that the relationship between the change in unemployment and GDP growth is both strong and reliable, even after addressing potential econometric issues such as endogeneity and serial correlation. The consistency of the positive effect in Okun’s coefficient across the FLGS model further reinforces the robustness of the finding, suggesting that, in the long run, increases in the unemployment rate do not adversely affect economic output in the case of South Africa.

Although the positive relationship between increases in unemployment rates and GDP growth can seem counterintuitive, in recent times, scholars⁴ have suggested different factors that explain this phenomenon. Oner (2020) argues that unemployment does not fall in lockstep with an increase in growth. Higher output may be achieved by having the same number of employees doing more work as the companies try to recover from economic downturns. Also, structural unemployment may persist even during periods of strong economic growth because of skills mismatch, usually resulting from shifts in industry composition or technological advancement (Pettinger, 2019). Similarly, improvements in productivity due to automation can result in improved efficiency and subsequent higher output, accompanied at times by job displacements. Moreover, increasing the unemployment rate caused by more people entering the job market may coincide with GDP growth (Suma, 2017).

⁴Oner, 2020; Pettinger, 2019; and Suma, 2017.

Table 11. Empirical Results for the FGLS Model

Error structure across the panels	FGLS: Long run results					
	Independent and Identically distributed (IID)			Heteroscedastic but uncorrelated		
Form of Autocorrelation	Independent	AR(1)	Panel-specific AR(1)	Independent	AR(1)	Panel-specific AR(1)
Model	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln_diffgdpr	ln_diffgdpr	ln_diffgdpr	ln_diffgdpr	ln_diffgdpr	ln_diffgdpr
diffunempet	0.0333*** (4.130)	0.0349*** (4.205)	0.0358*** (4.289)	0.00278* (1.851)	0.00287* (1.824)	0.00310** (1.961)
Constant	14.62*** (662.0)	14.62*** (746.4)	14.62*** (755.2)	14.64*** (4,064)	14.64*** (4,484)	14.64*** (4,426)
Observations	602	602	602	602	602	602
Number of provinces	9	9	9	9	9	9
chi2 (Wald test)	17.05***	17.69***	18.40***	3.426*	3.327*	3.847**
z-stats in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

Conclusion and Policy Implications

Conclusion

The empirical analysis of Okun's Law across the three baseline models, that is, the DFE, MG, and PMG, provides valuable insights into the relationship between changes in the unemployment rate and GDP growth in South Africa. In the short run, the baseline models showed mixed results, with DFE and MG suggesting a very small and statistically insignificant negative relationship between changes in unemployment rate and GDP growth, while the PMG indicated a statistically significant small positive relationship. In contrast, the long-run relationships highlighted a more consistent and statistically significant positive effect of unemployment rate increases on GDP growth.

The introduction of more advanced estimators, namely the PCSE and the FLGS, improved the robustness of the results by addressing challenges of heteroscedasticity, contemporaneous correlation, and endogeneity. Both the PCSE and FLGS models revealed a positive and statistically significant relationship between the change in the unemployment rate and GDP growth in the long run.

Overall, the results suggest that, while the short-run impact of unemployment on GDP is less clear, the long-run effects, as well as those estimated using more advanced econometric techniques, indicate a positive and significant relationship, debunking the relevance of Okun's Law in understanding the dynamics between unemployment and economic output. For instance, in the Northern Cape province, despite experiencing high economic growth, unemployment remains persistently elevated. This observation underscores the non-relevance of Okun's 1962 study, which was based on a model with only two factors of production, labour (L) and capital (K). In contrast, the modern production environment incorporates a third

factor, artificial intelligence (AI), alongside labour and capital. Additionally, labour in South Africa is inherently expensive, largely due to the influence of powerful trade unions. Also, in sectors such as mining, where deep and hazardous mines are now safely operated with the use of robotic technologies, the role of labour in the productive apparatus has significantly declined.

Therefore, the necessary economic policy orientation to address high unemployment rates and low GDP growth in South Africa should not be anchored on the intuitive inverse relationship of the two variables. Instead, a mixture of policies that directly and indirectly target unemployment and improved productivity should be implemented. Such policies should be deployed from both the demand side and the supply side. For example, the expansionary demand-side policies like increased government spending on infrastructure projects, public services, and social welfare programs can directly boost employment by creating jobs and increasing consumption. On the supply side, policies that seek to improve productivity, while at the same time making some labour market reforms to directly address unemployment, would help stabilise the economy. Therefore, to address the positive long-term relationship between unemployment and GDP growth highlighted in our study, policymakers should adopt a balanced approach that combines demand stimulation with structural reforms aimed at reducing unemployment. These efforts should be complemented by investments in human capital and incentives for private sector job creation to ensure sustained long-term economic growth.

Limitations

This study had its limitations, like any other study. Firstly, the study uses quarterly data from 2008 to 2024, which provides a relatively short time frame for testing Okun's Law. While this period covers various economic cycles, including the 2008 financial crisis and the subsequent recovery, it may not fully capture the long-term structural shifts or longer-term trends in the South African economy. Additionally, potential data quality issues or gaps in reporting across provinces could limit the accuracy of the results. Secondly, while the models applied in this study accounted for the provincial heterogeneity to some extent, the vast economic differences between provinces may still lead to biases in the estimation of Okun's coefficient. For instance, while the PMG model allows for different short-term dynamics, it assumes common long-term relationships across provinces, which may not always hold due to the provincial differences in labour markets and industrial sectors. Equally, the DFE model assumes time-invariant individual effects, which might not be true in the presence of rapidly changing economic conditions in South Africa.

Recommendations

We recommend that future studies extend the time frame of the study to include data before 2008 and provide a more comprehensive view of the long-term dynamics between economic growth and unemployment, especially in periods of economic stability and crises. Moreover, future studies should incorporate other relevant variables, such as AI, labour market policies, migration patterns, and provincial differences in

education levels, to gain a more holistic understanding of the factors influencing the relationship between GDP growth and unemployment. Further research could explore whether structural breaks have occurred in the relationship between economic growth and unemployment, especially due to the adoption of AI and automation, which might lead to job displacement in the mining and agricultural sectors of South Africa.

References

- Aaronson SR, Daly MC, Wascher WL, Wilcox DW (2019) Okun revisited: Who benefits most from a strong economy? *Brookings Papers on Economic Activity*, 2019(1), 333-404.
- Al-Habees MA, Rumman MA (2012) The relationship between unemployment and economic growth in Jordan and some Arab countries. *World Applied Sciences Journal*, 18(5), 673-680.
- Ali A, Osman A, Hassan AY, Osman M (2022). Macroeconomic determinants of unemployment in Somalia: the case of Okun's law and the Phillips Curve. *Asian Economic and Financial Review*, 12(11), 938-949.
- Baltagi BH, Baltagi BH (2008) *Econometric analysis of panel data* (Vol. 4, pp. 135-145). Chichester: John Wiley & Sons.
- Banda H, Ngirande H, Hogwe F (2016) The impact of economic growth on unemployment in South Africa: 1994-2012. *Investment Management and Financial Innovations* (13, Iss. 2 (contin1)), 246-255.
- Christopoulos DK (2004) The relationship between output and unemployment: Evidence from Greek regions. *Papers in Regional Science*, 83(3), 611-620.
- Conteh K (2021) *Economic growth and unemployment: An empirical assessment of Okun's law in the case of Liberia*.
- Dajcman S (2018) A regional panel approach to testing the validity of Okun's Law: The case of Slovenia. *Economic Computation & Economic Cybernetics Studies & Research*, 52(3).
- Evans GW (1989) Output and unemployment dynamics in the United States: 1950-1985. *Journal of Applied Econometrics*, 4(3), 213-237.
- Gonese D, Sibanda K, Ngonisa P (2023) Trade openness and unemployment in selected Southern African Development Community (SADC) Countries. *Economies*, 11(10), 252.
- Hjazeen H, Seraj M, Ozdeser H (2021) The nexus between the economic growth and unemployment in Jordan. *Future Business Journal*, 7(1), 42.
- Ibourk A, Elaynaoui K (2024) Policy lessons from Okun's law for African countries. *International Review of Applied Economics*, 1-30.
- Jacob P, Wong MG (2018) *Estimating the NAIRU and the natural rate of unemployment for New Zealand*. Reserve Bank New Zealand.
- Khan I, Xue J, Zaman S, Mehmood Z (2023) Nexus between FDI, economic growth, industrialization, and employment opportunities: empirical evidence from Pakistan. *Journal of the Knowledge Economy*, 14(3), 3153-3175.
- Lancaster D, Tulip P (2015) *Specification Issues | RDP 2015-14: Okun's Law and Potential Output*. Reserve Bank of Australia Research Discussion Papers, (December).
- Marinkov M, Geldenhuys JP (2007) Cyclical unemployment and cyclical output: An estimation of Okun's coefficient for South Africa. *South African Journal of Economics*, 75(3), 373-390.
- Miller S, Startz R (2018) *Feasible generalized least squares using machine learning*. Available at SSRN 2966194.
- Oner C (2020) *Unemployment: The Curse of Joblessness*. International Monetary Fund.

- Pettinger T (2019) *Structural Unemployment*, Economics. <https://www.economicshelp.org/blog/27657/unemployment/structural-unemployment/>
- Priambodo A (2021) The impact of unemployment and poverty on economic growth and the human development index (HDI). *Perwira International Journal of Economics & Business*, 1(1), 29-36.
- Suma S (2017) Analysing the relationship between unemployment and economic growth. *JETIR*. Volume 4, Issue 10
- Tabash MI, Farooq U, Safi SK, Shafiq MN, Drachal K (2022) Nexus between Macroeconomic Factors and Economic Growth in Palestine: An Autoregressive Distributed Lag Approach. *Economies*, 10(6), 145.
- Villaverde J, Maza A (2009) The robustness of Okun's law in Spain, 1980–2004: Regional evidence. *Journal of Policy Modeling*, 31(2), 289-297.
- Wooldridge JM (2009) *Econometrics: Panel Data Methods*.