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A PROPOSED MODEL FOR OKUN LAW IN THE SHORT-RUN AND LONG-RUN THE CASE OF EGYPT (1982-2018)

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ABSTRACT

The paper aims to study the dynamic interaction between GDP growth rate and unemployment rate, or unemployment rate responsiveness to changes in GDP growth rate. Using a set of Egyptian data (from 1982 to 2018), error correction model, and production function version of Okun law. The paper adds to empirical evidence that the relationship is clearer between growth rate and employment than between growth rate and unemployment, in other words concept of Okun's law is linear between employment and GDP growth and not linear between unemployment and GDP growth. The long run coefficient shows (other things remain constant) that, 1% GDP growth rate more than 1.472%, is associated with 1.17% change in the employment rate in the same direction. At the same time, the short run coefficient shows (other things remain constant) that, 1% GDP growth rate more than 2.564%, associated with 0.961% change in the employment rate in the same direction. The value of this finding is that it helps policymakers to understand the mutual independence between Okun law variables and the way they interact.

Keywords: Okun law coefficients, Egypt, Error correction model

1. INTRODUCTION

Okun's law is a well-known empirical law that expects a negative correlation between the change in the unemployment rate and the change in output; or a negative association between the deviation of the unemployment rate (from its long run rate or the so called natural rate of unemployment) and the deviation of output growth (from its long run rate or the so called the growth rate of potential output). In his seminal work, Okun (1962) used US quarterly data from 1947 to 1960 and found that for each 3% GDP growth, the unemployment rate would decrease by about 1%, so one can say that Okun law is a short run phenomenon between the fluctuations

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in the growth rate and the fluctuations in unemployment rate. On the other hand, macroeconomics theory as it seeks to explain the relationship between economic variables; it usually divided into long run theory and short run theory. The long run theory concerns (among other things) with economic growth and its determinants. However the short run theory concerns (among other things) with business cycles and so the fluctuations in unemployment rate. Therefore, it is not conceptually easy to connect the long run nature of economic growth with short run nature of unemployment rate fluctuations, for instance; the standard neoclassic growth model represented by Solow (1956) and Swan (1956) expects that the rate of growth is independent of the unemployment rate, since it includes no unemployment in the long run. So, if this is the case, it is desirable to analyze a growth model that explains this relationship.

2. LITERATURE REVIEW

2.1 Summary of some empirical studies

In almost every study of Okun law, there have been two common variables namely unemployment rate and GDP or GDP growth rate. Gap, difference and dynamic versions (VAR, VECM and TVECM) have been applied to calculate Okun's coefficient, which shows the negative association between unemployment and GDP growth.

[Mitchell and Pearce (2010)] stated that understanding Okun's Law does not require a large economic knowledge, which makes it attractive and useful for forecasting. On the other hand Okun's law created many debates among researchers, many studies showed how unstable and not trustful is this rule, and many studies not. The results of some empirical studies can be summarized as the following:

1. Adachi (2007) stated that the quantitative form Okun law is different between countries, and it also changes over the time period[1]. For example, Stober (2015,) found a small negative correlation between unemployment and economic growth rate in UK (if GDP increases by 1%, the unemployment rate will decrease by 0.074%). However Oluyomi et al (2016) found a large negative correlation between unemployment and economic growth rate in Nigeria, (if GDP increases by 1.75%, the unemployment rate will decrease by 1%), Nektarios (2016) found that if GDP increases by 2%, the unemployment rate will decrease by 1%, although this coefficient fluctuated slightly during the analyzed period.
2. That is, the relationship applied across many developed and less developed countries and the estimated coefficient found to vary across countries. For instance, Dritsaki *et al*

[1] Adachi (2007) also argued that the current version of Okun's law in the US is stated that a1% decrease in the unemployment rate is associated with about 2% growth rate.

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(2009) estimated Okun law in Spain, Portugal, Italy and Greece; he found that unemployment cost (real GDP loss) is greater three times in Italy than in Greece. Ball et al (2013, 2016) found evidence in favor of Okun´s Law in developed and in developing countries with differences in estimated coefficient; he argued that many of these coefficient differences may be due to differences in data or estimation methods, but the relationship has remained robust.

3. Researchers extended their focus to examine whether the unemployment response is stable over time or not as economic conditions change. That is, as economic, institutions, social, labor regulations are varying between countries; the mechanisms of Okun's Law in each country may vary. So, researchers examine other variables alongside the main two variables of Okun law. For example, Ball, et al (2016) found that Okun´s Law is lower response to economic fluctuations in developing countries than in developed countries and the mean unemployment rate and the share of services sector in GDP are the key variables to explain this difference between countries.
4. Gomme (1999) had studied unemployment response to various shocks, and he found that the unemployment response to a negative shock is greater than the unemployment response to a positive shock, Daly, et al., (2012) found a similar conclusion that there is a higher unemployment response to growth rate during recessions as compared to expansions.
5. Nonlinear correlation between unemployment and growth in Okun law had been studied by Meyer and Tasci (2012), Owyang and Sekhposyan (2012), and Daly, et al., (2012), and they found a nonlinear correlation between unemployment and growth.
6. Relationship between unemployment and growth in Okun law in the sort run and long run had been studied by Shin et al (2014) and Chinn et al (2013), and they found (by using cointegration models) that the short and long run dynamics could be unequal. However, Knotek (2007) found a substantial variation in the relation between unemployment rate and real GDP growth in the short run, that is, he found that there is not always a negative relationship between unemployment and output growth in the short run.
7. More recently, Okun law had been estimated for some regional groupings within a country, and most of this studies found regional differences in Okun's coefficient (see [Durech et al., 2014], and [Binet and Facchini, 2013]), however some studies were found no regional variation (see [Villaverde and Maza, 2009]).
8. The stability of Okun law verified by White and Chu (2013), and he found two ways causal relationships between unemployment rate and GDP in the US, while they could not find any causality in France and Japan, this variance in results may be due to variances in demographics, legal systems, cultures.

2.2 Okun law forms

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In his seminal work, Okun (1962) proposed two linear forms to illustrate the relationship between the unemployment rate and the GDP growth:

i) The difference specification form
ii) The gaps form

Additionally many other forms had used in imperial studies, such as:

iii) Vector Autoregressive models (VAR)
iv) Vector Error Correction models (VECM)
v) Threshold vector error correction models (TVECM)

1. The difference form

In the *difference form*, the correlation between the change in unemployment and GDP growth is studied, so that:

$$u_t - u_{t-1} = \beta_0 + \beta_1(y_t - y_{t-1}) + e_t \text{ ----(1)}$$

This equation shows how the growth rate and unemployment rate change simultaneously, where u represents the unemployment rate (usually in quarterly change) and y is the logarithm of GDP (so the difference represents the quarterly growth). Accordingly, the model illustrates how changes in growth rate from one period to the next affects the unemployment rate. The parameter $\beta 1$ (Okun coefficient) is expected to be negative, as the correlation between unemployment rate and growth rate is expected to be negative; where The amount (-$\beta 0/\beta 1$) represents the level of growth rate that keeps unemployment rate constant, so that, higher levels of economic growth (with respect to this level) will lead to a reduction in the unemployment rate. However, the difference form of Okun law looks easy to estimate, it has a main weakness that it does not capture structural changes in output or in unemployment.

2. The gap form

In the *gap form of Okun law* the cyclical relationship between unemployment rate and growth rate is illustrated, where the cyclical component is computed by eliminating the permanent component (subtraction of the long-run trend) from the time series.

$$u_t - u_t^* = \beta_1(y_t - y_t^*) + e_t \text{ ------(2)}$$

Where u_t^* represents the natural rate of unemployment or NAIRU (non- accelerating inflation rate of unemployment) so that

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$$u_t^c \cong u_t - u_t^*$$

Where u_t^c is the cyclical unemployment rate (or the unemployment gap). Similarly, y_t^* represents the potential level of GDP or the full employment level, y_t is the current GDP, so the cyclical level of output or output gap is

$$y_t^c \cong y_t - y_t^*$$

In other words, the gap model illustrates the cyclical component of both GDP growth and employment rate, or the difference between actual and potential GDP, and the difference between the current and the so called Non-Accelerating Inflation Rate of Unemployment NAIRU which is consistent with potential GDP. The main weakness of gap form is that potential GDP and NAIRU are definitely unknown and estimated by using econometric methods.

3. Vector Autoregressive models (VAR)

Vector Autoregressive models (VAR) have been used in estimating Okun law, so that the past levels of GDP may affect current unemployment through the multiplier or accelerator effect, where the whole effect of both effects are not take place at one point in time, so lags of the change in both variables have to be included. So, the form of Okun law as a Vector Autoregressive model, or VAR (*p*) model will be:

$$\Delta u_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{p} \theta_i \Delta u_{t-i} + e_t \quad (3)$$

4. Vector Error Correction models (VECM)

If the existence of a long-run correlation between GDP growth and unemployment rate expect, then the possibility of cointegration among the variables have to be included; in this case is a Vector Error Correction Model (VECM), should be used as it takes into account the long-run relation.

$$\Delta u_t = \alpha e_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{p} \theta_i \Delta u_{t-i} + \varepsilon_t \quad (4)$$

So in previous equation the change in the unemployment rate does not only depend on the VAR(p) model, but also on the previous period deviation from the long run equilibrium. Where α represents the speed of adjustment of the unemployment rate to the long run equilibrium and the (e) is the error term of long-term relationship between unemployment rate and GDP. So, Vector Error Correction Model is expected to be better predict the response of unemployment to the

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change in GDP than a VAR model.

5. Threshold vector error correction models (TVECM)

The threshold cointegration model (TVECM) introduced by Balke and Fomby (1997) represents a specification of the presence of different regimes which implies an asymmetric relation between unemployment rate and growth rate.

That is institutions, regulations and other variables may change across countries or over time, so the relation between the unemployment rate and growth rate will change accordingly. Then (TVECM) assumes a long-term relationship with short- run coefficients (and adjustment quickness) depend on the regime. So, TVECM specification will depend consequently on the number of regimes that takes into consideration. As Hansen and Tseo (2002) the two regimes model for unemployment rate can be illustrated as follow:

$$\Delta u_t = \alpha_L(e_{t-1}) + \sum_{i=1}^{p} \beta_{Li}\, \Delta y_{t-i} + \sum_{i=1}^{p} \emptyset_{Li}\, \Delta u_{t-i} + e_t \quad \text{if}(y_{t-1} + \delta u_{t-1} + c) \leq \gamma$$
$$\Delta u_t = \alpha_H(e_{t-1}) + \sum_{i=1}^{p} \beta_{Hi}\, \Delta y_{t-i} + \sum_{i=1}^{p} \emptyset_{Hi}\, \Delta u_{t-i} + e_t \quad \text{if}(y_{t-1} + \delta u_{t-1} + c) > \gamma$$
$$\text{--------------} \quad (5)$$

Where, (e_{t-1}) represents the previous lag of the error-correction term, and used to define the threshold parameter (Υ) which represents the change in the regime.

2.3 The Methodology

This study based on the so-called production function version of Okun law, because it provides a better explanation of unemployment rate and GDP relationship compared to other versions of Okun law. But to combine both short- run and long-run relationship; the error correction model will be used. So; the model is divided into two stages. The first is about the estimation of the production function equation that establishes the long-run relationship between GDP and unemployment rate. The second stage is about error correction model (ECM) to merge the short-run and long-run relationship between unemployment and GDP or GDP growth rate.

2.3.1 Production- function version:

Production-function can be used in Okun law formulation, that is, the production of GDP requires a combination of labor, and other factors of production such as capital and technology. So, other factors such as population, labor force participation rate, capital and technology should be combined to have a clear analysis of Okun law. Hence, the production function may be used to explain Okun law especially in the long run in which labor, capital and technology is

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combined to produce output.

2.3.2 Augmented Dickey Fuller (ADF) Test:

The Augmented Dickey Fuller (ADF)) tests are used to the stationarity examination of time series data. The tests attempt to find whether time series data are stationary or not before performing other analyses. Therefore, to estimate the proposed model, the stability of the time series of the logarithm of gross domestic income, the logarithm of labor and the logarithm of the worker share of capital tested using the Augmented Dickey-Fuller test that consider three different three regression equations for the time series X that used to test the unit root.

$$x_t = (\alpha - 1)\, x_{t-1} + e_t$$
$$x_t = c + (\alpha - 1)\, x_{t-1} + e_t$$
$$x_t = c + (\alpha - 1)\, x_{t-1} + \beta t + e_t$$

HO: Time series is not stationary if $\alpha = 0$

H1: Time series are stationary, $\alpha \neq 0$

2.3.3 The error correction model (ECM) and co-integration:

While co-integration test used to check the existence of relationship between two non-stationary time series variables in the long run, the error correction model (ECM) will be applied to get the information about short and long run dynamics of economic relationships between GDP growth and unemployment rate. Therefore, after regressing two variables of GDP growth and unemployment rate (which represents the long run relationship), the residual will be used in the regression of the differences of the two variables to obtain the short run relation coefficient.

2.3.4 The simple model:

Assuming that physical capital is continually changed (more advanced technic) as a process of depreciation, then one can simply conclude that technical progress is a function of time, and the output function could illustrated as:

$$Y_t = L_t^{\propto 11} \left(\frac{K_t}{L_t}\right)^{\alpha 12} e^{\propto 13T} + \propto_{14} e^{R} \text{---------} (6)$$

Where:

Y: is the gross domestic product or GDP

L: is the labor units (the number of employed worker) K: the capital stock.

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R: is a dummy variable for 25th revolution (=1 in the years after 2011)
α_{11}: return to scale[2]
α_{11}- α_{12}: Output elasticity of labor
α_{12}: Output elasticity of capital[3]
α_{13}: The coefficient of technical progress

So:

$$lnY_t = \propto_{11} lnL_t + \propto_{12} ln\left(\frac{K_t}{L_t}\right) + \alpha_{13}T + \propto_{14} R \text{ --------- (7)}$$

In addition, where R is constant, then;

$$g_{Yt} = \propto_{11} g_{Lt} + \propto_{12} g_{\left(\frac{K}{L}\right)t} + \propto_{13} \text{--------- (8)}$$

Where;

g_{Yt} : The growth rate of GDP
g_{Lt} : The growth rate of labor input

$g_{\left(\frac{K}{L}\right)t}$: The growth rate of the worker share of capital

<u>Assuming that</u>

$L_t = [(1-u_t)LF_t]$

<u>Then</u>

$$Y_t = [(1-u_t)LF_t]^{\propto 11}\left(\frac{K_t}{L_t}\right)^{\propto 12} e^{\propto 13T} + \propto_{14} e^{R} \text{--------- (9)}$$
$$lnY_t = \propto_{11} ln(1-u_t) + \propto_{11} ln\, LF_t + \propto_{12} ln\left(\frac{K_t}{L_t}\right) + \alpha_{13}T + \propto_{14} R \text{--------- (10)}$$

So that:

$$g_{Yt} = \propto_{11} g_{(1-u_t)} + \propto_{11} g_{LFt} + \propto_{12} g_{\left(\frac{K}{L}\right)t} + \propto_{13} \text{ --------- (11)}$$

---

[2] this could be concluded if the function transformed into the form $Y_t = L_t^{\alpha 11-\alpha 12} K^{\alpha 12} e^{\alpha 13T}$
[3] The use of the amount of capital per worker will avoid the function multicolinearity problem.

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And;

$$g_{Yt} = \propto_{11} \frac{u_{t-1} - u_t}{1 - u_{t-1}} + \propto_{11} g_{LFt} + \propto_{12} g_{\left(\frac{K}{L}\right)t} + \propto_{13} \text{---------} \ (12)$$

Therefore, one can simply conclude the following:

1. The relationship between growth rate and unemployment is not linear
2. The relationship is clearer and linear between growth rate and employment than between growth rate and unemployment.
3. It depends upon the return to scale level or $\propto_{11}$
4. It is affected by the labor force growth in the long run
5. It affected also by the worker share of capital

3. ESTIMATION AND RESULTS

1. To estimate the proposed production function, the stability of the time series of the logarithm of gross domestic income, the logarithm of the number of workers and the logarithm of the worker share of capital tested using the Augmented Dickey-Fuller test, which shows that the series were not stable at their first level.

Augmented Dickey-Fuller test statistic				
		Intercept	**Intercept & trend**	**none**
LN GDP	**t-Statistic**	-0.922849	-3.637131	3.059642
	prob	0.7678	0.0413	0.9990
LN L	**t-Statistic**	-1.367577	-1.265681	7.744116
	prob	0.5871	0.8805	1.0000
LN K/L	**t-Statistic**	-0.846278	0.761140	0.039958
	prob	0.7935	0.9995	0.6891

2. In this case, the Cointegration Tests are to be carried out to check the existence of long run relationship between variables. If this is the case, the error correction mechanism performed to ensure that there is a relationship between the variables and to avoid the spurious regression. This done by regression of the variables at their first level using OLS. The results were as follows:

Dependent Variable: LNY
Method: Least Squares
Sample: 1982 2018
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNL	1.170391	0.047862	24.45366	0.0000
LNKL	0.524070	0.068830	7.613948	0.0000
T	0.014726	0.002118	6.952855	0.0000
R	-0.062064	0.022636	-2.741792	0.0098

R-squared	0.997586	Mean dependent var	25.60738
Adjusted R-squared	0.997366	S.D. dependent var	0.483272
S.E. of regression	0.024802	Akaike info criterion	-4.453967
Sum squared resid	0.020300	Schwarz criterion	-4.279814
Log likelihood	86.39840	Hannan-Quinn criter.	-4.392570
Durbin-Watson stat	0.841955		

3. The value of the Durbin-Watson statistic = 0.841, which is less than the value of the R-squared, which suggests the possibility of a spurious regression resulting from the instability of time series, the tests of cointegration should be carried out.

Sample (adjusted): 1984 2018
Included observations: 35 after adjustments
Trend assumption: Linear deterministic trend
Series: LNY LNL LNKL
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.414063	29.27634	29.79707	0.0573
At most 1	0.251764	10.56736	15.49471	0.2396
At most 2	0.011817	0.416048	3.841466	0.5189

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

4. According to the Johansen Cointegration test, the null hypothesis (no cointegration) is rejected at and the alternative is accepted, that shows that there is a single long-term equilibrium equation between the variables and the error correction mechanism is then performed. The unit root of the random error was also tested, which should be stable if there is a long-term integrative relationship between the variables. The test recognizes the stability

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of the time series of random error, and hence the existence of a long-term equilibrium relationship between the variables.

Augmented Dickey-Fuller test statistic			
	Intercept	**Intercept & trend**	**none**
t-Statistic	-3.324566	-3.290675	-3.361977
prob	0.0210	0.0840	0.0014

5. So the long run relationship between GDP growth rate and unemployment is as follow:

$$g_{Yt} = 1.1703 \frac{u_{t-1} - u_t}{1-u_{t-1}} + 1.1703\, g_{LFt} + 0.5240\, g_{\left(\frac{K}{L}\right)_t} + 0.01472 + e_t \text{ ------(13)}$$

6. Error correction mechanism implemented to obtain the short-run relationship, the result is as follow:

Dependent Variable: D(LNY)
Method: Least Squares
Sample (adjusted): 1983 2018
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025647	0.006897	3.718690	0.0008
D(LNL)	0.961127	0.261717	3.672385	0.0009
D(LNKL)	0.932193	0.242966	3.836722	0.0006
R	-0.028464	0.006482	-4.391397	0.0001
U(-1)	-0.313007	0.088875	-3.521898	0.0014

R-squared	0.530817	Mean dependent var	0.045149
Adjusted R-squared	0.470277	S.D. dependent var	0.016327
S.E. of regression	0.011883	Akaike info criterion	-5.899190
Sum squared resid	0.004377	Schwarz criterion	-5.679257
Log likelihood	111.1854	Hannan-Quinn criter.	-5.822427
F-statistic	8.768075	Durbin-Watson stat	1.372478
Prob(F-statistic)	0.000074		

So,

$$g_{Yt} = 0.9611 \frac{u_{t-1} - u_t}{1-u_{t-1}} + 0.9611\, g_{LFt} + 0.9321\, g_{\left(\frac{K}{L}\right)_t} + 0.02564 + -0.313\, e_{t-1} + \varepsilon_t \text{ ------(13)}$$

Where, (e_{t-1}) represents the previous lag of the error-correction term

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7. Error correction mechanism showed that the speed of response of the dependent variable to the independent variables is 0.313 per year. So the full response period is = 1 / 0.313 = 3 years.

4. CONCLUSIONS

1. Using Error Correction Model (ECM) this paper attempts to examine the significant short run and long run relationship between GDP growth rate and unemployment rate in the Egyptian economy. The paper empirically concludes a significant negative relationship in both short run and long run between GDP growth rate and unemployment rate, which validates concept of Okun's law in both terms.
2. According to the production function version of Okun law (which reflects the gradual effect of the reduction in unemployment on GDP growth rate through the increase in new workers effectiveness) the relationship between growth rate and unemployment is not linear, so the previous level of unemployment affects the current level of growth.
3. The relationship is clearer between growth rate and employment than between growth rate and unemployment, in other words concept of Okun's law is linear between employment and GDP growth and not linear between unemployment and GDP growth.
4. The long run coefficient shows (other things remain constant) that, if there is one percent GDP growth rate more than 1.472%, there will be 1.17 percent change in the employment rate in the same direction. The long run Okun's coefficients also show that the GDP growth rate and employment rate are co-integrated since residuals of regressed variable are stationary at I(0).
5. At the same time, the short run coefficient shows (other things remain constant) that, if there is one percent GDP growth rate more than 2.564%, there will be 0.961 percent change in the employment rate in the same direction. Besides, the time to full adjustment between the two variables is about 3 years, which mentioned to the Variability of Okun's coefficient over time.
6. The result gives us a clear image of the mutual correlation between unemployment rate and GDP growth rate in the Egyptian economy. The result supported by various studies for Egypt (see Elshamy 2013) and different countries, which used as a good guide to determine the appropriate analysis.
7. The effect of the 25th January revolution (and the followed political disturbance) is clear and negative both in the short run equation (other things being equal it cause a reduction in growth rate by 2.84%), and long run equation (other things being equal it cause a reduction in growth rate in total by 6.2%). This effect in turn makes a disturbance in the relationship between unemployment rate and growth rate in Okun law.
8. The relationship in Okun law depends upon the return to scale level (or$\propto_{11}$); in

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other words, the more the return to scale is the more the effect between the two variables.

9. The worker share of capital also affects the relationship in Okun law, so that, as labor and capital are substitutes growth rate may increase as a result to the increase in worker share of capital.
10. The effect in unemployment rate reduction on GDP growth rate is higher in the long-run than it is in the short-run.

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