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Effect of economic growth and inflation on unemployment: An empirical analysis in Senegal from 1991 to 2018

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Abstract. Nowadays, unemployment is a big issue for policymakers. The high rate of unemployment can lead to instability such as crime and poverty. For this reason, unemployment can be viewed as heartbreaking for the country's economy. This paper mainly studies the relationship between Senegal's unemployment rate, economic growth and the inflation rate for the period 1991-2018. In this study, the autoregressive distributed lag (ARDL) modeling approach (Pesaran & Shin, 1999) and the bound test of cointegration were applied. Furthermore, the Augmented Dickey-Fuller Test (ADF) and Phillips Perron (PP) was applied to the test unit root or stationary issue. Finally, the Granger Causality Test also was conducted to check if it exists a unidirectional or bidirectional causality among variables. The findings show a negative long-run and short-run relationship between unemployment, growth, industry and age dependency ratio whereas it appears a positive relationship between unemployment and inflation in both periods. It is also indicated that there is no Granger causality relationship between unemployment, economic growth, and inflation. Whereas unemployment and economic growth have a Granger causality on the industry.

Keywords. Unemployment rate, Inflation, Economic growth, ARDL, Granger Causality.
JEL. F53, E31, J60.

1. Introduction

The debate on economic growth, unemployment, and inflation is still an interesting topic for economists but also for governments. These three macroeconomic aggregates are essentials in the economic policy of a country. Regardless of their economic and social development, these variables are major challenges facing by governments.

Nowadays, one of the major characteristics of developing countries is the high rate of unemployment. This trend of unemployment only reflects the importance that economic growth can bring to these countries in order to cut down the unemployment rate. These three variables cannot be isolated because they are interdependent on another. It reflects a social contribution but also the life of the economy of the country.

During the last decade, many African countries have experienced relatively high economic growth, but this has not helped to reduce the unemployment rate in these countries.

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In Senegal, since independence in 1960 to the present day, it has seen many changes, but also in a broad struggle to revive its economy while fighting against unemployment and to keep inflation stable. During this last decade, Senegal experienced a growth of its economy and good control of its inflation. Despite this growth noted, the rate of unemployment remains a time bomb for policymakers. Unemployment is a heavy burden in low-income economies as well as developed countries. According to the international labor organization (ILO) report, the unemployment rate in 2019 is 7.9 %. In Senegal, the unemployment rate in 1991 was 5.37% and continues to increase until 2011 at 10.54%. With efforts in its economy, the unemployment rate began to decline until 2017 at a 6.43% rate expects to continue to grow to 6.46%, in 2018 an increase of 0.03%.

The following graph shows the trend in the unemployment rate in Senegal from 1991 to 2018.

Figure 1. *Unemployment trend*

Inflation, which is also an important aggregation in an economy, is an economic problem for these countries. Senegal, like many developing countries, has experienced this problem of inflation. According to ANSD, after a negative inflation rate in 2014 of -2.11%, this rate has increased to reach 2.34% in 2018 and estimates are at 3% by 2020.

This graph below figure out the trend of inflation in the study period.

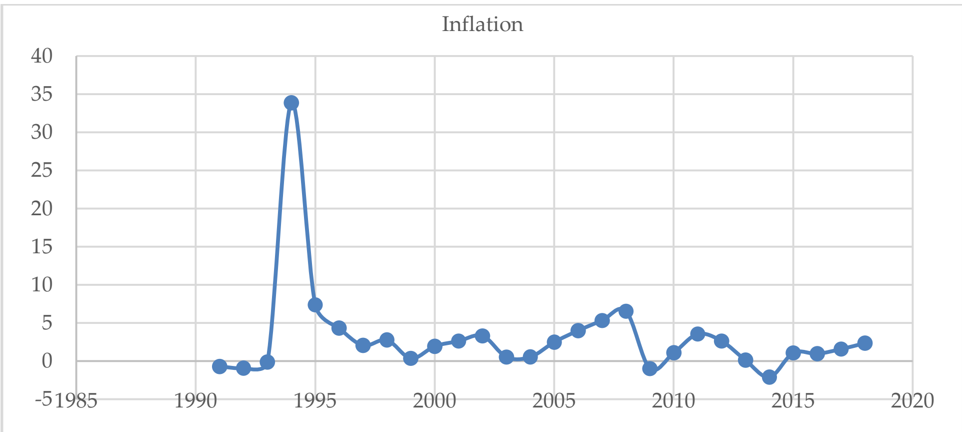


Figure 2. *Inflation rate trend*

Economic growth is seen as a macroeconomic aggregate that assesses the health of a country's economy. In our study, growth is defined as the quantitative increase in GDP. According to the World Bank, the annual growth of the gross domestic product (GDP) in% represents the relative change in the volume of GDP in constant dollars between two years. It reflects the increase (or decrease in the case of negative growth) of the level of economic activity in a country. It is an aggregate often used when one wants to make forecasts in the short and medium-term on the economic situation of a country.

Senegal has experienced different rates of growth for decades. These fluctuations in its economy are mainly due to unfavorable economic shocks and especially at the international level, as well as low production during these years.

It is in 2017 that it is recorded the highest rate of growth of 7.08% and the lowest value registered in 2002 is 0.6548%.

In favor of the start of oil and gas production planned for 2022, this growth can reach two numbers. The following figure allows us to understand the evolution of Senegal's growth between 1991 and 2018.

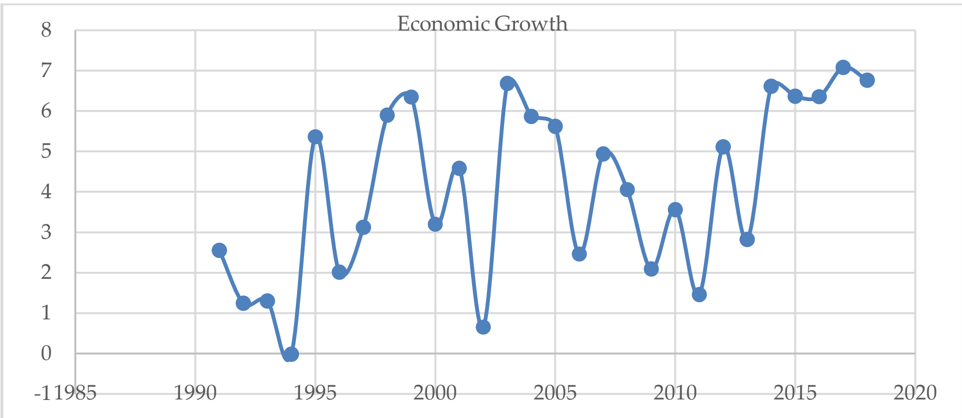


Figure 3. *Economy Growth rate trend*

The paper will be organized in the four main sections: the first section is related to the literature review: theoretical literature review and empirical literature review. The second section will focus on the methodology, variables and data we used through this study. The third concern the empirical results and finally the conclusion and recommendation.

2. Literature review

In the literature review, several studies have been investigated theoretical and empirical relationships between economic growth, inflation, and unemployment.

2.1. Theoretical literature review

The Phillips curve and Okun's Law constitute one of the main economic theories about the relationship between economic variables.

Okun's law is the work of Arthur M. Okun in 1968. This empirical relationship figures out the production lost in a country. Okun Law studies the relationship between the US economy's unemployment rate and its GNP. This study shows that when unemployment falls by 1%, GNP will rise by 3%. Okun's Law tries to explain how a rise in unemployment affects GNP, where a percentage increase in unemployment causes a 2% fall in GDP.

The weaknesses of Okun's law is related to the fact that its theoretical foundations have not yet been established (Zerbo, 2017). Also, many of Okun's Law coefficient is determined. Stephan (2014) listed 269 Okun coefficients varying between -3.22 and 0.17.

In the macroeconomic area, Okun's Law is important to show the structural change between economic growth and unemployment.

Another important tool to figure out is the relationship between inflation and unemployment: the Phillips curve. This is an inverse relationship between the rate of unemployment and the rate of inflation. This curve shows that the lower unemployment rate will cause a high rate of inflation. The Phillips curve is developed by William Phillips. In his paper, he described the inverse relationship between money wage change and unemployment in the British economy. The Phillips curve theory claims that economic growth comes with inflation, which in turn should lead to more jobs and less unemployment.

2.2. Empirical literature review

According to Tanha (2018), investigated the effect of economic growth and inflation on unemployment in Bangladesh, discovered an insignificant positive impact of economic growth on unemployment. This invalidates the Okun's laws. It shows also that inflation has an insignificant negative impact on unemployment. This result was confirmed with the Philips curve theory. His work carries out that the industry affect inversely unemployment and it is the same for age dependency.

Makun & Azu (2015) analyzing the relationship between economic growth, unemployment, and investment in Fiji by using the data from 1982 to 2012, found a long run connection between growth and unemployment. In this study, they used the unit root tests for checking the stationary and applied Johansen Cointegration Test and dynamic error correction model in order to determine the long run connection among the variables.

Sir (2014) examining the effect of economic growth on unemployment found that the GDP has a positive effect on unemployment even if this isn't a significant effect on unemployment. According to the author, only inflation significantly reduces unemployment. Firstly, the result shows a unidirectional causality between inflation and unemployment, and a bidirectional causality among unemployment, inflation, and GDP.

In China, the work of Liu & Li (2012) using the data from 1978 to 2010 and following the VAR model and co-integration method, analyze the interaction between Economic Growth, inflation, and unemployment. They carry out a long and short period relationship. In the long run, an equilibrium relationship between the Chinese unemployment rate, Economic Growth, and Inflation was established. First, Economic growth is negatively related to unemployment and positively related to inflation. So the fast Economic Growth can improve employment but can bring the pressure to high inflation. Secondly, inflation is negatively related to both factors. So high inflation can also improve employment. In the short run, high Economic Growth and high unemployment rates can coexist because of the positive correlation of the variables (Lui & Li, 2012). This violates Okun's laws.

Njoku & Lhugba (2011) analyzing the impact of unemployment and economic growth in Nigeria from 1985 to 2009 concluded that only the agriculture sector can reduce the unemployment rate. In addition, Muet (1995) thinks that the rise in unemployment has undoubtedly its origin in the slowdown in economic growth and the imbalances that each caused by the oil shocks.

Oriji, Orji, & Okafor (2015) studying the unemployment rate and inflation nexus in Nigeria from 1970-2011 and using the Philips curve demonstrated that the unemployment rate is a significant determinant of inflation and it exists a positive relationship among these variables.

Xiao-peng & Pei-dong (1999) showed a stable long-term equilibrium derivative based on the analysis of the coefficient of their study on economic growth, unemployment, and inflation in China in the short term. It has a relationship between the three variables.

According to Bayar (2014), there is a long-run relationship between economic growth, exports and foreign direct investment on unemployment in Turkey from 2000 to 2013. In his work, he applied the Augmented Dickey-Fuller Test for checking the stationarity of time series. The Auto-regressive Distributed Lag (ARDL) and Error Correction Model (ECM) was used to investigate the long term as well as short term connection among the explained variable and predicted variables.

The study of the impact of unemployment on the economic growth of Karikari-Apau & Abeti (2019) shows a negative short-run and long-run between unemployment and economic growth and also no Granger causality between variables.

3. Empirical analysis

3.1. Data

In this paper, the time-series data is used and selected from Senegal's annual economic data during the period 1991 to 2018 as a sample. The secondary data will be used and all are from the National Agency of statistics and demographic (NASD), WB, and WDI.

3.2. Variables

We have five variables: Economic Growth measured by gross domestic product (GDP) at current prices in US dollars, unemployment (UNEMP) total % of total labor force, inflation (INF), age dependency ration (ADR) and industry (IND).

The dependent variable is taken as Unemployment and Economic growth and inflation as independent variables. Besides these variables, we added the age dependency ratio and the industry as predictor variables.

3.2.1. Unemployment

According to ILO, unemployment refers to the share of the labor force (age between15-64) that is without work but available for and seeking employment. The unemployment rate, which is the number of unemployed people divided by the number of people in the labor force, is most frequent measure of unemployment,

The level of unemployment in Senegal is worrying for the policymaker despite the economic growth recorded during the last years.

3.2.2. Inflation

Inflation is a quantitative measure and can be estimated by the annual growth rate of the GDP implicit deflator, which shows the rate of price change in the economy as a whole. In computing, the GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. In 2014, Senegal has achieved a negative inflation rate. This include that the general price level is declining and consumer prices get cheaper.

3.2.3. Economic growth

Economic growth is measured by the GDP which is an increase in the number of goods and services produced per head of the population over a period of time. In our work, it is taken the annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. The increase in GDP can increase the output which means that households can enjoy more goods and services and it can also improve living standards especially in developing countries where it is noted a high level of poverty. The most important for an increase in GDP is it can reduce unemployment.

3.2.4. Age dependency ratio

The age dependency ratio, young, is the ratio of younger dependents people younger than 15 to the working-age population (ages 15-64). This variable highlights the number of people of nonworking age, compared with the number of those of working age. This is important to understand the impacts of changes in population structure. A lower ratio is preferred.

3.2.5. Industry

An industry is a sector that produced goods or related services within an economy. It include value added in mining, manufacturing, construction, electricity, water, and gas. Industrialization is important for development. It can generate many opportunities such as employment, it can also provide educational opportunities, encourages advancement and innovation, and better utilizes resources. All of these advantage and more make industrial development extremely valuable to a population and the local economy.

3.3. Methodology

To check which method to use, the unit root test which determines the stationarity of the variables must be done for time series analysis to avoid using the wrong approach.

3.3.1. The unit root test

A unit root test was performed to check the stationarity of the data. To avoid spurious and unreliable estimates, the unit root test of stationary should be conducted because most of the economic time series shows a non-stationary.

Several tests such as Dicker-Fuller Test, Augmented Dicker-Fuller Test (ADF), Phillips Perron (PP) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) are available to test the unit root in time series. For this study, Augmented Dickey-Fuller and Phillips Perron will be conducted to check the stationarity of the variables and their order of integration

The ADF model used can be written as follow:

$$\Delta Y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

From the above equation, we use the following hypothesis:

-Null hypothesis: The variable has unit root or non-stationary

-Alternative: Variable is Stationary

The ADF test suggested that the Null hypothesis is rejected when the t-statistic in absolute value is greater than the absolute critical value at 5%, and we will conclude that the series is stationary; *otherwise, if the t-statistic is significant we accepted the null hypothesis, and we agree that the variables have unit root.*

3.3.2. Autoregressive distributed lag (ARDL) bound cointegration analysis

The application of the bound test approach required three variations. First, come from the suggestion of Pesaran *et al.*, (2001) to use the ARDL method in order to estimate the relationship level. The second one is the possibility to conduct the analysis in presence of mixture variable. For example when variables are in order of integration I(0) and I(1) but not I(2). According to Johansen & Juselius (1990) in the case of mixed variables, the Johansen cointegration test cannot be used.

Finally, for Pesaran *et al.*, (2001), ARDL is the most appropriate technique for small and finite-size data sets. To carry out the existence of a long-run relationship or not in series analysis with a different order of integration, the best test is the bound test which is proposed by Pesaran. For the bound test results, if the series are co-integrated, the short-run and long-run should be specified. In this case, the ECM should be used to determine the short-run and long-run. Otherwise, only the short-run should be done. In that case of non-cointegration, the short-run is obtained in ARDL regression.

In order to perform the bound test for cointegration, the ARDL model is specified as follow:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \,\Delta y_{t-i} + \sum_{j=0}^{q} \delta_j \,\Delta x_{t-j} + \phi_1 y_{t-1} + \phi_2 x_{t-1} + \mu_t$$

Where Δ denotes the first difference operator, β_i, δ_j stand for the short-run coefficients, ϕ_1, ϕ_2 are for the long-run coefficients

and μ_t is the disturbance(white noise) term.

This method requires to choose the maximum lag for p and q with the unrestricted error correction model.

Several methods such as Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC) or Hannan-Quinn Criterion (HQC) was used to determine the optimal lag length. This selection will be done under the VAR modeling

The VAR dimension for two variables X and Y by using one lag can be specified as follow:

$$Y_t = \gamma_1 + \vartheta_{11} y_{t-1} + \vartheta_{12} x_{t-1} + \mu_{1t}$$
$$X_t = \gamma_2 + \vartheta_{21} y_{t-1} + \vartheta_{22} x_{t-1} + \mu_{2t}$$

Where μ_{1t} and μ_{2t} are the error terms or uncorrelated white noise disturbances.

The bound test follows two main steps. First, we estimate the ARDL equation in order to check if there a long-run relationship between the variables. The second step is the calculation of F-statistic and the decision rule will be taken as follow:

-The null hypothesis ($H_0 = \phi_1 = \phi_2 = 0$) of no long-run relationship is rejected if the calculated F-statistic is greater than the critical value for the upper bound I(1). In this case, the alternative decision($H_1 = \phi_1 \neq \phi_2 \neq 0$) is accepted, we conclude that there is cointegration or a long-run relationship.

-if the F-statistic is less than the critical value for the lower bound I(0), we cannot reject the null hypothesis ($H_0 = \phi_1 = \phi_2 = 0$), this means that no cointegration and the long-run relationship cannot be established.

-Finally, an inconclusive result occurs where the F-statistic falls below between the lower bound I(0) and upper bound I(1). Hence, the short-run and long-run can be conducted.

4. Empirical results and discussion

4.1. Empirical results

In this paper, we used 28 observations as a sample and the summary statistics of all variables that are used in the study is given in the following table:

Table 1. *Summary Statistics*

Variables	Obs	Mean	Std.Dev.	Min	Max
UNEMP	28	7.245	1.846	5.3711	0.541
GROWTH	28	4.076	2.156	-0.017	7.083
INFL	28	3.083	6.440	-2.118	33.891
INDUST	28	21.876	1.050	19.8392	4.097
ADR	28	85.205	6.294	78.7509	8.853

Source: National Agency of Statistic and Demographic Senegal

Using the maximum and minimum values, the results show a gap in unemployment from 1991 to 2018 which shows unstable unemployment in Senegal. Besides unemployment, economic growth shows a large gap between the minimum and maximum values. For inflation, it is noted also a large gap. The minimum and maximum value of age dependency ration and industry also show a large gap. Finally, these show a high inconsistent of the variables.

4.2. The unit root test

According to the data, methodology and the econometric model we have, we first of all test if our selected variables are stationary or not. For this study, Augmented Dickey-Fuller (ADF) was used to check the stationarity of the variables.

The results of these tests are shown in the following table:

Table 2. *Augmented Dicker-Fuller Test*

Variables	ADF		PP	
	At level	Atfirst Difference	At level	At first Difference
UNEMP	Non-stationary	Stationary	Non-stationary	Non-stationary
GROWTH	Stationary	Stationary	Stationary	Stationary
INF	Stationary	Stationary	Stationary	Stationary
IND	Non-stationary	Stationary	Non-stationary	Stationary
ADR	Stationary	Stationary	Stationary	Stationary

Source. Author's computation from Eviews10

The test of stationarity shows that at level, the Economic Growth, Inflation and Age Dependency Ratio variables are all stationary. Besides these variables, unemployment and industry variables are non-stationary at level. To overcome this non-stationary evolution an Augmented Dickey-Fuller Test was conducted again for the 1st difference.

It shows that at 1st difference, the unemployment and industry variables became stationary at first difference. The results of the unit root test show that we have mixed variables in different order of integration I(0) and I(1) but none is I(2), hence it is suitable to apply the ARDL method.

4.3. Results of the bound test

In order to carry out the long-run relationship, the bound test was applied. The results are indicates in Table-3.

Table 3. *Bound Test Result*

	Lower bound		Upper Bound	
K	5%	10%	5%	10%
4	2.56	3.49	2.2	3.09
Model		F-statistic		Inference
UNEMP (GROWTH, INF, IND, ADR) 4.991				Cointegration

Source: Author's computation from Eviews10

Following the methodology, the F-statistic and the upper and lower bound were used for the rejection rule. The result shows that the F-statistic calculated (4.991) is greater than the lower bound (2.56) and upper bound (2.2) at 5%, and it is the same for lower bound (3.49) and upper (3.09) at 10%. Hence, it is found a cointegration between unemployment, growth, inflation, industry and age dependency ratio. Therefore it exists a long-run relationship among the variables.

4.4. Autoregressive distributed lag(ARDL) results

As it appears in the results of the bound test, there is a long-run and short-run relationship among economic growth, inflation, industry, and age dependency ratio. It is necessary to estimate the error correction model (ECM). This ECM, it is used to correct the short-run behavior of the variables alongside to the behavior of the long-run variables.

The error correction model of the ARDL method is given by:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{j=0}^{q} \delta_j \Delta x_{t-j} + \gamma z_{t-1} + \mu_t$$

Where the error correction obtained by cointegration is represented by z_t. The results of the short-run and long-run estimations are in the below table:

Table 4. *ARDL Test*

Coefficient	Estimates	t-statistic	p-value
Long-run Estimation			
GROWTH	-1.1214	-6.846*	0.0000
INF	0.2515	3.773*	0.0036
IND	-1.2799	0.388*	0.0081
ADR	-0.6786	-5.717*	0.0002
C	96.7420	5.502*	0.0003
Short-run Estimation			
ΔGROWTH	-0.088	-2.992**	0.0135
ΔINF	0.068	5.165*	0.0004
ΔIND	-0.575	-6.853*	0.0000
ΔADR	-0.277	-3.925*	0.0028
CointEq(-1)	-0.517	-6.702*	0.0001
F-statistic	4.991		
DW-statistic	1.959		
Adj R^2	0.903		

Notes: ***, **, * indicates respectively significance level at 1%, 5% and 10%. *** p<0.1, **p<0.05, *p<0.01. ARDL (2,3,2,2,1) was based on the Aikake Information Criterion(AIC)
Source: Author's computation from Eviews10

In the long-run, all variables are statistically significant at 1% level and have an impact on the dependent variable (Unemployment). The long-run coefficients show that any increase by one unit in economic growth will lead to reducing the unemployment rate by 1.1214 units. This situation is more suitable for the government who tries to fight against unemployment. This confirms also that the Okun law's in Senegal was not violated. In addition, an increase in inflation by one unit will raise unemployment by 0.2515 units which are not suitable for an economy and it is risky for policymakers. Besides the growth variable, we noted that the inflation variable is statistically significant and has a positive correlation with unemployment. According to Phillips Curve, this result is in contradiction with the theory of the Phillips curve which holds an inverse relationship between the two variables.

In the short-run, the ECM coefficient was -0.517 and statistically significant at 1% level. This implies that any deviation happened in the short-run will be corrected by 51.7% over the next period.

4.5. Diagnostic test results

In this section, we are going to verify some assumptions in linear regression, such as stability, linearity, serial correlation, and heteroscedasticity issue.

For the stability diagnostic, the Ramsey RESET test and Cusum Test were used. The Ramsey test (t-statistic=0.464, p=0.5343>0.10) and the Cusum Test (see figure 4) where the residual plot did not fall outside the significant boundaries (5%), show that the model is largely stable over the period and correctly specify.

To verify if the model suffers from the autocorrelation problems, the serial correlation test such as Breusch-Godfrey LM andCorrelogram-Q-

Statistic tests were conducted. The Breusch-Godfrey LM test (F-statistic = 0.433, Prob F(3,7) = 0.7356>0.10) shows that there is no serial correlation among variables by using. It is the same for Correlogram-Q-Statistic where all Q-statistics(see in appendix) are insignificant. Hence, we can conclude that there is no autocorrelation and partial correlation.

The heteroscedasticity issue was tested by using the Breusch-Pagan-Godfrey test. The heteroscedasticity test (F-statistic=0.330, ProbF (14,10) = 0.9710>0.10) appears that the model don't suffer from heteroscedasticity.

4.6. Granger causality test

Several methods of causality were developed in the literature. One of the earliest is the Granger causality which is developed Granger (1969). This method is a tool to check the causal effect of time series data.

The results are in the below table:

Table 5. *Granger Causality Results*

Null Hypothesis:	F-Statistic	Prob.	Decision
GROWTH does not Granger Cause UNEMP	0.34149	0.7956	Cannot reject the Null Hypothesis
UNEMP does not Granger Cause GROWTH	0.57382	0.6395	
INF does not Granger Cause UNEMP	0.02368	0.9949	Cannot reject the Null Hypothesis
UNEMP does not Granger Cause INF	0.98789	0.4207	
INF does not Granger Cause GROWTH	0.46625	0.7094	Cannot reject the Null Hypothesis
GROWTH does not Granger Cause INF	1.91053	0.1641	

Source: Author'scomputation from Eviews10

The finding of the Granger causality test shows that there is no Granger causality effect at level between unemployment, economic growth and inflation. In addition, it appears a unidirectional causality between unemployment and industry (see appendix). Industry has also the same unidirectional effect on economic Growth.

5. Conclusion and recommendations

5.1. Conclusion

In many countries especially in developing countries such as Senegal, unemployment has been a huge problem and so difficult for policymakers and households to manage. Achieving full employment has always been an objective of any government or an economy, even if this concept of full-employment seems to be a utopia to be reached. This paper carries out the effect of economic growth, inflation, industry and age dependency ration on unemployment in Senegal from 1991 to 2018.

Our findings show that economic growth, industry and age dependency ratio have a negative effect in long-run and short-run on unemployment and inflation affects unemployment positively in both period. It carries out also that the Okun law's in Senegal is established contrary to the Phillips curve which is violated in Senegal's economy.

5.2. Recommendation

The policymakers should put their efforts to boost economic growth in order to reduce unemployment but this economic growth must be controlled to be more inclusive than not too much exclusive. In addition to this, the industry sector could be a good way and should be developed and encourage. A great industry policy will create many jobs and will lower unemployment rate. The government must work for an industrialization economy to keep higher the employment. Finally, the inflation must be controlled because any increase in inflation will increase unemployment rate. Further studies can be conducted in order to add more variables such as FDI, worker qualification, to check out the determinants of unemployment and the variables which can negatively affect this unemployment and tickle it down.

Appendix

Appendix 1. *Test of unit root*

Augmented Dickey-Fuller Test Results

At level						At first difference					
Variables	t-statistics	Critical values			p-value	Variables	t-statistics	Critical values			p-value*
		1%	5%	10%				1%	5%	10%	
UNEMP	-1.900	-3.711	-2.981	-2.630	0.3274	UNEMP	-2.430	-2.657	-1.954	-1.609	0.0173
GROWTH	-3.708	-3.700	-2.976	-2.627	0.0098	GROWTH	-9.737	-3.711	-2.981	-2.630	0.0000
INFL	-4.537	-3.700	-2.976	-2.627	0.0013	INFL	-7.540	-3.711	-2.981	-2.630	0.0000
ADR	-3.229	-3.711	-2.981	-2.630	0.0065	ADR	-4.667	-3.711	-2.981	-2.630	0,0010
INDUST	-2.910	-3.700	-2.976	-2.627	0.0573	INDUST	-8.178	-3.711	-2.981	-2.630	0.0000

Phillips-Perron Test Results

At level						At first difference					
Variables	t-statistics	Critical values			p-vlue	Variables	t-statistics	Critical values			p-value*
		1%	5%	10%				1%	5%	10%	
UNEMP	-1.422	-3.700	-2.976	-2.627	0.3210	UNEMP	-2.505	-2.656	-1.954	-2.609	0.0144
GROWTH	-3.729	-3.700	-2.976	-2.627	0.0093	GROWTH	-14.724	-3.711	-2.981	-2.630	0.0000
INF	-3.899	-3.753	-2.998	-2.639	0.0069	INF	-4.455	-3.857	-3.040	-2.660	0.0030
ADR	-5.016	-3.700	-2.976	-2.627	0.0004	ADR	-5.411	-3.887	-3.052	-2.667	0,0005
IND	-2.146	-3.753	-2.998	-2.639	0.2299	IND	-6.897	-3.770	-3.005	-2642	0.0000

Appendix 2. *ARDL test results*

VAR Lag Order Selection Criteria

Endogenous variables: UNEMP GROWTH INF IND ADR
Exogenous variables: C
Date: 03/04/20 Time: 05:46
Sample: 1991 2018
Included observations: 25

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-265.0265	NA	1657.302	21.60212	21.84589	21.66973
1	-166.0586	150.4311	4.678828	15.68469	17.14734	16.09037
2	-123.8438	47.28058*	1.553376	14.30751	16.98903	15.05125
3	-72.36223	37.06677	0.441018*	12.18898*	16.08938*	13.27078*

Notes: * indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

ARDL Test

Dependent Variable: UNEMP
Method: ARDL
Sample (adjusted): 1994 2018
Included observations: 25 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic): GROWTH INF IND ADR
Fixed regressors: C
Number of models evalulated: 512
Selected Model: ARDL(2, 3, 2, 2, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
UNEMP(-1)	0.952255	0.238149	3.998571	0.0025
UNEMP(-2)	-0.46942	0.207974	-2.257113	0.0476
GROWTH	-0.088139	0.047292	-1.863715	0.092
GROWTH(-1)	-0.140488	0.054903	-2.558862	0.0284
GROWTH(-2)	-0.190426	0.052863	-3.60225	0.0048
GROWTH(-3)	-0.160884	0.05836	-2.75673	0.0202
INF	0.068335	0.029979	2.279409	0.0458
INF(-1)	0.086699	0.041086	2.110162	0.061
INF(-2)	-0.024959	0.019425	-1.284861	0.2278
IND	-0.575242	0.123848	-4.644743	0.0009
IND(-1)	-0.363977	0.174855	-2.081586	0.064
IND(-2)	0.277304	0.097842	2.834202	0.0177
ADR	0.182687	0.289433	0.63119	0.5421
ADR(-1)	-0.533638	0.24685	-2.161787	0.0559
C	50.03158	13.52296	3.69975	0.0041

R-squared	0.988521	Mean dependent var	7.459376
Adjusted R-squared	0.972451	S.D. dependent var	1.840667
S.E. of regression	0.305511	Akaike info criterion	0.750045
Sum squared resid	0.933368	Schwarz criterion	1.481371
Log likelihood	5.624436	Hannan-Quinn criter.	0.952884
F-statistic	61.51299	Durbin-Watson stat	1.959621
Prob(F-statistic)	0.0000		

Note: p-values and any subsequent tests do not account for model selection.

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(UNEMP)				
Selected Model: ARDL(2, 3, 2, 2, 1)				
Case 2: Restricted Constant and No Trend				
Date: 03/04/20 Time: 04:24				
Sample: 1991 2018				
Included observations: 25				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50.03158	13.52296	3.69975	0.0041
UNEMP(-1)*	-0.517165	0.102529	-5.044058	0.0005
GROWTH(-1)	-0.579937	0.137894	-4.205661	0.0018
INF(-1)	0.130075	0.042054	3.093041	0.0114
IND(-1)	-0.661914	0.23147	-2.859611	0.017
ADR(-1)	-0.350951	0.097148	-3.612547	0.0047
D(UNEMP(-1))	0.46942	0.207974	2.257113	0.0476
D(GROWTH)	-0.088139	0.047292	-1.863715	0.092
D(GROWTH(-1))	0.35131	0.095531	3.677428	0.0043
D(GROWTH(-2))	0.160884	0.05836	2.75673	0.0202
D(INF)	0.068335	0.029979	2.279409	0.0458
D(INF(-1))	0.024959	0.019425	1.284861	0.2278
D(IND)	-0.575242	0.123848	-4.644743	0.0009
D(IND(-1))	-0.277304	0.097842	-2.834202	0.0177
D(ADR)	0.182687	0.289433	0.63119	0.5421

Long-run Estimation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GROWTH	-1.121377	0.16379	-6.84645	0.0000
INF	0.251516	0.066657	3.773292	0.0036
IND	-1.27989	0.388211	-3.296889	0.0081
ADR	-0.678605	0.118706	-5.716668	0.0002
C	96.74205	17.58185	5.502382	0.0003
EC = UNEMP - (-1.1214*GROWTH + 0.2515*INF -1.2799*IND -0.6786*ADR +96.7420)				

ARDL Bounds Test				
F-Bounds Test		Null Hypothesis: No long-run relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	4.99137	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.50%	2.88	3.87
		1%	3.29	4.37

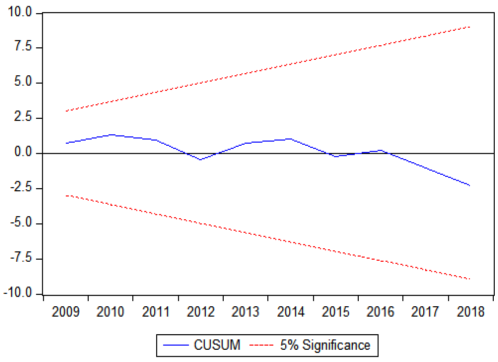
ARDL Error Correction Regression
Dependent Variable: D(UNEMP)
Selected Model: ARDL(2, 3, 2, 2, 1)
Case 2: Restricted Constant and No Trend
Date: 03/04/20 Time: 04:25
Sample: 1991 2018
Included observations: 25
ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(UNEMP(-1))	0.46942	0.090642	5.178841	0.0004
D(GROWTH)	-0.088139	0.029453	-2.992563	0.0135
D(GROWTH(-1))	0.35131	0.067511	5.203766	0.0004
D(GROWTH(-2))	0.160884	0.039618	4.060911	0.0023
D(INF)	0.068335	0.013229	5.165567	0.0004
D(INF(-1))	0.024959	0.00923	2.704186	0.0222
D(IND)	-0.575242	0.083939	-6.853131	0.0000
D(IND(-1))	-0.277304	0.070648	-3.925155	0.0028
D(ADR)	0.182687	0.061817	2.955299	0.0144
CointEq(-1)*	-0.517165	0.077161	-6.702412	0.0001
R-squared	0.903019	Mean dependent var		0.0342
Adjusted R-squared	0.844831	S.D. dependent var		0.633253
S.E. of regression	0.249448	Akaike info criterion		0.350045
Sum squared resid	0.933368	Schwarz criterion		0.837595
Log likelihood	5.624436	Hannan-Quinn criter.		0.485271
Durbin-Watson stat	1.959621			

Notes: * p-value incompatible with t-Bounds distribution.

Appendix 3. *Diagnostic test*

-Stability Test(CUSUM Residual Test)



Ramsey RESET Test			
Equation: UNTITLED			
Specification: UNEMP UNEMP(-1) UNEMP(-2) GROWTH GROWTH(-1) GROWTH(-2) GROWTH(-3) INF INF(-1) INF(-2) IND IND(-1) IND(-2) ADR ADR(-1) C			
Omitted Variables: Powers of fitted values from 2 to 4			
	Value	df	Probability
F-statistic	0.873104	(3, 7)	0.4991
F-test summary:			
	Sum of Sq.	df	Mean Squares
Test SSR	0.254153	3	0.084718
Restricted SSR	0.933368	10	0.093337
Unrestricted SSR	0.679214	7	0.097031

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.330282	Prob. F(14,10)	0.971
Obs*R-squared	7.90475	Prob. Chi-Square(14)	0.8942
Scaled explained SS	2.42814	Prob. Chi-Square(14)	0.9997

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.43368	Prob. F(3,7)	0.7356
Obs*R-squared	3.918305	Prob. Chi-Square(3)	0.2704

Date: 03/04/20 Time: 04:35
Sample: 1991 2018
Included observations: 25
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.032	-0.032	0.0292	0.864
		2	-0.259	-0.260	1.9906	0.370
		3	0.087	0.073	2.2234	0.527
		4	-0.311	-0.403	5.3330	0.255
		5	-0.014	0.031	5.3392	0.376

*Probabilities may not be valid for this equation specification.

Appendix 4. *Granger Causality Test*

Pairwise Granger CausalityTests

Date: 03/04/20 Time: 04:37

Sample: 1991 2018

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
GROWTH does not Granger Cause UNEMP	25	0.34149	0.7956
UNEMP does not Granger Cause GROWTH		0.57382	0.6395
INF does not Granger Cause UNEMP	25	0.02368	0.9949
UNEMP does not Granger Cause INF		0.98789	0.4207
IND does not Granger Cause UNEMP	25	1.80853	0.1817
UNEMP does not Granger Cause IND		2.54177	0.0887
ADR does not Granger Cause UNEMP	25	0.45696	0.7157
UNEMP does not Granger Cause ADR		0.03475	0.991
INF does not Granger Cause GROWTH	25	0.46625	0.7094
GROWTH does not Granger Cause INF		1.91053	0.1641
IND does not Granger Cause GROWTH	25	3.04922	0.0553
GROWTH does not Granger Cause IND		1.85675	0.1731
ADR does not Granger Cause GROWTH	25	0.61852	0.612
GROWTH does not Granger Cause ADR		0.13467	0.9381
IND does not Granger Cause INF	25	1.7035	0.202
INF does not Granger Cause IND		0.49068	0.6931
ADR does not Granger Cause INF	25	10.712	0.0003
INF does not Granger Cause ADR		37.3254	6.00E-08
ADR does not Granger Cause IND	25	0.78595	0.5173
IND does not Granger Cause ADR		1.10363	0.3734

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