Validity of Okun’s Law

Empirical Evidence from Pakistan
(1981-2005)

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Abstract

The main objective of this research paper is to find the association between unemployment rate and GDP growth which is presented empirically by Arthur Okun’s in early 1960s. For this purpose I have used annual time series data during the period 1981-2005 of Pakistan. I applied difference version of Okun’s law which is more appropriate to access results directly from empirical data. In order to find long run relation between the variables I used Engle-Granger cointegration technique and Error Correction Mechanism (ECM) to find the short term behavior of GDP growth to its long run value. This paper verifies negative relationship between unemployment rate and GDP growth and both variables have long run relation with each other. Moreover GDP growth will adjust more quickly towards equilibrium in the long run.

Keywords: Error Correction Mechanism (ECM), Engle-Granger, Cointegration, Gross Domestic Product (GDP), unemployment rate, difference version, Okun’s Law.
Acknowledgement

Firstly, I present my genuinely honest gratefulness to my supervisor, Professor Xiang Lin who has carried on my research project with his acquaintance and passionate exposure. I really find him very competent and cooperative instructor. It is not easy to complete this research work without his support. My fellows establish very strong learning atmosphere that was very creative and positive. I particularly appreciate to Saqib Masood for his critical analysis regarding various issues of this research. Finally, I would like to pay my kind regards to my parents and also my wife who supported me during my studies in University.
Chapter 1: Introduction

The economy of Pakistan has experienced many ups and downs in economic growth during previous years. GDP growth can be described as increase in the real goods and services produced within the geographical boundaries of any country. GDP growth depends upon the maximum utilization of resources which can be possible with factors of production to be employed till maximum capacity, simply we can say that more labor employed to work at given capital and hence less will be unemployed and vice versa as unemployment rate is the ratio of total workers out of work to labor force. Literally it can be extracted that if more labor hired there will be more output and causes GDP to increase over time results economic growth, so employment level and GDP growth are positively correlated.

With the help of above described information one can estimate in other way around, relationship between unemployment rate and economic growth. Policy makers figured out the association of unemployment rate and GDP growth for several economies with different sample sizes with variety of methods depicted by Arthur Okun, who first introduced empirical relationship of GDP growth and unemployment rate in early 1960’s. This unemployment rate and GDP growth association motivates me to draw conclusions about Pakistan’s economy.

This paper estimates the validity of Okun’s law in Pakistan economy, whether both unemployment rate and GDP growth are associated with each other or not; to find the intensity of this relationship as well as direction of association. According to Okun’s formulation, GDP growth causes diminishing trend in unemployment rate.
There are different versions of Okun’s law such as difference version, gap version and production function approach. I used difference version of Okun’s law due to its simplicity and directly applicable to the available economic data. Another main reason of this research is to analyze short run and long run relationship between unemployment rate and output using Error Correction Mechanism (ECM) and cointegration respectively. Dickey-Fuller (DF) test is used to find the stationarity of both economic variables involved.

Annual time series data of GDP growth and unemployment rate from 1981 to 2005 is used to estimate the validity of Okun’s law in Pakistan economy. The source for statistical data is State Bank of Pakistan (SBP). According to my knowledge this is the pioneer and more appropriate study which is conducted to find unemployment rate GDP growth relationship for Pakistan economy for period 1981 to 2005.

This paper is organized as follows. The introduction chapter is followed by Okun’s law description, then review of literature, with unemployment rate and GDP trends in Pakistan economy and after this data and methodology chapter together with results and discussions ended up with conclusion and references.
Chapter 2: Theoretical Framework

The GDP growth refers to increase in real GDP over time and real GDP refers to value of goods and services produced in any economy adjusted for price changes. In order to achieve positive growth there must be an increase in real GDP i.e. production of more goods and services. Output can be produced with the help of inputs (capital, labor), if there will more workers employed at the given capital stock by utilizing economic resources at their optimum level, then we can observe real GDP growth.

So from this theoretical aspect we can say that there is positive relationship between real GDP growth and employment level, as employment level will be high so according to William Phillips the economy will observe higher price level and consequently there will be low level of unemployment as empirically estimated using Phillips curve. Phillips curve shows negative relationship between unemployment rate and price level.

From the above reasons one can observe that in order to have more employment level the economy has to face inflation and if we correlate inflation and unemployment then there is inverse result i.e. higher price level with low unemployment rate. If we consider two economic variables from above discussions; unemployment rate and real GDP growth then we can estimate the impact of unemployment rate over GDP growth. As employment and GDP growth are positively related with each other therefore unemployment rate and GDP growth will be negatively associated with each other i.e. a positive economic growth diminishes the unemployment rate in the economy.
Both economic variables may have short as well as long run relation between them. Arthur Okun defined association between GDP growth and unemployment rate and he verifies empirically their negative relationship. This is the only empirical hypothesis which explains relationship between unemployment rate and GDP growth. The following is brief explanation of this empirical hypothesis and its different versions which are widely used by different researchers for different economies.

2.1 Okun’s Law

The negative association between unemployment rate and GDP growth is first documented by Arthur Okun in early 1960s. According to this empirical hypothesis growth slowdown also causes unemployment rate to increase. This relationship is more statistical rather then structural economic framework. Moreover there is no economic theory which explains relationship between unemployment rate and economic growth, so the Okun’s hypothesis can be used as a yardstick to measure the association between these two variables. Its simplicity makes this hypothesis better in understanding.

Okun’s law has different versions which are: difference version, gap version, dynamic version and production function approach. Every method has its own pros and cons which is based on assumptions formulated by the researcher. Only the difference version has purely statistical and simple calculations, which can be directly calculated from the available empirical data without making any assumptions. The difference version approach simply regress GDP growth over changes in unemployment rate whereas in gap version, dynamic version and production function version there are
different techniques are applied to the data with different interpretations and assumptions. After applying this empirical hypothesis by using different versions, it is compared with the original estimates of Okun’s law.

2.1.1 The Difference Version Approach:

The difference version of Okun’s law can be empirically expressed as follows:

\[(U_t - U_{t-1}) = \alpha + \beta (Y_t - Y_{t-1}) + \epsilon_t\]

Where \(U_t\) = Unemployment rate in period \(t\)
\(Y_t\) = GDP growth in time period \(t\)
\(\epsilon_t\) = Error term in time period \(t\)

In this version GDP growth is regressed changes in unemployment rate, ‘\(\beta\)’ is called Okun’s coefficient (a rate of change in dependent variable due to independent variable) and its sign can be expected as negative because Okun proposed negative relationship between unemployment rate and GDP growth.

2.1.2 The Gap Version Approach:

In the gap version of Okun’s law there are some complications involved in order to calculate natural rate of unemployment and potential output, which can be calculated using different methods. The gap version can be showed empirically as follows:
Unemployment gap = β (Output gap)

\[(U_t - U^*) = \beta (Y_t - Y^*) + C_t\]

Where \( U^* \) = Natural rate of unemployment

\( Y^* \) = Potential output

\( C_t \) = Error term in time period t

Here we have two economic measurements as potential output (which means the total output attained if the resources are fully employed) and natural rate of unemployment (the unemployment rate associated with constant inflation rate) and both cannot be directly estimated from economic data. In this context how much output is to be produced at natural rate of unemployment, can be estimated. If there is high rate of unemployment then according to this version we can say that there is underutilization of resources and if the economy is working at its potential output then unemployment rate will also be at natural level.

2.1.3 The Dynamic Version Approach:

Arthur Okun also observed that something is missing in the difference version as he believed that both current and past level of output effect current unemployment rate. The dynamic version includes current and past GDP growth on the right side of model and then both will explain variation on the left side of equation in current unemployment rate (Knotek 2007). As far as the drawback is concerned, this version has no simple interpretation as compared to difference version and even gap version. This version has some resemblance with difference version of Okun’s law. Empirically the form of dynamic version can be expressed as follows:
\[ \Delta U_t = \beta_0 + \beta_1 Y_t + \beta_2 Y_{t-1} + \beta_3 Y_{t-2} + \beta_4 \Delta U_{t-1} + \beta_5 \Delta U_{t-2} \quad \text{(Knotek 2007)} \]

\[ \Delta U_{t-1} = \text{First lag of unemployment rate} \]
\[ \Delta U_{t-2} = \text{Second lag of unemployment rate} \]
\[ \Delta Y_{t-1} = \text{First lag of GDP growth} \]
\[ \Delta Y_{t-2} = \text{Second lag of GDP growth} \]

Here \( U_t \) and \( Y_t \) denote unemployment rate and GDP growth respectively and in this dynamic version there are two lags of GDP growth and unemployment rate are on the right side and they explain variation in current level of unemployment. (Knotek 2007)

2.1.4 The Production-Function Version Approach:

Okun also consider another shortcoming that unemployment rate is also affected by non-utilization of resources in different sectors of society. In production process, in order to produce output there must be an optimum combination of inputs and according to economic framework that inputs are labor, capital and technology. But now a day most studies focus on labor force, working hours and technological advancement which really effects GDP growth. So according to Production-Function approach output is the function of capital, labor and technology. The production function can be expressed empirically as:

\[ Y = \alpha (k+c) + \beta (\gamma n + \delta h) + \tau \quad \text{(Prachowny 1993)} \]
Where $Y$ is output, $k$ is capital input, $c$ is its utilization rate, $n$ represents number of workers, $h$ is the number of hours they work, $\alpha$ and $\beta$ are output elasticities and $\gamma$ and $\delta$ are contributions of the workers and weekly hours to the total labor input, $\tau$ is disembodied technology factor. (Prachowny 1993)
Chapter 3: Review of Literature

At earlier studies Arthur Okun proposed a standard of 3\% change in unemployment rate for every 1\% change in GDP growth but in modern research most of the economists claimed through empirical evidences that now Okun’s coefficient assumed values other than 3 which can be more or less in magnitude. Several studies have been carried out in order to check the validity of Okun’s law for different regions during different time periods with the application of different methods and techniques.

Knotek (2007) also estimated Okun’s law using its difference, gap and dynamic versions in which he calculated effects on unemployment rate by current output, past output level, past unemployment rate and analyzed that slowdown in economy coincided with increase in unemployment rate is not always the case in both short and long run.

Mitchell and Pearce (2010) also found that as far as economist’s predictions are concerned unemployment rate and GDP growth move in opposite direction but the change in unemployment rate causes less influenced in GDP growth as compared to Okun’s coefficient benchmark.

Christopoulos (2004) also estimated Okun’s law at regional level in Greece by applying unit root tests and cointegration tests on panel data and found that results are consistent in six out of thirteen examined regions. Sogner (2001) estimated Okun’s law on Austrian economy by using quarterly data of unemployment rate and GDP
growth. The Okun’s coefficient found to be 4.16 which are almost 2 to 3 percent initially.

Freeman (2000) also described his key findings in which he estimated Okun’s law for US economy and its regions and found that Okun’s coefficient has stable value 2 for all time periods and across regions of United States. Prachowny (1993) estimated Okun’s law using its gap version and then he calculated non-accelerating inflation rate of unemployment (NAIRU) and output gap and verifies negative association between variables involved.

Donald (2001) tested Okun’s law for ten industrial countries (US, UK, Japan, Canada, Germany, Italy, France, Netherlands, Sweden, Australia) including new developments with trend decomposition and found that Okun’s coefficient which was originally three points is now only less than two point’s growth in GDP for every one percent change in unemployment rate for selected countries.

Moosa (1996) tested Okun’s law for G7 (Canada, Italy, UK, US, France, Germany, Japan) countries. Cyclical factor is extracted from output and unemployment rate using Harvey’s structural time series model. The empirical results showed Okun’s coefficient is higher in North America and lower in Japan.

Irfan Lal, et al. (2010) checked the validity of Okun’s law in some Asian countries using annual data from 1980-2006. Engle Granger cointegration technique is used for long term association and error correction mechanism for short run. They found that Okun’s law interpretation is not applicable in some of Asian developing countries.

Marinkov and Geldenhuys (2007) also calculated Okun’s coefficient for the economy of South Africa during 1970 to 2005. They used different methods to de-trend unemployment rate and output variables and calculated Okun’s coefficient. Villaverde and Maza (2008) analyzed Okun’s law for Spanish regions for the period of 1980-2004. They used gap version of Okun’s law for most of the regions of Spain and found inverse relation between both variables but empirical results differ quantitatively.

To sum up the above review of literature, it can be clearly seen that the variables under consideration are only unemployment rate and GDP growth, whereas different versions are applied to the empirical data of various countries with different sample periods to compute Okun’s coefficient.
Chapter 4: Unemployment rate and GDP Trends in Pakistan

4.1 Unemployment rate Trends in Pakistan

The following graph showing the unemployment rate trends in Pakistan from 1980-2005; it almost shows an upward trend during this time period. In 1989 the unemployment rate was 3.1% but in next year it becomes 6.3%. During Military Government of General Zia (1977-1988), the economy was more liberal and hence sustained the unemployment rate at very low level. The Soviet invasion of Afghanistan and excessive involvement of US make sure the steps necessary for economic growth.

Figure 1:

Unemployment Trends in Pakistan

Source: State Bank of Pakistan (SBP)
Remittances from Middle East and Aid from abroad helped Pakistan a lot to initiate second Economic Revolution. After ten years of democratic Government from 1989 – 1999, again dictatorship came into power.

4.2 GDP Growth trends in Pakistan

In the following graph, it shows growth trends in Pakistan from 1981-2005; there is downfall in growth from 1982 to 1984 by 2.0% to 1.4% followed by sharp increase in growth in 1985 by 2.2%. The overall direction of economic growth in Pakistan remains mostly negative. In some cases, when there is transition in Government then real GDP decreases adversely. In Pakistan, there are two major political parties
Pakistan Muslim League (PML) and Pakistan Peoples Party (PPP), both came into power again and again, they are mainly responsible for present economic and law and order condition in Pakistan. Normally a political party can rule for five years in Pakistan but before last decade no party has completed its tenure. Consistently, when new elected party came into power they formulate new policies and reject the previous work in processes and work only for their names not for the general public welfare.

4.3 Unemployment rate and GDP Growth Trends in Pakistan:

Figure 3:

![Unemployment and Economic Growth in Pakistan (1981-2005)](image)

The political instability and incapable leaders are the main causes which affect a lot the economy of Pakistan. That’s why unemployment rate has been increasing over
time with negative economic growth. Using above scatter diagram, in order to see whether Okun's law is applicable in the economy of Pakistan, I took economic growth on x-axis and unemployment rate on y-axis and observe the negatively correlated variables. As the values are more dispersed and not lying on the regression line so we can say that there is very weak negative relationship between them.

In Pakistan economy both democratic and military Governments ruled out again and again, but Pakistan has made rapid progress during military administration. However the democratic regime ended up with corruption, privatization of nationally governed organizations, incapable rulers, injustice, unproductive policy making and tax evasion etc.
Chapter 5: Data and Methodology

In order to check the validity of Okun’s law in Pakistan I have selected annual time series data from 1981 to 2005 and the source of data is State Bank of Pakistan (SBP). There are two variables involved in this research, unemployment rate and GDP growth. Unemployment rate is calculated as ratio of total workers out of work to labor force; the calculation of unemployment rate varies from country to country.

In Pakistan for census 1951, all persons whose age are 10 or more years old, considered in labor force. Pakistan came into being on 14th August 1947, since then five census have been made in the following mentioned years 1951, 1961, 1972, 1981 and 1998. In Pakistan the empirical data is available mostly on yearly basis in past years, but from last few years some of economic variables have quarterly basis data reports as well.

I have adopted difference version of Okun’s law due to its simplicity, accuracy and direct application to the original data for getting results. As far as the results are concerned Okun’s law is more empirical and statistical relation of economic variables therefore the selection of difference version is made because it can provide more accurate results as compared to other versions of Okun’s law.

The validity of results depends upon the stationarity of variables involved. Stationarity is very much necessary segment of any kind of research, if the variables

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1 Explanatory notes (Handbook of Statistics on Pakistan Economy 2005)
2 Real gross domestic product is calculated with the quantities of 1999-00 as base at constant factor cost in which taxes and subsidies are not considered whereas at market prices both are considered.
are stationary then the results will be meaningful otherwise both the variables will give spurious results. Stationarity means that variance is constant over time and estimated coefficients from such stationary analysis can provide desired results for forecasting. On the other hand if the variables involved are non-stationary then there variance will not be constant over time and hence we cannot achieve meaningful results.

**Econometric Technique:**

**5.1 Stationary Analysis:**

In order to avoid inadequate results I precede step by step, first of all I will check the stationarity of variables involved, unemployment rate and GDP growth, by using Dickey-Fuller (DF) test. The DF test is estimated in the following three ways:

**For GDP growth**

- $Y_t$ is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$
- $Y_t$ is a random walk with drift: $\Delta Y_t = \gamma_1 + \delta Y_{t-1} + u_t$
- $Y_t$ is a random walk with drift around a stochastic trend: $\Delta Y_t = \gamma_1 + \gamma_2 t + \delta Y_{t-1} + u_t$

where $Y_t = \text{Output growth at period } t$

$Y_{t-1} = \text{Output growth at period } t-1$
Then we design null and alternative hypothesis as follows in order to check the stationarity of GDP growth:

Null hypothesis, $H_0$: $\delta = 0$ (GDP growth is nonstationary)

Alternative hypothesis, $H_1$: $\delta$ less than 0 (GDP growth is stationary)

**For unemployment rate**

$U_t$ is a random walk:  
$\Delta U_t = \delta U_{t-1} + u_t$

$U_t$ is a random walk with drift:  
$\Delta U_t = \gamma'_{1} + \delta U_{t-1} + u_t$

$U_t$ is a random walk with drift around a stochastic trend:  
$\Delta U_t = \gamma'_{1} + \gamma'_{2} t + \delta U_{t-1} + u_t$

Where $U_t =$ Unemployment rate at period $t$

$U_{t-1} =$ Unemployment rate at period $t-1$

$t =$ trend variable

Again we formulate null and alternative hypothesis as follows in order to check the stationarity of unemployment rate:

Null hypothesis, $H_0$: $\delta = 0$ (unemployment rate is nonstationary)

Alternative hypothesis, $H_1$: $\delta$ less than 0 (unemployment rate is stationary)

In this case, null hypothesis is $\delta = 0$, which means the data contains unit root i.e. the $Y_t$ and $U_t$ are nonstationary. On the other hand the alternative hypothesis is $\delta$ is less then zero i.e. the data does not contain unit root and the time series is stationary. If the
null hypothesis is rejected then we will conclude that the given time series is stationary. Moreover Dickey-Fuller (DF) critical tau values are used for statistical inference.

5.2 Cointegration:

If the time series involved contained unit root i.e. I(1) process, then there is another concept of cointegration, which means if the residuals of nonstationary time series do not have unit root i.e. they are stationary I(0): then they have long run or equilibrium relationship with each other. For this purpose I will run the long run regression of unemployment rate and GDP growth and save the residuals:

\[ U_t = \eta_0 + \eta_1 Y_t + \eta_2 T + \mu_t \]

Where \( U_t \) = unemployment rate at period t,
\( Y_t \) = growth rate at period t,
\( T \) = trend variable (for long term relation),
\( \mu_t \) = Residuals in time period t

In order to find cointegration between both variables Engle-Granger (EG) test will be applied on the above saved residuals. Now we will test the hypothesis for checking stationarity of residuals using Engle-Granger (EG) test as follows:

Null hypothesis, \( H_0: \delta' = 0 \) (residuals are nonstationary)
Alternative hypothesis, \( H_1: \delta' \text{ less then } 0 \) (residuals are stationary)
\[ \Delta \mu_t = \delta' \mu_{t-1} \]

The Engle-Granger (EG) critical tau values are used for statistical inference.

5.3 Difference Version of Okun’s Law:

After this I will estimate the Okun’s Law using its difference version because this law has more statistical relation between changes in unemployment rate and output growth therefore I opted difference version which clearly fulfill this statistical purpose. It can be shown empirically as:

\[ (U_t - U_{t-1}) = \alpha + \beta (Y_t - Y_{t-1}) + \epsilon \]

Where \( U_t \) = Unemployment rate at period \( t \)
\( Y_t \) = Output level at period \( t \)
\( U_{t-1} \) = Unemployment rate at period \( t-1 \)
\( Y_{t-1} \) = Output level at period \( t-1 \)
\( \beta \) = Okun’s coefficient
\( \alpha \) = Intercept term

In this regression \( \beta \) explains the variation in changes in unemployment rate due to one unit change in output growth whereas \( \alpha \) is the intercept term which can be defined as the unemployment rate associated with zero output growth in that time period. In addition \( \beta \) is also known as Okun’s coefficient which can be negative so that GDP growth can be associated with decrease in unemployment rate and vice versa.
5.4 Error Correction Mechanism (ECM):

Once the time series is cointegrated it means they have long term or equilibrium relation between them, due to existence of such relation there must be some association during short term. There may be disequilibrium in the short run and we can refer the error term as an equilibrium error. We can use this error term to find the short run behavior of unemployment rate to its long run value. An important theorem, known as Granger representation theorem indicates that if the two variables are cointegrated then the relationship between them can be explained through ECM (Gujarati 4th Edition).

Empirically this can be shown as:

\[ \Delta U_t = \theta_0 + \theta_1 \mu^*_{t-1} + \lambda_1 \Delta Y_t + \varepsilon_t \]

Where \( \mu^*_{t-1} = U_{t-1} - \eta_0 - \eta_1 Y_{t-1} - \eta_2 T \)

In the above equation of Error Correction Mechanism, \( \Delta \) states first order difference and \( \varepsilon_t \) is the random error and \( \mu^*_{t-1} \) is the one period lagged value of the error from cointegrating regression. The above model states that \( \Delta U_t \) depends upon both \( \mu_{t-1} \) and \( \Delta Y_t \), if the \( \mu_{t-1} \) is different from zero then there will be disequilibrium.

Suppose \( \Delta Y_t \) is zero and \( \mu_{t-1} \) is positive. This means \( U_{t-1} \) is too high to be in equilibrium, that is, \( U_{t-1} \) is above its equilibrium value. Since \( \theta_1 \) is expected to be
negative, the term $\theta_1 \mu_{t-1}$ is negative and, therefore, $\Delta U_t$ will be negative to restore the equilibrium. That is, if $U_t$ is above its equilibrium value, it will start falling in the next period to correct the equilibrium error; hence the name Error Correction Mechanism. By the same token, if $\mu_{t-1}$ is negative (i.e., $U_t$ is below its equilibrium value), $\theta_1 \mu_{t-1}$ will be positive, which will cause $\Delta U_t$ to be positive, leading $U_t$ to rise in period ‘$t$’. Thus, the absolute value of $\theta_1$ decides how quickly the equilibrium is restored (Gujarati 4th Edition).

On the other hand same procedure will be repeated in the following way:

$$\Delta Y_t = \theta'_0 + \theta'_1 \mu^*_{t-1} + \lambda'_1 \Delta U_t + \varepsilon'_t$$

Where $\mu^*_{t-1} = Y_{t-1} - \eta'_0 - \eta'_1 U_{t-1} - \eta'_2 T$

In this model I just switch dependent and independent variables to verify that same conclusion from the first ECM model is justified. In this model I will check the significance and the magnitude of $\theta'_1$ whether it is significant and negative or not. Moreover if it will be positive and insignificant then results from first ECM model will be verified.
Chapter 6: Results and Discussions

After applying all methods and techniques step by step, as described in the previous chapter, I found following results and interpretations as well.

6.1 Stationarity

GDP growth:

Now I will test the hypothesis for checking stationarity of GDP growth using Dickey-Fuller (DF) test as follows:

Null hypothesis, $H_0$: $\delta = 0$ (GDP growth is nonstationary)

Alternative hypothesis, $H_1$: $\delta$ less then 0 (GDP growth is stationary)

$Y_t$ is a random walk: $\Delta Y_t = \delta Y_{t-1}$

$\Delta Y_t = -0.04 Y_{t-1}$

$t = -0.642$ \quad R Square = 0.018

The Dickey-Fuller (DF) critical tau value at 1% level of significance is -2.66, whereas the calculated $t$ value is -0.642 which is much less then critical value in absolute terms, therefore I rejected null hypothesis and concluded that the GDP growth time series is nonstationary.
\( Y_t \) is a random walk with drift:
\[
\Delta Y_t = \gamma_1 + \delta Y_{t-1} + u_t
\]
\[\Delta Y_t = 1.194 - 0.759 Y_{t-1}\]
\[t = (3.450) \quad (-3.534) \quad R \text{ square} = 0.362\]

After adding drift to the model the critical DF value is -3.75, which is greater then the calculated -3.534 in absolute terms also estimated same result of nonstationary.

\( Y_t \) is a random walk with drift around a stochastic trend:
\[
\Delta Y_t = \gamma_1 + \gamma_2 t + \delta Y_{t-1} + u_t
\]
\[\Delta Y_t = 1.627 - 0.017 t - 0.892 Y_{t-1}\]
\[t = (3.146) \quad (-1.122) \quad (-3.653) \quad R \text{ square} = 0.398\]

In this model I also included trend variable and for such kind of model DF critical value at 1% is -4.38 for 25 observations and the estimated t value is -3.653, also less then critical in absolute terms, hence I can say that GDP time series is non-stationary.

In the above all three models the value of \( \delta \) is negative since \( \delta = \rho - 1 \) and therefore \( \delta \) should be negative to remain the population correlation less then or equal to 1 otherwise there will be specification error.

**Unemployment rate:**

Now I will test the hypothesis for checking stationarity of Unemployment rate using Dickey-Fuller (DF) test as follows:
Null hypothesis, $H_0$: $\delta = 0$ (Unemployment rate is non-stationary)

Alternative hypothesis, $H_1$: $\delta$ less than 0 (Unemployment rate is stationary)

$U_t$ is a random walk: $\Delta U_t = \delta U_{t-1} \quad \ldots \ldots \ldots \ldots (1)$

$\Delta U_t = 0.02 U_{t-1}$

$t = 0.645$ \hspace{1cm} $R$ Square $= 0.018$

$U_t$ is a random walk with drift: $\Delta U_t = \gamma'_{1} + \delta U_{t-1} + u_t \quad \ldots \ldots \ldots (2)$

$\Delta U_t = 0.850 - 0.126 U_{t-1}$

$t = (1.465) \quad (-1.192)$ \hspace{1cm} $R$ square $= 0.061$

$U_t$ is a random walk with drift around a stochastic trend: $\Delta U_t = \gamma'_{1} + \gamma'_{2} t + \delta U_{t-1} + u_t \quad \ldots \ldots \ldots \ldots (3)$

$\Delta U_t = 1.682 + 0.146 t - 0.663 U_{t-1}$

$t = (2.925) \quad (2.933) \quad (-3.241)$ \hspace{1cm} $R$ square $= 0.334$

The DF critical values at 1% for model 1, 2 and 3 are -2.66, -3.75 and -4.38 whereas the estimated $t (=tau)$ values are 0.645, -1.192 and -3.241 respectively. In order to avoid specification error we will not prefer model 1 because $\delta = \rho - 1$ and according to this formula it will make the value for population correlation more than 1 which is not statistically feasible. The estimated values in model 2 and 3 are less then the critical values in absolute terms therefore I rejected null hypothesis $\delta = 0$ and concluded that the unemployment rate time series is also non-stationary.
6.2 Cointegration:

As both output growth and unemployment rate is nonstationary i.e. I (1) process, therefore to make sure that whether this regression gives useful result or spurious results, concept of cointegration will be applied using Engle-Granger (EG) test. Firstly, I run the long run regression between unemployment rate and output growth and save the residuals. Secondly, I applied EG test on residuals and get the following results:

\[
U_t = \eta_0 + \eta_1 Y_t + \eta_2 T + \mu_t \\
U_t = 2.501 - 0.007 Y_t + 0.215 T \\
t = (3.210) \quad (0.019) \quad (9.311) \quad \text{R square} = 0.816
\]

Engle-Granger (EG) Test:

Now I will test the hypothesis for stationarity of residuals using Engle-Granger (EG) test as follows:

Null hypothesis, \( H_0 \): \( \delta' = 0 \) (residuals are nonstationary)

Alternative hypothesis, \( H_1 \): \( \delta' \) less then 0 (residuals are stationary)

\[
\Delta \mu_t = \delta' \mu_{t-1} \\
\Delta \mu_t = -0.663 \mu_{t-1} \\
t = -3.389 \quad \text{R Square} = 0.333
\]
The Engle-Granger (EG) critical tau value for 1% is -2.5899 and the estimated t value is greater than critical value in absolute terms, therefore I rejected null hypothesis and concluded that the residuals are stationary i.e. I(0) process. So this regression is not spurious even I can say that this regression is meaningful. Moreover, both variables have long run or equilibrium relation.

**6.3 Difference Version of Okun’s Law:**

The results are as follows:

\[(U_t - U_{t-1}) = \alpha + \beta (Y_t - Y_{t-1}) + \epsilon\]

\[(U_t - U_{t-1}) = 0.193 - 0.028 (Y_t - Y_{t-1})\]

\[t = (1.047) \quad (-0.081) \quad R \text{ square} = 0.00\]

I found inverse association between unemployment rate and output growth, 1% increase in growth causes 2.8% decrease in unemployment rate changes whereas 0.193 is the intercept term which can be defined as the unemployment rate associated with zero output growth.

**6.4 Error Correction Mechanism (ECM):**

Now consider the following model:

\[\Delta U_t = \theta_0 + \theta_1 \mu^*_{t-1} + \lambda_1 \Delta Y_t + \epsilon_t\]

Where \(\mu^*_{t-1} = U_{t-1} - \eta_0 - \eta_1 Y_{t-1} - \eta_2 T\)
And the results are:

\[
\Delta U_t = 0.198 - 0.664 \mu_{t-1} - 0.031 \Delta Y_t
\]

\[
t = (1.285) \quad (-3.237) \quad (0.106)
\]

R square = 0.333

The value of \( \theta_1 \) is statistically significant and negative; absolute value of coefficient of \( \theta_1 \) tells how quickly the equilibrium is restored. ‘\( U_t \)’ would adjust to the equilibrium at speed of 0.664 times deviation from equilibrium, the error term in previous period. This model suggests that both output growth and unemployment rate have short run and negative association with each other. The coefficient 0.031 refers to short run variation in ‘\( U_t \)’ changes due to ‘\( Y_t \)’.

Now I will run the equation as follows and check the results:

\[
\Delta Y_t = \theta'_0 + \theta'_1 \mu^*_{t-1} + \lambda'_1 \Delta U_t + \varepsilon'_t
\]

\[
\Delta Y_t = 0.010 + 0.056 \mu_{t-1} - 0.018 \Delta U_t
\]

\[
t \quad 0.085 \quad 0.297 \quad 0.106
\]

R square = 0.004

In this model of Error Correction Mechanism (ECM) the error term is almost zero which explains that ‘\( Y \)’ adjusts to changes in ‘\( U \)’ in the same period. As the above results show that the short run coefficient is 1.8% which explains that 1% decrease in unemployment rate causes 1.8% economic growth in the short run. The value of \( \theta'_1 \) is insignificant and positive (0.056). However in this ECM model the speed coefficient
is positive, ‘$Y_t$’ would adjusts within this time period. Therefore it cannot capture the effect. As a conclusion ‘$Y_t$’ adjusts faster then ‘$U_t$’.
Chapter 7: Conclusion

This essay has major focus on validity of Okun’s law as well as short-term and long-term relationship between unemployment rate and GDP growth in Pakistan. I applied difference version of Okun’s law and found negative relationship between two variables involved. The use of empirical data for a period of twenty five years reduces the possibility of deviation from the productive result. The Okun’s coefficient is ‘-2.8%’ which explains ‘1% increase in GDP growth causes 2.8% decrease in unemployment rate’ whereas 0.193 is the intercept term which can be defined as the unemployment rate associated with zero GDP growth.

Firstly, Dickey-Fuller test is applied to find stationarity of unemployment rate and GDP growth by using random walk, with drift and stochastic trend, and found both variables nonstationary. As both variables are I (1) process, therefore Engle-Granger (EG) test is applied to check whether both variables are cointegrated or not. The Engle-Granger (EG) critical tau value for 1% is -2.5899 and the estimated t value is more less than critical value, therefore residuals are found to be stationary i.e. I(0) process. So this regression is not spurious even both variables have long run or equilibrium relation.

The time series is cointegrated it means they have long term or equilibrium relation between them, due to existence of such relation there must be some association during short term. Error Correction Mechanism (ECM) is applied and found that output growth adjusts more quickly towards equilibrium. Moreover I found that in short run 1% economic growth causes 3.1% decrease in unemployment rate.
This study has left some questions unanswered, and it will give motivation to further researchers to apply different versions of Okun’s law with expanding time series as well as more countries of observation. This will make sure to produce more productive results.
Chapter 8: References


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