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Asymmetric Effect of GDP on Unemployment in North African Group Countries According to Okun's Law

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Abstract: The purpose of this work is to study Okun's law in a sample of North African economies (Algeria, Tunisia, Morocco, Libya, and Egypt) by examining the impact of the output gap on the unemployment gap and contributing to economic growth to reduce unemployment. These investigations aim to fill a significant gap in the empirical literature on the motives of Okun law in developing countries in general and North African countries in particular. The panel nonlinear ARDL model was used to examine the presence of Okun's law in North African economies over the period 1991-2023. The results of testing Okun's law in the sample of selected countries showed that Okun's law is valid for North African countries but in smaller amounts than those reached by Okun (between -2 and -3). Algeria recorded the highest value of -0.36. In addition, it was noted that the negative impact of GDP on unemployment rates is more significant than the positive impact in all the countries under study and is more critical in the cases of Algeria and Egypt. The study recommends prioritising economic growth through investments in labour-intensive sectors such as agriculture and industry, reducing bureaucratic inefficiencies, combating corruption, and fostering a favourable investment climate.

Moreover, actions that can be taken involve improving training initiatives and implementing policies that promote the sector to stimulate the growth of stable employment opportunities. As a result, these empirical research findings regarding Okun's Law are essential in shaping nations' economies and offer actionable suggestions for policymakers.

Keywords: Okun's law, unemployment rate, GDP, inflation rate, ARDL

Introduction

North African countries face significant challenges related to unemployment and economic growth. High unemployment is a major obstacle affecting social and financial stability in the region, as it increases poverty and crime rates and weakens the social fabric. In contrast, the macroeconomic policies of North African governments have not been able to achieve a sustained reduction in unemployment. It has also been unable to maintain economic growth, as it recently went into recession. After the economic downturn of the late 1980s and early 1990s, unemployment problems revert to the hasty introduction of an economic reform program.

Economic growth is the key to tackling unemployment, as it contributes to creating new jobs and improving the standard of living. Economic growth can reduce unemployment, stabilise inflation, and promote innovation to achieve inclusive and sustainable economic growth. Economic growth also allows for the emergence of entrepreneurs who reduce unemployment by creating new jobs.

Many studies have proven that the relationship between economic growth and unemployment worldwide is conflicting. Some studies have shown a positive relationship, while others have shown an inverse relationship, and we will present this in the second part of this work.

Research Problem

The value of this work compared to previous studies on the same topic includes the use of the Panel Nonlinear Ardl model. Through this work, we will try to provide an advanced way to examine the existence of Okun's law, which will enhance the accuracy of the results and contribute to a deeper understanding of the relationship between GDP and unemployment in North African countries.

The research will also include a comprehensive analysis from 1991 to 2023, providing a long-term view of the evolution of the relationship between GDP and unemployment.

In addition, we will try to focus in particular on North African countries, while most of the previous studies focused on developing countries in general. This research will also focus on North African countries, filling a gap in the empirical literature on this region.

Research Aim and Research Questions

This study seeks to investigate Okun's Law within a selection of North African economies (Algeria, Tunisia, Morocco, Libya, and Egypt) by assessing the influence of the output gap on the unemployment rate gap. The research addresses a notable deficiency in the literature about Okun's Law in emerging nations, focusing on North African countries. The objective is to assess the applicability of Okun's Law in these nations utilising the Panel Nonlinear ARDL model from 1991 to 2023. This study will analyse the relationship between GDP and unemployment, emphasising the variations in this relationship among nations, particularly in Algeria and Egypt. The research will examine critical inquiries, including: Is Okun's Law applicable to the economies of North Africa? How robust is this relationship in comparison to the conventional values of Okun's Law? In what ways does the influence of GDP on unemployment differ among countries? The study will examine essential strategies to bolster economic growth in these nations, including increasing investments in labour-intensive industries and formulating social and monetary policies. The research will offer a novel contribution by employing a

nonlinear panel model to enhance result accuracy and deepen the knowledge of the relationship between GDP and unemployment in this region.

Literature Review

The relationship between gross domestic product (GDP), inflation, and the unemployment rate is a core macroeconomic issue and has been extensively researched by many researchers. Let's examine the studies that have explored the connection between GDP and inflation rates on unemployment.

The Negative Link Between Economic Growth and Unemployment

Many research papers have looked into the relationship between growth and unemployment, which is going in different directions rather than positively correlated. In a study by Hjazeen et al. (2021), the impact of unemployment on Jordan's economy was analysed from 1991 to 2019 through the auto-regressive distributed lag (ARDL) model. The study revealed a connection between economic growth and unemployment levels in Jordan, underscoring the importance of tackling unemployment as a key factor for ensuring continuous economic progress in the country. Furthermore, Altunöz (2024) investigates the relationship between unemployment and actual output for OECD nations from 2007 to 2022. They utilise Okun's Principle. Law to Explore the idea of unemployment inertia.

Their discoveries support the idea that when GDP goes up, unemployment goes down – indicating that a higher GDP leads to higher unemployment rates. The research highlights the enduring importance of Okun's Law, which states a correlation between unemployment and economic growth. Muhammad (2023) investigates the effects of unemployment and inflation on economic development, indicating that while unemployment positively correlates with growth, its influence is not statistically significant. The study highlights the substantial impact of inflation on economic growth and underscores the imperative for effective strategies to manage both inflation and unemployment to foster overall financial stability. The combined research emphasises decreasing joblessness within a plan to promote expansion and stability.

The Negative Link Between Inflation and Unemployment

Niken et al. (2023) looked into how inflation and unemployment relate to economic growth in Ethiopia based on data from 1980 to 2020. Their research using VAR and ECM models unveiled interconnected dynamics among these factors. The long-term data indicates that inflation and unemployment have limited effects on Ethiopia's economic development, which suggests that these factors may not be crucial for the country's growth trajectory. Inflation shows a negative correlation with unemployment.) The paper recommends that Ethiopia focus on labour-intensive industries and enhance productivity, especially in agriculture, to sustain income growth and effectively manage inflation.

The Positive Correlation Between GDP and the Unemployment Rate

Ben Amor (2023) investigates the relationship between economic growth and unemployment in Tunisia, assessing Okun's Law using data from 1980 to 2020. A significant long-term association exists between actual output and unemployment, such that a 1% increase in production leads to a 1.6% reduction in unemployment. The analysis highlights the importance of employment-focused economic strategy in addressing these tendencies in Tunisia.

The Positive Correlation Between the Inflation Rate and the Unemployment Rate

Numerous studies examine the positive association between inflation and unemployment. Using panel data and regression analysis, Fauzan et al. (2023) investigate the correlation among income inequality, economic growth, inflation, and unemployment in West Java Province. The findings demonstrate that income inequality, inflation, and unemployment negatively influence economic growth, particularly affecting unemployment. In contrast, economic development and inflation positively correlate with increased unemployment rates. Buthelezi (2023) examines the influence of

inflation on unemployment in South Africa, utilising data from 2008 to 2022 within the framework of the Phillips curve. The analysis identifies two unemployment scenarios, indicating that a 1% increase in inflation raises unemployment by 2.61% in one scenario, while in the other, it slightly decreases unemployment by 0.06%. This suggests that the Phillips curve relationship lacks consistent reliability, and the study recommends improving job opportunities and reassessing the trade-offs between inflation and unemployment. Robu (2023) analyses the impact of inflation on unemployment rates across genders, concluding that women are more predisposed to accept low-wage employment, resulting in lower unemployment rates among them. In contrast, men typically avoid such roles, resulting in higher unemployment rates. The research demonstrates that during periods of heightened inflation, low-income workers, particularly women, are disproportionately affected, leading to a rise in female unemployment. Conversely, during periods of low inflation, women's unemployment declines as they accept lower-paying jobs, which, nonetheless, reduces their standard of living. The study aims to investigate gender discrepancies in inflation and unemployment while providing policy recommendations to alleviate the impacts of unemployment.

Materials and Methods

This study examines the asymmetric effects of GDP on unemployment rates in a selection of North African countries (Algeria, Tunisia, Morocco, Libya, and Egypt) using data from 1991 to 2023. The research adopts a correlational design, employing the Panel Nonlinear ARDL model to explore the relationship between the variables. The study examines how the output gap influences the unemployment gap in adverse ways in developing economies, using Okun's law as a framework for analysis. Data on unemployment, GDP, and inflation rates were gathered from accessible sources like the World Bank. An in-depth statistical analysis was conducted to uncover patterns and fluctuations in the data with tests for stationarity confirming that the variables are appropriate for dynamic modelling. Estimations were conducted using MG, PMG, and DFE methods to account for heterogeneity across the countries. The Hausman test was employed to identify the optimal estimation approach.

Study Variables Data Sources

Annual data were used for the unemployment rate, domestic product, and inflation rate in the selected North African countries sample (Algeria, Tunisia, Morocco, Libya, and Egypt) extracted from the World Bank (n.d.). The unemployment and inflation rates were expressed in percentages, while the domestic product was expressed in billions of US dollars. The study methodology will be divided into several parts, starting with the descriptive analysis of the variables to determine the extent of these variables' development during the approved study period (1993–2023). Then, we move to the stationarity of the variables study to ensure that there is no stable variable in the second difference and then to conduct a dynamic non-linear panel model test to find out whether there is a similar or asymmetric impact of the GDP on unemployment rates in the North African countries. This is to ascertain the validity of the law of the selected countries.

Descriptive Analysis of Model Variables

The descriptive analysis aims to give an overview of the trends of the variables under study from a statistical point of view. It also tests the normal distribution through the kurtosis coefficient and the probability of Jarque-Bera (Domański, 2010).

Table 1

Analyse Descriptive Statistics of Variables

Country	Value	LNUNEMP	LNGDP	LNINF
ALGERIA	Mean	2.793	41.502	1.665
	Std.dev	0.421	1.045	0.985
	Min	2.284	37.481	-1.081
	Max	3.461	42.305	3.455
TUNISIA	Mean	2.716	24.926	1.437
	Std.dev	0.101	0.321	0.394
	Min	2.515	24.303	0 .684
	Max	2.909	25.296	2.233
MOROCCO	Mean	2.391	38.484	0.585
	Std.dev	0.177	0.997	0 .850
	Min	2.187	35.951	-1.193
	Max	2.645	39.316	2.078
LYBIA	Mean	2.952	28.996	1.117
	Std.dev	0.015	5.592	1.406
	Min	2.924	24.421	-2.282
	Max	2.978	37.072	3.252
EGYPT	Mean	2.276	40.064	2.145
	Std.dev	0.180	1.019	0.669
	Min	1.989	37.746	0.820
	Max	2.576	41.140	3.523

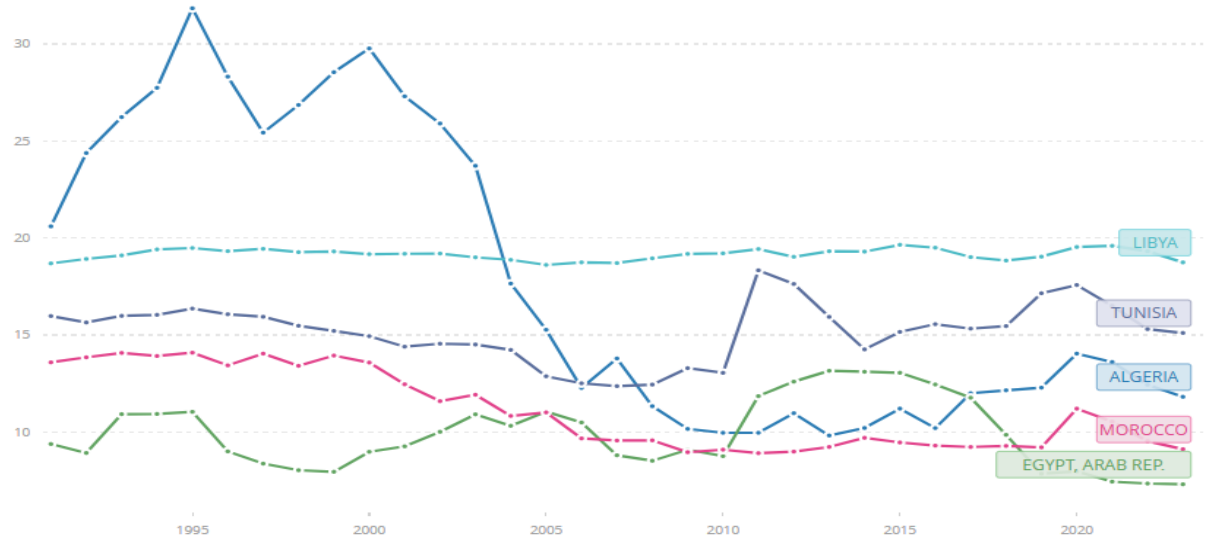
Source: Prepared by the researcher using Stata 17.

Table 1 summarises the descriptive statistics on the study variables (unemployment rate, GDP, and inflation rate) for each North African country (Algeria, Tunisia, Morocco, Libya, and Egypt) separately.

The average unemployment rate in the countries under study reached 13.79%, the same rate that Algeria recorded, and Tunisia recorded an average of 15.33%. The average unemployment rate in Morocco, Libya, and Egypt reached 10.54%, 19.19%, and 9.38% during the study period (1991–2023). Algeria recorded the highest unemployment rate during the study period (1991–2023) compared to the rest of the countries in 1995 at a rate of 31.84%. The reason is due to the security conditions that prevailed in the country at the time, in addition to the transition of the Algerian economy from socialism to a market economy (1990-2000) in contact with international financial institutions, which imposed a series of reforms similar to the privatisation of sectors, which resulted in the dismissal of thousands of workers who lost their jobs.

Figure 1

Unemployment Rate in North African Group Countries

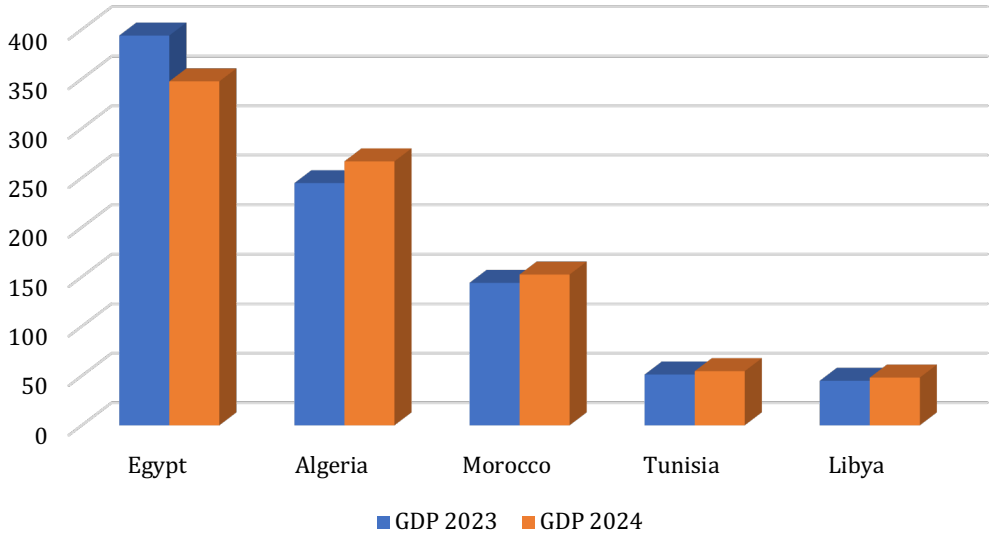


Source: World Bank Group (n.d.).

Figure 2 shows the ranking of the countries under study in terms of total output for 2023, as follows: Egypt first with 387.1 billion US dollars (the second Africa after South Africa and 44 globally). Algeria comes second with US $239.9 billion (third in Africa and 51 globally). Morocco followed with US $152.4 billion (sixth in Africa and 61 globally). Tunisia with US $54.7 billion (14 Africa). Finally, Libya had 48.2 billion US dollars (16 Africa).

Figure 2

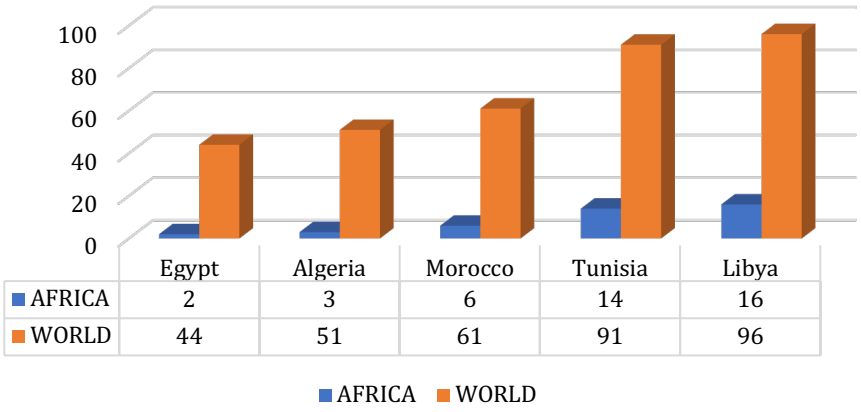
GDP in North Africa Group Countries (in Billions of USD)



Source: https://statisticstimes.com/

Figure 3

Ranking of North African Group Countries by their GDP (in Billions of USD)



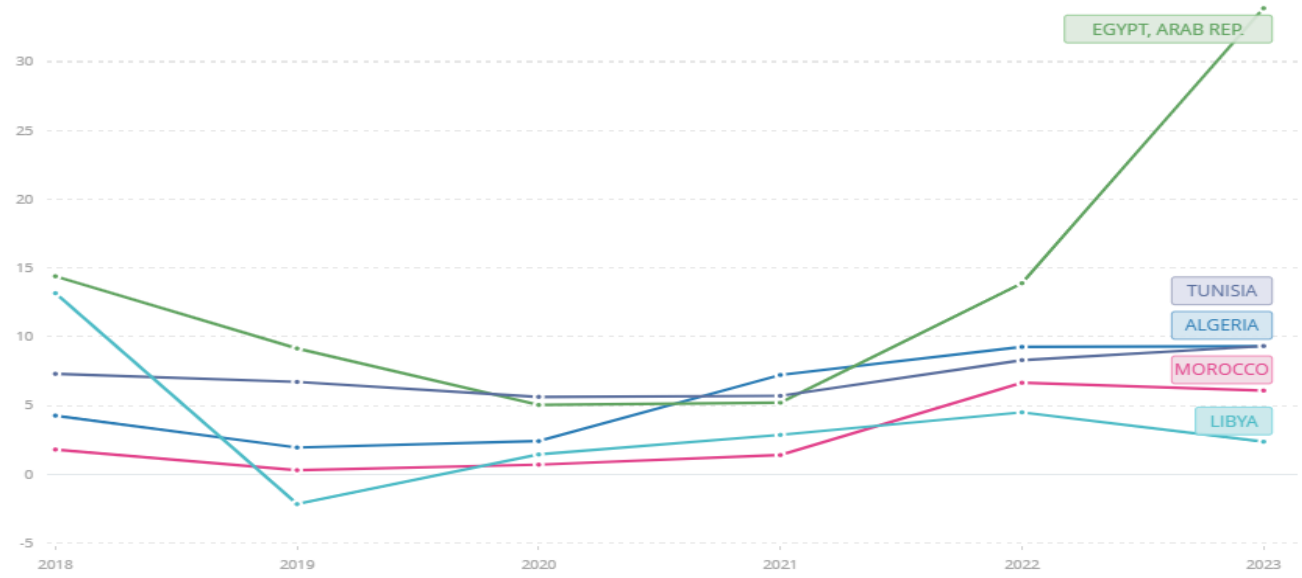
Source: https://statisticstimes.com/

The average inflation rate reached 4.34% in the total countries during the study period, and Egypt recorded the highest inflation rate among countries, reaching 33.9% in 2023 and 13.9% in 2022, an increase of 143.88%, an increase of about one and a half times (Figure 3). This is due to the Ukrainian-Russian crisis, a significant reason for the rise in inflation, as Egypt relies heavily on Russia and Ukraine to import wheat. Restrictions on the global grain market have led to a doubling of wheat import prices, significantly impacting Egypt's food costs and the global rise in oil prices, which increased the cost of production and manufacturing in Egypt, where Egypt imports about 100 million barrels of oil annually.

The lowest inflation rate recorded by Libya among the North African countries under study, reaching 2.4% in 2023. This is due to the stability of oil production after a decline due to the unstable security situation. Libya has witnessed an improvement in this field. Security stability contributed to sustained oil production, which helped boost economic returns and reduce inflationary pressure. Not to mention the Libyan authorities' implementation of monetary and fiscal policies to help control inflation. For example, the management of foreign reserves has been improved and used more efficiently to support price stability.

Figure 4

Inflation rate in North African Group Countries (2028–2023)



Source: World Bank (n.d.).

Study Model

To study the validity of the Okun Law in a sample of North African economies (Algeria, Tunisia, Morocco, Libya, and Egypt) during the period 1991–2023, the positive and negative impact of the output gap on the gap in unemployment rates will be examined. For this purpose, the employment rate will be considered a dependent variable, and the GDP and inflation rate inf will be independent variables. Dependence on the dynamic nonlinear panel model will be used to test the asymmetry between GDP and unemployment rates.

Okun's research in 1962 became among the most critical macroeconomic conclusions related to unemployment and growth. Economist A. Okun conducted two experimental tests on the relationship between the unemployment rate and actual output during his study from 1947 to 1957, in which he found an inverse relationship between unemployment rates and actual production. A decrease in the real output rate by 3% leads to an increase in the unemployment rate by 1% (Okun, 1963).

Evolution of Okun's Law

The relationship to which Oken contributed to the expansion of its circle of uses, especially since the latter did not confirm the existence of an inverse relationship between the economic growth rate and unemployment, which is the hypothesis based on which the relationship was adopted in most of the bilateral and triangular relations between the unemployment rate, the growth rate of the informal economy and the growth rate of the informal economy, in addition to the indirect ties between (Oken) the size of the informal economy and GDP, and the measure of impact between the unemployment rate and actual output in a way called the first Difference Version Formula. The second is called the Gap Version Formula and can be clarified through the following.

Difference version:

$$\Delta \boldsymbol{u} = \boldsymbol{\beta} - \boldsymbol{\alpha g} \tag{1}$$

So, u is the unemployment rate, g is the growth rate, α is the coefficient, β is the model's constant.

Gap version:

$$\frac{\boldsymbol{y}-\boldsymbol{y}^{-}}{\boldsymbol{y}^{-}} = \boldsymbol{c}\,(\boldsymbol{u}-\boldsymbol{u}^{-}) \tag{2}$$

So that: the y^{-}output that achieves potential growth, the research u^{-}coefficient, the natural unemployment u^{-} y^{-} rate, the natural unemployment rate. These two formulas are the essential formulas used in the analysis of deviations in the change in output resulting from the change in unemployment rates for any change in the rate of economic growth due to the ease of presenting the results reached and the uncomplicated interpretations related to them referred to in Okun's law.

The model of the relationship between the unemployment rate and the rate of economic growth contributed to adjusting the relationship between the two according to the requirements of modern variables. It explains the rate of economic development other than the integrated (formal and informal growth) through the two laws that were adopted by each of several academic papers dealing with informal economic growth, which came as follows:

$$\boldsymbol{g_t^y} = \boldsymbol{\alpha \Delta u_t} + \boldsymbol{\beta g_t^n} + \boldsymbol{\varepsilon_t} \tag{3}$$

So: g_t^y It expresses a difference between the official economic growth rate and(informal growth) across the average series of economic growth rates during the study period, it expresses the first differences of Δu_t the unemployment rate, it expresses the difference between the size of the informal economy, which is marked by the letter of the size of the informal economy during the study period, the

informal economic growth rate and the method of the average series size of the informal economy during the study period and the rand indices ε_t error of the model.

We will limit ourselves to the "Gap Version" method in this work. The non-linear dynamic panel model will be used where the series of the dependent variable represented by the unemployment rate is unstable at level I(0) and stabilises after making the first difference I(1). The equation of the model we are estimating will be according to the figure:

$$\boldsymbol{u_{gapt} = \beta_0 + \beta_1 GDP_{gap1} + \beta_2 inf_t + \varepsilon_t} \quad (4)$$

This version of Panel-Nardl, referred to as ARDL nonlinear panel data, allows for an asymmetric response to GDP on the unemployment rate. In other words, under this scenario, the positive and negative effects of GDP are not expected to have similar effects on unemployment rates. Thus, the asymmetric version of the model is expressed below:

$$\boldsymbol{\Delta U_{it} = \beta_{0i} + \beta_{1i} U_{i,t-1} + \beta_{2i}^{+} GDP_{t-1}^{+} + \beta_{2i}^{-} GDP_{t-1}^{-} + \sum_{j=1}^{N1} \delta_{ij} \Delta U_{i,t-j} + \sum_{j=0}^{N2} \left(\sigma_{ij}^{+} \Delta GDP_{t-j}^{+} + \sigma_{ij}^{-} \Delta GDP_{t-j}^{-}\right) + \mu_i + \epsilon_{it}} \quad (6)$$

Where:

U_{it}: Unemployment rate per country *i* over some time *t*

GDP: representing oil prices during the period t

μ_i: group-specific effect

i: Represents the group of sample countries

t: Represents the period of study

$GDP_{t-1}^{-}, GDP_{t-1}^{+}$: Positive and negative effects are represented respectively:

The error correction coefficient is expressed in the equation:

$$\boldsymbol{\Delta U_{it} = \tau_i \omega_{i,t-1} + \sum_{j=1}^{N1} \delta_{ij} \Delta U_{i,t-j} + \sum_{j=0}^{N2} \left(\sigma_{ij}^{+} \Delta GDP_{t-j}^{+} + \sigma_{ij}^{-} \Delta GDP_{t-j}^{-}\right) + \mu_i + \epsilon_{it}} \quad (6)$$

It $\omega_{i,t-1}$ expresses the long-term error correction coefficient.

This work will be based on the study presented by Mihajlović (2020), who tried to study the validity of the Okun Ali Law in Serbia and relied on both the GDP and inflation rate as independent variables, but by projecting it to the North African countries using the dynamic non-linear panel model Panel Nonlinear Ardl

Results

The study confirms the validity of Okun's law in the selected countries but finds coefficients significantly smaller than those reported in Okun's original findings (-2 to -3). Algeria demonstrated the highest coefficient (-0.36), while Libya's and Egypt's coefficients were less pronounced. The results indicate that GDP's negative impact on unemployment is consistently more substantial than its positive effects. Inflation was observed to affect unemployment in a manner that aligns with the Phillips Curve. The error correction process uncovered enduring balance connections in Tunisia, Morocco, and Libya; however, the outcomes were not as strong in Algeria and Egypt. These discoveries underscore the diversity and structural distinctions within the area.

Correlation Matrix Between Variables

Table 2

Correlation Matrix

	LNUNEMP	LNGDP	LNINF
LNUNEMP	1.00		
LNGDP	-0.37	1.00	
LNINF	0.02	0.12	1.00

Source: Authors' computation using Stata 17 software.

The results of the correlation matrix shown in Table 2 show that the variables are not related to each other and, therefore, that there is no problem of multicollinearity between them. These results help us conduct the rest of the tests normally without any correlation problems.

Studying the Stationarity of Time Series

In this part, the temporal properties of the variable used in this study will be tested using panel unit root tests such as Augmented Dickey-Fuller (ADF), Phillip Perron (PP), Im, Pesaran, and Shin (IPS), and Levin, Lin, and Chu (LLC) (Harris, 1992; Im et al., 2003; Levin et al., 2003, Perron, 1988). The rule of thumb is that if the absolute p-value for an LLC test, IPS test, ADF test, or PP test is less than 5 per cent of the critical value, the tested variable will be considered stationary or not contain a unit root. On the other hand, if the absolute probability value of an LLC test, IPS test, ADF test, or PP test is greater than 5 per cent of the critical value, then the tested variable is judged to be unstable or contain unit root and as shown in Table 3, the GDP is stationary at level while the rest of the variables all stationary after making the 1st difference and thus we treat the GDP as I(0) and the rest of the variables as I(1). All variables are transformed and expressed by including the logarithm at the estimation level.

Table 3

Stationarity Test

	Level Form								
	LLC			IPS			ADF		
	T-Stat	P-Value	IMPL	T-Stat	P-Value	IMPL	T-Stat	P-Value	IMPL
LNUNEMP	-0.77	0.22	Non-Stationary	-1.10	0.13	Non-Stationary	0.23	0.41	Non-Stationary
LNGDP	-2.55	0.01	Stationary	-2.60	0.00	Stationary	9.36	0.00	Stationary
LNINF	-0.57	0.29	Non-Stationary	-1.42	0.08	Non-stationary	4.44	0.00	Stationary
	Difference Form								
LNUNEMP	-3.77	0.00	Stationary	-4.67	0.00	Stationary	22.41	0.00	Stationary
LNGDP	-5.56	0.00	Stationary	-7.69	0.00	Stationary	55.41	0.00	Stationary
LNINF	-5.41	0.00	Stationary	-6.60	0.00	Stationary	45.63	0.00	Stationary

Source: Authors' computation using Stata 17 software.

Optimal Lag Order for the Panel-ARDL Model

After conducting the unit root tests (Table 3), we ensured there was no stable time series of the second degree. Therefore, at this stage, the Panel-ARDL model for dynamic panel data will be estimated using the following estimation methods: MG average estimators, PMG average estimators, and the DFE method. These methods give the long and short-term parameters and the parameter of the speed of adjustment to the balance in the long term. However, before that, the optimal slowness periods for the Panel-Ardl model will be determined, as shown in Table 4.

Table 4

Lag Length Criteria

	LNUNEMP	LNGDP	LNINF
Algeria	1	0	0
Tunisia	1	1	0
Morocco	1	0	0
Libya	2	0	0
Egypt	2	0	0
Lag Length	1	0	0

Source: Authors' computation using Stata 17 software.

The results of Table 4 show that the lowest value of the slowdown period for the variables unemployment rate, GDP, and inflation rate are respectively 1, 0, and 0. Therefore, the dependent variable represented by the unemployment rate is slowed down by one period Lag (1) only, while the rest of the variables are at the level.

Panel NARDL: MG, PMG, and DFE Estimators

From the unit root test results in Table 3, we can say that the variables combine stationarity between I(0) and I(1), so we can estimate the Panel-ARDL model.

We will apply the (1,0,0) Panel Non-linear ARDL model using the positive and negative impact of the GDP for the estimation of PMG, MG, and DFE to the panel data of the studied group of countries to obtain the coefficients of the relationship between the variables of the model. Then, we will apply a test for the binary comparison between the estimates of MG, PMG, and DFE to determine which methods are most preferred so that we can provide a consistent and effective result by testing the null hypothesis of homogeneity restrictions. The Hausmann test results are in Table 5 (Amini et al., 2012). This indicates the rejection of the null hypothesis, meaning that the MG method is appropriate in this case.

Table 5

Panel-NARDL Estimations Okun's Law for North Africa Group Countries

	MG			**PMG**			**DFE**		
	COEFF	Std-error	p-value	COEFF	Std-error	p-value	COEFF	Std-error	p-value
Long Run									
LNINF	-0.004	0.075	0.953	-0.070	0.030	0.018**	0.068	0.118	0.566
LNGDP +	-0.260	0.265	0.327	-0.056	0.035	0.109	0.003	0.044	0.941
LNGDP -	0.057	0.430	0.895	0.013	0.041	0.759	0.011	0.047	0.823
Short Run									
ECT	-0.307	0.084	0.000**	-0.188	0.086	0.029**	-0.069	0.031	0.028
D.LNINF	0.009	0.014	0.502	0.011	0.006	0.092	-0.006	0.010	0.545
D.LNGDP +	-0.368	0.352	0.296	-0.336	0.329	0.307	-0.003	0.004	0.491
D.LNGDP -	-0.217	0.250	0.386	-0.158	0.165	0.338	0.000	0.004	0.945
C	0.888	0.240	0.000**	0.550	0.243	0.024**	0.172	0.083	0.039**
OBS	32			32			32		
Hausman test									

MG	PMG	Prob>chi2	0.229	PMG is efficient
DFE	PMG	Prob>chi2	0	DFE is efficient
MG	DFE	Prob>chi2	0.987	MG is efficient
R2	**0.93**			
Wooldridge test for autocorrelation in panel data				
F (1.4)	0.008	Prob > F	0.93	
Wald test for asymmetric effect				
Short term				
	Chi 2 (1)	1.17	Prob > chi2	0.279
Long term				
	Chi 2 (1)	45.73	Prob > chi2	0

The research found effects, in countries. Algeria had a more pronounced negative correlation while Libya's results were influenced by its reliance on oil production. Recent research studies like Pizzo (2020) corroborate the role of economic structure in influencing Okun's coefficients.

The PMG and DFE MG estimation results were calculated, and then the results were subjected to a test (Hausman, 1978) to determine the appropriate method of use. Rejection of the null hypothesis indicates the absence of proper long-term homology (MG), while non-rejection of the null hypothesis suggests the existence of appropriate long-term homology (PMG). In this study, Hausmann's test result indicates that MG is the appropriate estimator as the null hypothesis is rejected, as shown in Table 3. Thus, the results will be explained by the preferred estimator, MG.

The asymmetry test using the Wald test (Wang et al., 2024) was significant in the long term and non-significant in the short term. The asymmetry hypothesis states no asymmetry (prob<0.05), while the alternative hypothesis states that there is asymmetry. Through the results of the table, the probability of prob=0.000<0.05 in the long term was reached, which leads us to accept the asymmetry hypothesis in the long term, which confirms the existence of a long-term equilibrium relationship between the unemployment rate, the domestic product, and the inflation rate.

The error correction coefficient was negative and moral using the MG and PMG methods. This indicates a long-term equilibrium relationship and the existence of a mechanism to correct the error from the long term to the short term by about 30%. At the level of each country separately, its signal was negative and moral in Tunisia, Morocco, and Libya with coefficients -0.34, -0.46, and -0.50, respectively, meaning that the adjustment periods in these countries need 3 years, 2 years, and 2 years respectively, and harmful and immaterial in the cases of Algeria and Egypt.

We now estimate the results of Oken's law by estimating Equation 2. Table 4 contains estimates of the Oken coefficient for North African countries by evaluating the three models (MG, PMG, and DFE).

The estimates of the Okun coefficient by the MG and PMG methods are -0.26 and -0.056, respectively. In the short term, the transactions using MG, PMG, and DFE were -0.36, -0.33, and 0.0029, respectively.

This suggests that Okun's law applies to North African countries (Algeria, Tunisia, Morocco, Libya, and Egypt), although its amount is much lower than that proposed by Okun (1963). However, the estimate of the Okun coefficient using the MG method is -0.36, which means that the increase in GDP by one unit leads to a decrease in the unemployment rate by 0.36 units, which is the most significant Okun

coefficient compared to the three methods used, although it is relatively far from the expected ratio between 2 and 3. The value of the coefficient is in line with several similar studies. For example, Doğru (2013) and Tatoğlu (2011), while discussing the size of Okun's coefficient, argued that although Okun (1963) himself found the coefficient to be between -2 and -3 in the United States, subsequent empirical studies have found that this coefficient is less than two have been notably low or nearly zero in emerging and developing countries (An et al., 2017; Lee et al., 2020; Pizzo, 2020).

When comparing the results of the Okun coefficient in each country separately, we find that it reached -1.30, -0.13, -0.04, -0.0016, and 0.24 in Algeria, Tunisia, Morocco, Libya, and Egypt, respectively. This indicates that the changes in the unemployment rate were more sensitive in Algeria compared to other countries, meaning that an increase in GDP by one unit leads to a decrease in the unemployment rate by 1.36 units, a rate somewhat close to the 1969 Okun coefficient (-2 and -3) and more significant than the one reached, which examined the impact of the output gap on the gap in unemployment rates in Saudi Arabia during the period 1991–2017 and reached a rise in GDP by 1%, which led to a decrease in the unemployment rate by 0.29% (Louail & Riache, 2019).

Noting the results of Table 6 (the estimation of the Okun model in each country), it appears that the Okun law is valid in the case of Tunisia and Morocco in particular, and this is because the increase in GDP^{+} leads to a decrease in the unemployment rate and vice versa. In contrast, in other countries, for example, in the case of Algeria, the increase in GDP+ leads to a decrease in unemployment. In contrast, the reduction in GDP leads to a decrease in the unemployment rate, which is incompatible with the Okun law, which is done using the MG method. In contrast, the Okun law becomes valid in the case of using the PMG method (the case of Algeria, Morocco and Egypt), and the same is true for Libya and Egypt.

Despite the difference in the estimation of the Okun coefficient using the three methods (MG, PMG, and DFE), one thing remains strikingly clear, which is that the Okun law remains valid in Algeria, Morocco, and Egypt compared to Tunisia and Libya (Figure 4), where we note that the negative impact of GDP on unemployment rates is more significant than the positive in all the countries under study and is more critical in Algeria and Egypt, while in Tunisia, the absence of asymmetry of GDP on unemployment (approaching the horizontal line of the curve) was observed.

Figure 5 shows the positive ($lngdp^{+}$) and negative ($lngdp^{-}$) impact of GDP on the unemployment rate in the five North African countries studied (Algeria, Tunisia, Morocco, Libya, and Egypt) over time from 1990 to 2020. The horizontal axis represents years, while the vertical axis represents relative changes in data (positive and negative).

In Algeria, the positive impact of GDP ($lngdp^{+}$) after 2000 was due to government investments in infrastructure and improvement in the business environment. Still, these investments were not enough to overcome challenges such as corruption and political instability (the negative impact $lngdp^{-}$ is greater than the positive $lngdp^{+}$ given Oken's short- and long-term transactions).In Tunisia, the relative stability in the impact of GDP on unemployment indicates that the economy did not witness significant changes or that the reforms were balanced, and the negative impact is due to the lack of investments to achieve substantial growth or to absorb the increase in the workforce.

Morocco has observed stability in the impact of positive and negative GDP. This reflects a relatively stable economic environment with gradual improvements, perhaps due to government policies that maintain economic stability but slowly stimulate significant growth.

In Libya, the significant increase in the positive impact of GDP after 2010 was attributed to the improvement in oil production after internal conflicts, which decreased the negative effect on unemployment. As for Egypt, the increase in the positive impact of GDP after 2000 is due to the economic reforms adopted by the state, such as liberalising the economy and increasing foreign investments. However, the negative impact appears to result from other factors, such as inflation and financial crises.

The impact of GDP on unemployment in these countries can be complex and depends on many economic, social, and political factors. Its economic growth focuses on sectors that do not need a lot of labour, such as the oil and gas sector (Algeria) or some heavy industries. This can lead to an increase in GDP without significantly impacting unemployment rates. Economic growth in these countries can also be non-inclusive, as the benefits do not reach all segments of society equally. This leaves a large number of people unemployed even if GDP rises. Workers in developing countries also lack the skills or education needed to enter jobs that require advanced skills, leading to structural unemployment. In North African countries, the informal economy constitutes a large proportion of total economic activity. This type of economy may not appear fully in GDP statistics and may lead to disguised unemployment as people work in precarious or informal jobs.

Returning to the results of Table 5 (total estimate), in the long term, we find that the impact of the inflation rate on unemployment is negative using the MG and PMG methods with coefficients -0.04 and -0.07, respectively. These results are consistent with the Phillips curve, as high inflation is associated with low unemployment and vice versa. Also, in the short term, policies that boost demand (such as increasing government spending or lowering taxes) can reduce unemployment but may lead to higher inflation. Conversely, policies to reduce inflation (such as raising interest rates) can lead to higher unemployment. While a positive impact of the inflation rate on unemployment was reached using the DFE method, this can be explained by the fact that developing countries are greatly affected by changes in the global economy in the long term, such as commodity price fluctuations, changes in exchange rates, and trade policies of developed countries. These factors can lead to imported inflation and an increase in unemployment rates.

In the short term, we have found a positive impact of the inflation rate on the unemployment rate using the MG and PMG methods with coefficients of 0.0091 and 0.01, respectively. That is, an increase in the inflation rate can lead to a rise in unemployment rates, which is the same result it reached (Singh, 2018). The study concluded that the relationship between unemployment and inflation is positive, 0.477, and immaterial at 10% significance.

Table 6

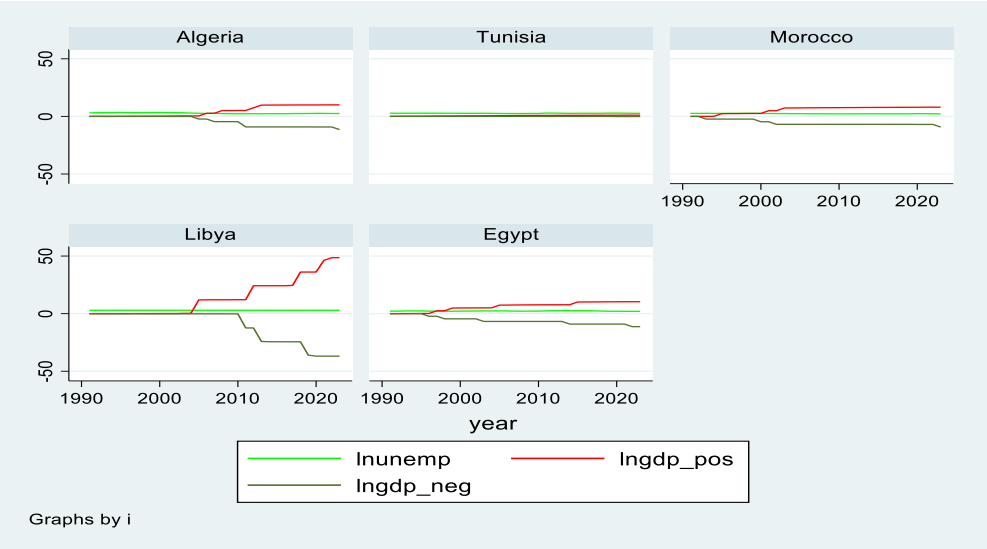
Panel-NARDL Estimations- Okun's Law by Country

		MG			**PMG**		
		COEFF	Std-error	p-value	COEFF	Std-error	p-value
	LNGDP + LR	-1.301	1.449	0.369			
	LNGDP - LR	-1.348	1.588	0.396			
ALGERIA	ECT SR	-0.099	0.106	0.350	-0.073	0.098	0.451
	D.LNGDP + SR	-0.217	0.069	0.002**	-0.059	0.030	0.052
	D.LNGDP - SR	0.010	0.022	0.655	0.013	0.023	0.558
	LNGDP + LR	-0.139	0.151	0.358			
	LNGDP - LR	1.356	2.020	0.502			
TUNISIA	ECT SR	-0.349	0.147	0.018 **	-0.282	0.096	0.003**
	D.LNGDP + SR	-1.822	0.766	0.017	-1.668	0.614	0.007
	D.LNGDP - SR	-0.737	0.858	0.390	-0.813	0.755	0.282
	LNGDP + LR	-0.044	0.044	0.328			
	LNGDP - LR	0.030	0.053	0.567			
MOROCCO	ECT SR	-0.462	0.123	0.000 **	-0.482	0.106	0.000**
	D.LNGDP + SR	0.004	0.025	0.874	-0.002	0.021	0.920
	D.LNGDP - SR	0.003	0.013	0.792	0.002	0.011	0.828
LIBYA	LNGDP + LR	-0.0016	0.0008	0.056 **			
	LNGDP - LR	-0.0018	0.0009	0.046 **			

	ECT SR	-0.5048	0.1686	0.003 **	-0.002	0.002	0.328
	D.LNGDP + SR	-0.0013	0.0005	0.022 **	-0.0009	0.0005	0.075
	D.LNGDP - SR	-0.0013	0.0006	0.039 **	-0.0012	0.0006	0.037
	LNGDP + LR	0.184	0.334	0.582			
	LNGDP - LR	0.249	0.392	0.526			
EGYPT	ECT SR	-0.124	0 .122	0.315	-0.105	0.059	0.074
	D.LNGDP + SR	0.023	0.051	0.655	-0.004	0.025	0.864
	D.LNGDP - SR	0.026	0.026	0.315	0.021	0.022	0.340

Figure 5

Asymmetric Effect of GDP on Unemployment Rate in North African Group Countries



Source: Authors' computation using Stata 17 software.

Discussion

This research project explores how changes in GDP impact unemployment rates in nations, with a specific focus on examining Okun's Law's validity. The study also discusses the research inquiries. It compares its results to recent research studies conducted on the subject and outlines the study's limitations and implications for generalizability.

Research Questions and Comparative Analysis

This research addresses the questions of interest: (1) Is Okun's Law applicable to North African economies, and how does it manifest in this region? (2) How robust is the relationship between GDP and unemployment in these countries compared to the original findings of Okun's Law? (3) What are the asymmetric effects of GDP on unemployment, particularly during economic expansions versus contractions? (4) How does inflation interact with unemployment in the context of North African economies? Through the examination of these inquiries. The research seeks to offer a comprehension of the trends in North Africa that could impact policies and strategies for economic advancement.

The Applicability of Okun's Law to North African Economies

The results confirm the validity of Okun's Law in the selected countries but with coefficients significantly smaller than those proposed by Okun (-2 to -3). Using the MG method, the coefficient was estimated at -0.36, suggesting that a 1% increase in GDP leads to a 0.36% reduction in unemployment. The discovery is consistent with Gonzalez's (2023) research, which also observed discrepancies in developing markets linked to job market inefficiencies and structural obstacles. To this point of view, Conteh's (2021) study 2021 highlighted how the connection between GDP and joblessness in developing

countries is less significant because of limited economic diversity and reliance on a small number of critical sectors.

The smaller coefficients observed in this study may reflect North African economies' reliance on capital-intensive industries, such as oil and gas, which contribute to GDP growth but do not generate significant employment. These results highlight the importance of implementing changes to enhance the link between development and employment opportunities.

The Relationship Between GDP and Unemployment in North African Countries Compared to Okun's Original Findings

The research emphasises differences among nations. According to the study findings, Algeria is responsive to GDP fluctuations; a rise in GDP leads to a more significant decrease in unemployment. In contrast, Libya and Tunisia displayed weaker and inconsistent relationships. These results echo those of (Al-kasbah, who found notable heterogeneity in Okun's coefficient across developing countries, highlighting the importance of national policy and structural differences.

Moreover, the findings indicate that merely focusing on GDP growth is not enough to tackle unemployment in nations with economic sectors or rigid labour markets.

What are the Asymmetries Impact of GDP on Unemployment?

The results indicate an imbalance in the correlation between GDP declines and unemployment compared to GDP growth's effect on reducing it. They show that negative impacts are more significant during contractions than during expansions. This is consistent with findings by Mihajlović (2020) in Serbia, which noted disparities linked to the labour market response to downturns in developing countries. Moreover, political unrest and economic fragility in North Africa intensify the repercussions of GDP contractions on employment.

Interaction of Inflation with Unemployment in the Studied Countries

A negative long-term relationship between inflation and unemployment was identified as consistent with the Phillips Curve in recent studies, such as Goutsmedt et al. (2021). This research highlights that higher inflation accompanies unemployment rates due to increased economic demand. However, in the term, there seem to be fluctuations in how inflation and unemployment relate to each other in economies like Egypt, which are significantly impacted by external factors like changes in global commodity prices.

Limitations and Implications for Generalizability

Several limitations of the study may affect the generalizability of the results:

Data Granularity. The examination is based on data. It might not accurately reflect short-term economic changes within a year or seasonal variations in employment patterns. This drawback could hide immediate shifts, especially in areas with substantial informal job sectors.

Sectoral Composition. The research does not consider the impacts of industries on the GDP measurement. For example, the significant influence of the oil and gas sector in Algeria and Libya may distort the connection between GDP and unemployment rates, making it harder to apply these findings to economies with industries.

Methodological Assumptions. The Panel Nonlinear ARDL model presupposes a level of uniformity among countries. It may oversimplify each nation's distinct socio-economic landscape. Further studies could delve into models to accommodate specific variations in different countries' contexts.

It's important to be careful when using the results in areas with setups or policies—like countries with varied economies or little informal sector.

Conclusion

This work aims to study the asymmetric effect of GDP on the unemployment rate in North African countries by testing the validity of Okun's Law on the sample of selected countries. The results of the study reached

The estimation results were calculated using the PMG and DFE MG methods, and the Hausman test was used to determine the appropriate method of use. The estimation results showed that the MG method is the appropriate estimator. Using the Wald test, the asymmetry test indicates an asymmetric effect in the long run.

The error correction coefficient was negative and significant using the MG and PMG methods, indicating a long-term equilibrium relationship and a mechanism for error correction of about 30%. This signal was negative and moral in Tunisia, Morocco, and Libya but not moral in Algeria and Egypt.

The results of the Okun Law test in the sample of selected countries showed that the Okun Law is valid for North African countries but in smaller amounts than what Okun reached (between -2 and -3). The Okun coefficient using MG was -0.36, which means that increasing GDP by one unit lowers the unemployment rate by 0.36 units.

When comparing the results of the Okun coefficient in each country, it was found that changes in the unemployment rate were more sensitive in Algeria. Okun's law was valid in Tunisia and Morocco but less in Algeria and Libya.

Algeria and Tunisia observed an increase in positive GDP impact after 2000, while Morocco stabilised its impact. In Libya, the positive impact increased after 2010 due to improved oil production, and in Egypt, the positive impact increased after 2000 due to economic reforms.

Finally, the results showed that the impact of GDP on unemployment is complex and depends on many economic, social, and political factors. The results also confirmed an adverse effect of the inflation rate on long-term unemployment using the MG method, which corresponds to the Phillips curve.

Based on the findings, promoting economic growth in North African countries is recommended by improving investments in high-employment sectors such as industry and agriculture, improving the investment environment by reducing bureaucracy, and combating corruption. Vocational education and training should be developed to qualify young people for the labour market and to encourage joining the formal economy by providing incentives and guarantees. Balanced monetary and fiscal policies should be implemented, and vulnerable groups should be supported with social programs to ensure a fair distribution of the gains of economic growth. The study recommends monitoring and evaluating economic policies regularly and strengthening regional cooperation among North African countries. Finally, innovation and modern technology should be encouraged to improve productivity and create jobs in the digital economy, improving economic performance and reducing unemployment rates sustainably.

Suggestions for Future Research

Future studies should broaden their scope to analyse additional factors affecting the relationship between unemployment and economic growth in North African countries, including monetary and fiscal policy. Moreover, other models, including structural and dynamic models, may be employed to analyse the data, facilitating result comparison and enabling more accurate findings. The research might investigate the long-term and short-term impacts of many economic factors on unemployment, emphasising the influence of education and vocational training in mitigating unemployment. The study must incorporate a comparative analysis of North African countries alongside analogous countries regarding economic growth and unemployment, aiming to discern shared variables and distinctions. This research will facilitate formulating more effective strategies to promote growth and mitigate unemployment in the region.

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