Estimation of Okun Coefficient for Algeria

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Abstract: The objective of this paper is to investigate the presence of Okun's (1962) relationship for Algeria for the 1970- 2015 period. Two methodologies are employed to estimate the Okun coefficient: An Autoregressive Distributed Lag (ARDL) linear model and a Bayesian Normal Linear Regression model. The results indicate an Okun coefficient of about -0.2 which suggests some rigidity of the labour market in Algeria.

Keywords: Dynamic Linear Models, Bayesian Techniques, Unemployment, Okun Coefficient, Simulation Techniques;

1. Introduction

The Okun's law investigates the empirical relationship between the unemployment rate and growth rate of gross domestic product (GDP) in a country (or ensemble of countries).

It is very important to estimate the relationship between unemployment and growth rate in an economy, because it suggests room for policymakers to improve aggregate output and reducing unemployment. This relationship is helping to explain the changes in unemployment when GDP growth is known, also predict changes in unemployment given predictions of GDP growth [1]. This approach builds on a simple theoretical view: "increased production in an economy leads to decreases in unemployment" [2].

This paper uses Okun's law to estimate the effects of GDP growth on unemployment in Algeria (Okun coefficient) using annual data from 1970 to 2015. Two methodologies will be investigated to support the results: An Autoregressive Distributed Lag (ARDL) linear model and a Bayesian Normal Linear Regression model.

Many studies have estimated the Okun coefficient in several countries using several approaches. In Algeria, Adouka and Bouguell (2010) using Error Correction Model (ECM) with annual data during the period 1970-2010, find a negative relationship between unemployment and output in the long term, an increase in real GDP of 1% decrease the unemployment rate by 0.2% [3].

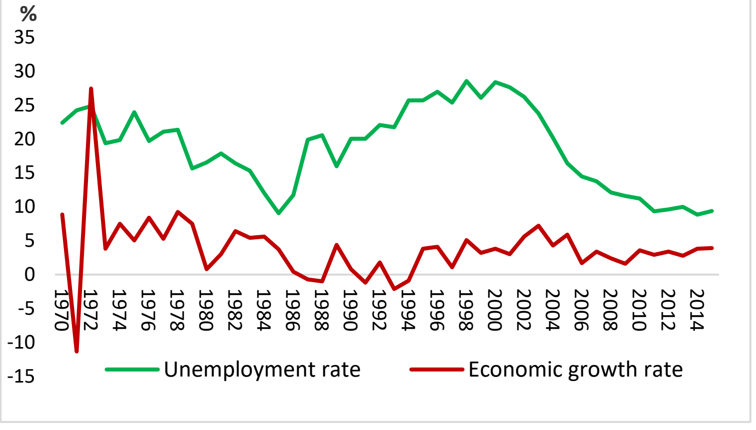
The remainder of this paper is organized as follows: Section 2 and 3 offers a descriptive analysis of unemployment in Algeria and theoretical framework of Okun's law respectively. Section 4 and 5 provides a literature review and the methodologies used. Section 6: reports the empirical results. The last section presents a conclusion.

2. Unemployment in Algeria

Figure 1 shows the evolution of unemployment rate and growth rate in Algeria during the period 1970- 2015:

- The overall unemployment rate in Algeria has declined considerably over the last decade falling from 28.3% in 2000 to 9.4% in 2015. The first analysis indicates that this decline was due in particularly to the public investment programmes implemented in the period 2000-2015. This public employment programs created about 6.25 million jobs between 1999 and 2008. [4]
- Economic growth has probably contributed to the fall in unemployment, real GDP growth increased from 3% in 2001 to 7.2% in 2003 and 5.9% in 2005, followed by a sharp slowdown in 2006 and 2007 to around 1.7% and 1.6% respectively, partly because the surge in international oil prices affected domestic demand. Noting that oil constitutes approximately 98% of the country's total exports, provides approximately 70% of government revenues and constitutes some 40% of GDP.
- The unemployment rate in Algeria (9.4% in 2015) remains high compared to other Middle East and North Africa (MENA) countries and in Eastern European transition countries. For instance, in 2014, the unemployment in Iran is 10.6%, Morocco 10.2%, Turkey 9.2%, MENA countries 8.8%, Venezuela 7%, Indonesia 6.2%, Saudi Arabia 5.6%, Russia 5.1%, China 4.7%, Nigeria 4.8%).

Figure 1: Unemployment rate and economic growth rate in Algeria 1970-2015



3. Okun´s law:

Economic theory suggests that increased production in an economy leads to decreases in unemployment [5]. This inverse relationship is known Okun's law. Okun described how percentage changes in the real growth rate affected the change in the unemployment rate in percentage points at a pre-defined period. [6]

In his paper, Okun (1962) used quarter data from 1948 to 1960 to explain the relationship between the unemployment rate (as the dependent variable) and the change in output (as independent variable) in USA. Since it, a several scientific contributions have investigated Okun's law using different methodological modelling approaches including: the difference method, the gap method and the dynamic method. (e.g., Viren 2001; Cuaresma 2003; Holmes and Silverstone 2006; Perman and Tavera, 2007; Zanin and Marra, 2012). We will present just the theoretical foundations of the difference method to use it in this paper.

The difference method relates the change in unemployment rate to real GDP growth is presented by the following equation:

$$D(U_t) = \alpha - \beta * Y_t \qquad (1)$$

where $D(U_t)$ represents the absolute change of unemployment rate U_t , Y_t is the growth rate of output ($Y_t = \frac{D(GDP_t)}{GDP_t}$), $t = 1,2,\ldots,T$ is the time (often quarter of a year). This equation captures the contemporaneous correlation between growth rate and changes in the unemployment rate. The intercept α equals the change in unemployment when economic growth is zero is expected positive; a high value of α suggests greater difficulties in reducing unemployment or that stronger growth is required to prevent from more unemployment [7]. The parameter β represents Okun's coefficient, which a priori is expected to be negative, since positive GDP growth is associated with a drop-in unemployment rate. High rates of economic growth indicate the need for additional labour to be employed from the surplus of the labour market. On the other hand, recession indicates increases the unemployment rates due to losing jobs, which explains why Okun's coefficient should be negative. The ratio $-\frac{\alpha}{\beta}$ represents the rate of output growth that is consistent with a stable unemployment rate or how quickly the economy would typically need to grow to maintain a given level of unemployment."[8]

4. Literature Review:

After the publication of Okun's seminal paper, many studies were carried out to test Okun's law in several countries. Table 1 provides estimates of the Okun coefficient in some developed and developing countries - including Algeria for various version of Okun's Law.

The Table 1 shows that the Okun's coefficient (Beta value) is between -0.52 and 0 with an average -0.18.

Table 1: Estimates of the Okun coefficient in some developed and developing countries.

Source	Country	Beta	Model used
Ezzahid E., El Alaoui A. (2014)	Morocco	-0.14	Linear Regression
Central Bank OF Malta, (2013)	Malta	-0.15	ARDL model
Caraiani, (2010)	Romania	-0.2	Bayesian Linear Regression
Alamro H, Al-dala'ien Q. (2014)	Jordan	0	ARDL model
Elshamy H., (2013)	Egypte	-0.02	Error Correction Model
Adouka L., Bouguell Z. (2010)	Algeria	-0.2	Error Correction Model
Abdula R., Hilal Juda N. (2010)	Irak	-0.11	ARDL and VAR models
Haririan M. et al. (2009)	Turkey	-0.14	Linear Regression
	Israel	-0.06	
	Jordan	-0.12	
	Egypt	-0.19	
Abou Hamia M. A., (2016)	Algeria	-0.51	ARDL model
	Egypt	-0.26	
	Iran	-0.09	
	Morocco	-0.06	
	Jordan	-0.33	
	Tunisia	-0.07	
	Turkey	-0.11	
	Lebanon	-0.12	
	Oman	-0.04	
	Qatar	-0.01	
Döpke J., (2001)	Austria	-0.1	Linear Regression
	Belgium	-0.15	
	Denmark	-0.36	
	Finland	-0.45	
	France	-0.21	
	Germany	-0.19	
	Greece	-0.15	
	Ireland	-0.06	
	Italy	-0.06	
	Netherlands	-0.38	
	Portugal	-0.12	
	Spain	-0.52	
	Sweden	-0.34	
	United Kingdom	-0.39	
	United States	-0.42	
	Switzerland	-0.06	
	Japan	-0.05	
	Norway	-0.17	

5. Methodology:

5.1.Autoregressive Distributed Lag (ARDL) linear model:

The Autoregressive Distributive Lag (ARDL) approach is proposed by Pesaran and Pesaran (1997) and Pesaran and Shin (1999), Pesaran and Shin (1999), Pesaran *et al.* (2001).

According Pesaran and Pesaran, the ARDL (p, q) model for the dependent variable (unemployment) U_t and the independents variables GDP_t is represented by the following equation [9]:

$$D(U_t) = c + \sum_{i=1}^{p} a_i D(U_{t-i}) + \sum_{j=0}^{q} b_j D(GDP_{t-j}) + v_t \qquad (2)$$

a_i, b_j are the parameters which is related to the short-run dynamics of the model, c : intercept, D: denotes the first difference, v is a $(T \times 1)$ vector of unobservable independent and identically distributed stochastic disturbances with a multivariate normal distribution, mean zero and covariance matrix $\sigma^2 I_n$, $\left(v_t \sim N\left(0, \sigma^2 I_T\right)\right)$.

The long-run coefficients and their asymptotic standard error are then computed for the selected ARDL model. According Pessaran and Pessaran (1997), the long-run elasticity can be estimated by [10]:

$$\hat{\alpha} = \frac{\hat{c}}{1 - \sum_{i=1}^{p} \hat{a}_i}, \quad \hat{\beta} = \frac{\sum_{j=0}^{q} \hat{b}_j}{1 - \sum_{i=1}^{p} \hat{a}_i}, \qquad (3)$$

Some advantages to using ARDL approach include the following:

- With the ARDL model, it is possible that different variables have different optimal lags, which is impossible with the standard cointegration test. [11]
- The model ARDL could be used with limited sample data (30 observations to 80 observations) in which the set of critical values were developed originally by Narayan (2004) [12].
- The ARDL approach yielding consistent estimates of the long-run coefficients that are asymptotically normal irrespective of whether the underlying repressors are I(1) or I(0), [13].
- The conventional cointegration method estimates the long run relationships within a context of a system of equations; the ARDL method employs only a single reduced form equation [14].

5.2. Bayesian linear regression model:

The theoretical background of Bayesian models is based on combine subjective prior knowledge with the information acquired from the data by using Bayes' theorem. According Schoot et al. "the key difference between Bayesian statistical inference and frequentist statistical methods concerns the nature of the unknown parameters. In the frequentist framework, a parameter of interest is assumed to be unknown but fixe, in the Bayesian view of subjective probability, all unknown parameters are treated as uncertain and therefore should be described by a probability distribution".[15]

By considering a random variable U_t as a function of a vector-valued variable X. This is modelled as a linear relationship:

$$D(U_t) = X_t\theta + v_t \qquad (4)$$

$X_t = (I_t, Y_t)$, I_t: is a $(T\times 1)$ vector with all components equal to one and Y_t is a $(T\times 1)$ vector defined by: $Y_t = \frac{D(GDP_t)}{GDP_t}$ (Growth rate of GDP); θ is (2×1) vector of parameters (α, β).

The maximum-likelihood estimate (MLE) of θ is based on the Gaussian likelihood:

$$p(U/\theta;\sigma^2) = N(X\theta, \sigma^2 I) \qquad (5)$$

Taking the log of likelihood and then taking the derivative θ, the OLS estimate of θ is: $\hat{\theta} = (X'X)^{-1}X'U$.

Inference in the Bayesian linear model is based on the posterior distribution posterior over the weights, computed by Bayes' rule,

$$p(\theta,\sigma^2/U) = \frac{p(U/\theta,\sigma^2)\times p(\theta,\sigma^2)}{p(U)} \qquad (6)$$

The marginal posterior distribution of θ and σ^2 is given by:

$$p(\theta/U) = \int p(\theta,\sigma^2/U)\,\mathrm{d}\sigma^2 \qquad (7)$$

$$p(\sigma^2/U) = \int p(\theta,\sigma^2/U)\,\mathrm{d}\theta \qquad (8)$$

Some advantages to using Bayesian analysis compared to frequentist statistical methods include the following:

- Results more intuitive: Bayesian results are more intuitive because the Bayesian posterior inference is exact and does not rely on asymptotic arguments. The posterior distribution obtained from a Bayesian model also provides a much richer output than the traditional point; in particularly, the ability to make direct probability statements about unknown quantities and to quantify all sources of uncertainty in the model, also for null hypothesis significance testing. [16]
- Effect of sample size and bias, when the sample size is small, it is often hard to attain statistical significant or meaningful results. Bayesian methods would produce a (slowly) increasing confidence regarding the coefficients. (see e.g: Schoot et al. (2013), Button et al. (2013), Lee and Song (2004), Hox et al. (2012))
- Handling of non-normal parameters: if parameters are not normally distributed, Bayesian methods provide more accurate results as they can deal with asymmetric distributions. (see e.g: Schoot et al. 2013, Zhao Lynch and Chen 2010, Yuan and MacKinnon 2009).
- Elimination of inadmissible parameters: with maximum likelihood estimation, it often happens that parameters are estimated with implausible values, for example, negative residual variances or correlations larger than 1. [17]

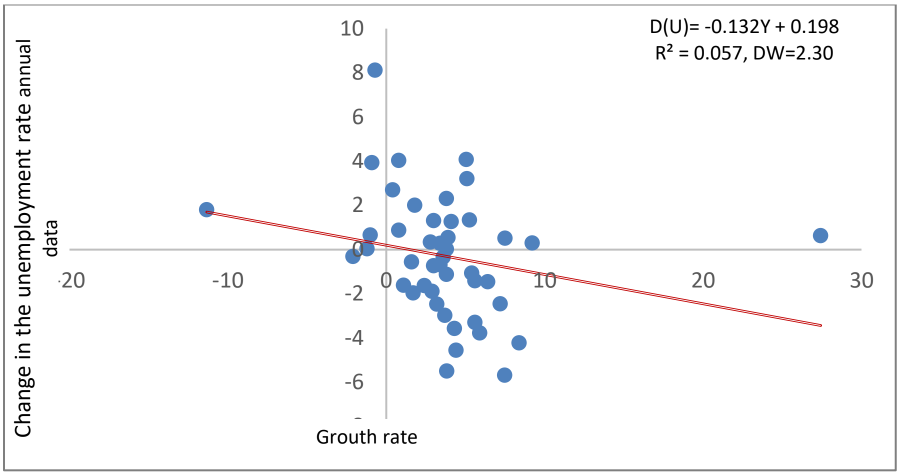
There are also disadvantages to using Bayesian analysis: the most often heard critique is the influence of the prior specification. Many more distributions are available for the prior distribution as an alternative for the normal distribution.

6. Empirical results:

The statistical analysis uses annual macroeconomic data from the national office of statistics (Algeria) for the period 1970-2015. The variables are: growth of output (Y) (measured by percentage change of real GDP); and the change of unemployment rate (U).

Figure 2 shows the changes in the unemployment rate as a linear function of the growth of output for Algeria. The chart shows that, as expected, there is a negative relationship between growth rate and the change in the unemployment rate. The value of Okun's coefficient is -0.13% using linear regression model, while the change in unemployment when economic growth is zero is estimated at 0.19. The Okun's coefficient is significantly not different from zero at conventional levels of significance (5%).

Figure 2: Scatter plot of change in the unemployment versus GDP growth



6.1. Autoregressive Distributed Lag (ARDL) linear model estimation for Okun coefficient:

Before estimating the ARDL model, an Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are used to check the stationarity for each variable. The unit root test could help in determining whether the ARDL model should be used [18].
The results of ADF and PP are reported in table 2 with 95% critical value. The null hypothesis of unit root cannot be rejected, which indicates that the series (U and GDP) have unit root, accordingly, the two variables are no stationary on level. Contrary, at first difference the null hypothesis is rejected and therefore U and GDP are stationary at the first difference.

Table 2: Summary of unit root tests

VAR	ADF								Phillips-Perron test statistic					
	Constant and trend			Constant, no trend			No constant, no trend		Constant and trend		Constant, no trend		No constant, no trend	
	Stats	p-value	t (trend)	Stats	p-value	t (drift)	Stats	p-value	Stats	p-value	Stats	p-value	Stats	p-value
U	-2.53	0.3	-0.65	-2.5	0.12	2.36	-1.08	0.24	-1.46	0.82	-1.3	0.61	-0.97	0.29
D(U)	-4.88	0	-0.16	-4.94	0	-0.76	-4.91	0	-5.6	0	-5.67	0	-5.68	0
GDP	0.26	0.99	0.09	1.49	0.99	1.38	4.81	1	-0.22	0.99	1.82	0.99	6.7	1
D(GDP)	-5.93	0.01	1.46	-5.68	0	4.76	-0.98	0.28	-6.21	0	-5.98	0	-2.5	0.01

To check the existence of a co-integration relationship among the variables, the bounds test, Pesaran et al. (2001), was implemented, which is a two-step procedure. In the first step, a lag order is selected based on the criterion information. In the second step, F-test is used for the presence of long-run relationship.
Akaike (AIC) and Schwarz (SC) criteria are used in the determination of optimum lag length of ARDL model (Table 3).

Table 3: Estimate the true orders of ARDL model using Akaike and Schwarz information criteria

	p=1	p=2	p=3	p=4
q=1	AIC: 4.696842 SC: 4.89959	AIC: 4.601643 SC: 4.847392	AIC: 4.65618 SC: 4.945792	AIC: 4.625835 SC: 4.960191
q=2	AIC: 4.752826 SC: 4.998575	AIC: 4.637074 SC: 4.923781	AIC: 4.703626 SC: 5.034611	AIC: 4.650182 SC: 5.026332
q=3	AIC: 4.779418 SC: 5.06903	AIC: 4.586221 SC: 4.917205	AIC: 4.632983 SC: 5.005341	AIC: 4.675224 SC: 5.093168
q=4	AIC: 4.821695 SC: 5.156051	AIC: 4.635699 SC: 5.011849	AIC: 4.684466 SC: 5.10241	AIC: 4.718051 SC: 5.17779

An ARDL (2, 1) model is selected as a common consequence of both criterion. The short run coefficients of ARDL (2, 1) are presented in Table 4.

Table 4: Results of ARDL(2,1) estimations

Dependent Variable: D(U)
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.758680	2.141919	1.287948	0.2058
D(U(-1))	-0.282331	0.152054	-1.856781	0.0713
D(U(-2))	-0.239576	0.138996	-1.723618	0.0931
D(GDP(-1))	-0.303031	0.071247	-4.253225	0.0001
U(-1)	-0.052337	0.074890	-0.698862	0.4890
GDP(-1)	0.000493	0.004850	0.101580	0.9196

The diagnostic tests in Table 5 shows that there is no evidence of autocorrelation at lag one and two because the p-values of these tests are more than 0.05, also there is no evidence of heteroscedasticity. The test Jarque Bera proved that the error is normally distributed.

Table 5: Residual tests of ARDL(2,1) model (normality, heteroscedasticity and autocorrelation)

Model	Jarque & Bera	p-value	Heteroscedasticity	p-value	Lag	LM- Stat	p- value
ARDL(2,1)	1.00	0.60	1.10	0.37	1	1.76	0.18
					2	0.22	0.63

To check the existence of a co-integration relationship among the variables, the bounds test of Pesaran et al. (2001) is implemented. The results of ARDL bound are presented in Table 6.

Table 6: Results of bounds test

F-statistic	K	90%		95%		98%		99%	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
0.363353	1	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84

The results show that the calculated F-statistics for model is less than the lower bound at the 5% significance level. Thus, the null hypothesis of no co-integration cannot be rejected. There is no evidence of a long-run relationship between the two variables U and GDP; and therefore, the restricted model become: (table 7).

Table 7: Results of ARDL(2,1) estimations (restricted model)

Dependent Variable: D(U)
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.893807	0.611373	3.097630	0.0036
D(U(-1))	-0.320008	0.140163	-2.283110	0.0280
D(U(-2))	-0.274828	0.129872	-2.116143	0.0408
D(GDP(-1))	-0.305815	0.065996	-4.633807	0.0000

Table (7) shows the results of the ARDL estimation in the short run, the coefficients are all significant at the 5 percent level.

The estimated values in the long run based on the relation (3) being:

$$\hat{\beta} = \frac{\sum_{j=0}^{q} \hat{B}_j}{1 - \sum_{i=1}^{p} \hat{a}_i} = -0.191, \quad \hat{\alpha} = \frac{\hat{B}_0}{1 - \sum_{i=1}^{p} \hat{a}_i} = 1.18, \quad \hat{\theta} = (1.18, -0.19)$$

The Okun coefficient $(\hat{\beta})$ is negative and significant which means that 1 percent increase in GDP growth will decrease unemployment rate by 0.19 percent.

To check the estimated ARDL model, some diagnostic tests are considered in table 8. The Table 8 shows that there is no evidence of autocorrelation at lag one and two, there is no evidence of heteroscedasticity, and the errors are normally distributed.

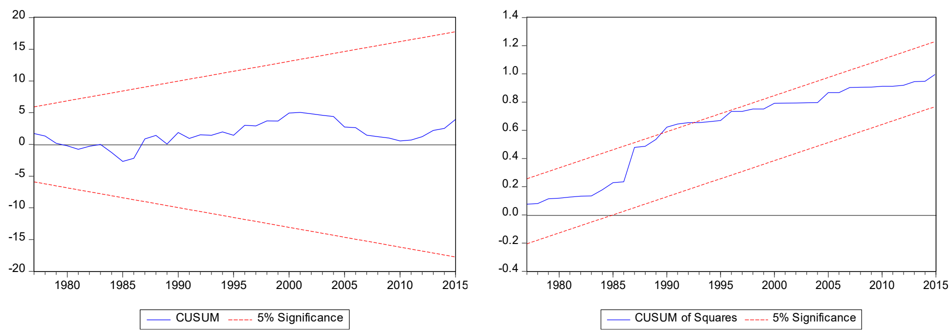
Table 8: Residual tests of ARDL(2,1) (restricted model)

Model	Jarque & Bera	p-value	Hetero-scedasticity	p-value	Lag	LM-Stat	p-value
ARDL(2,1)	1.69	0.42	0.63	0.59	1	1.74	0.19
					2	0.89	0.41

Finally, when analysing the stability of the long-run coefficients together with the short-run dynamics, the cumulative sum (CUSUM) is applied. According Bahmani-Oskooee and Wing [19], ‘’if the plot of these statistic remains within the critical bound of the 5% significance level, the null hypothesis (i.e. that all coefficients in the error correction model are stable) cannot be rejected’’.

The plot of the cumulative sum of the recursive residual is presented in figure 3. As shown, the plot of both the CUSUM test confirms the stability of the long-run coefficients of the GDP function in equations (1).

Figure 3: Cumulative Sum of Recursive Residuals



Another possibility of testing Okun’s coefficient can be done through a VAR modelling. I analyse the causality using Toda-Yamamoto test (1995): I estimate a VAR (3) model with three lags and two independents variables (GDP (-4), U(-4) based on the information given by AIC criterion) which uses the same two endogenous variables in level: U and GDP. It is clear from Table 9 that at 5% level of significance the hypothesis that GDP does not cause U is rejected, but the hypothesis that U does not cause GDP cannot be rejected. Therefore, it appears there is a unidirectional causality between U and GDP, which run strictly from GDP to U.

Table 9: Toda-Yamamoto test Result

VAR Granger Causality/ Block Exogeneity Wald Tests
Included observations : 42

Dependent variable : U

Excluded	Chi-sq	df	Prob.
GDP	15.13153	3	0.0017
All	15.13153	3	0.0017

Dependent variable : GDP			
Excluded	Chi-sq	df	Prob.
U	7.410677	3	0.0599
All	7.410677	3	0.0599

6.2. Bayesian linear estimation of Okun coefficient:

To estimate the Okun coefficient two different priors for the parameters Alpha and Beta are used as shown in the table 10. In either model the prior of variance is unknown.

Table 10: Bayesian linear estimation of Okun coefficient

Model	Prior	Posterior Mean	Confidence Interval	Log-Likelihood
Model 1, Normal prior	$\beta \sim N(-0.5,0.1)$	-0.21	[-0.31 - 0.13]	-70.60
	$\alpha \sim N(0.5,0.1)$	0.44	[0.08 0.80]	
Model 2, Uniform prior	$\beta \sim U(-1,\ 0)$	-0.21	[-0.30 - 0.12]	-70.51
	$\alpha \sim U(0,\ 1)$	0.54	[0.05 0.82]	

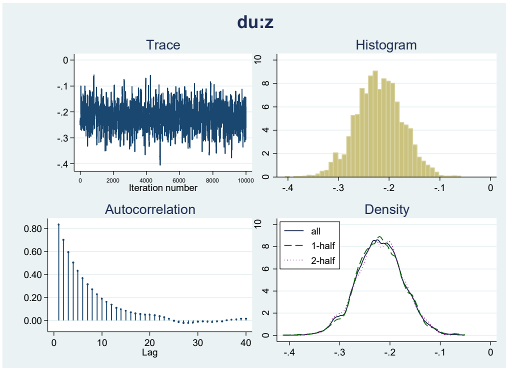
The models were estimated using two chains of 250000 extractions each using again the Monte-Carlo-Markov-Chains method. The parameters were monitored and statistics regarding its 95% confidence interval and mean were computed.

The results confirm that the effect of contemporaneous GDP growth on unemployment is statistically significant for the two models. This suggests that, there is contemporaneous relationship between unemployment and output in Algeria. The long-run Okun's coefficient is estimated at around -0.2%, which appear to be similar result in the ARDL model.

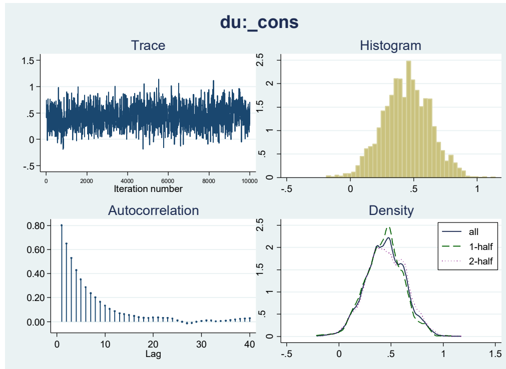
The Figure 4 also present detailed graphs regarding the posterior distributions. The autocorrelation dies off quickly for each of the cases and the posterior distributions of Okun coefficient resemble the normal distribution.

Figure 4: Scatter plot of change in the unemployment versus GDP growth

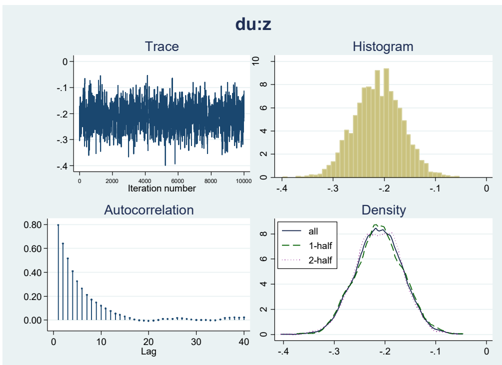
$\beta \sim N(-0.5, 0.1)$



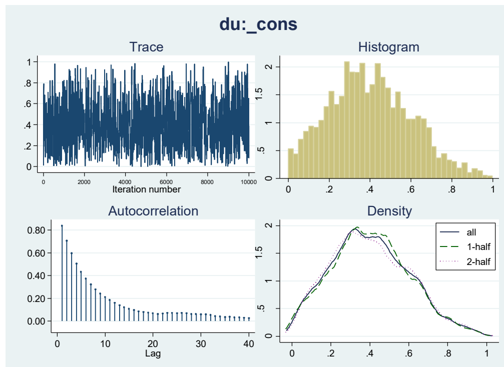
$\alpha \sim N(-0.5, 0.1)$



$\beta \sim U(-1,\ 0)$



$\alpha \sim U(0,\ 1)$



7. Conclusion and policy recommendations

The objective of this paper is to investigate the presence of Okun's (1962) relationship in Algeria for the 1970- 2015 period. Two methodologies are employed to estimate the Okun coefficient: An Autoregressive Distributed Lag (ARDL) linear model and a Bayesian Normal Linear Regression model.

By combining the results of research, we can conclude that: 1) analyse of data during the period 1970-2015 shows a negative correlation between changes of unemployment and economic growth, 2) By using an autoregressive distributed lag model, I obtain an estimation for the Okun coefficient of -0.19%. This result is confirmed through the Bayesian linear regression model (-0.21%); 3) The estimated value of the Okun coefficient (-0.2%) is considerably more reduced, in an absolute sense, than the standard Okun coefficient of -0.30%; 4) this result can be interpreted as an indication of a certain degree of rigidity of the labour market in Algeria, In particular; 5) an improvement in labour market conditions in Algeria could have a significant effect in reducing unemployment both in the short and long term.

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