The Validity of Okun’s Coefficient in Pakistan: A Time Series Analysis

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Author’s contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

ABSTRACT

The output – unemployment relationship was postulated by Arthur Okun in the beginning of 1960’s, known as Okun’s law. This study specifically contributes to the literature in Pakistan by estimating the production function version of Okun’s law using annual time series data over the period of 1973 to 2017 and generally helps in selecting a suitable test method for time series data. Linear regression and time series predictive models are used for the analysis to compare their predictive ability and analyze their performance to choose the best. The performance analysis shows that the time series forecasting model provides more efficient results as compared to the linear regression model. The empirical evidence suggests that Okun’s law holds its validity in the long run as well as in the short run in Pakistan. Thus, a decrease in economic output could lead to increase in unemployment, but unemployment has a less impact on real gross domestic product (GDP) for the case of Pakistan as compared to Okun’s coefficient benchmark.

Keywords: Okun’s law; Pakistan; real gross domestic product (GDP); unemployment rate; capacity utilization; capital formation; total labor force.

1. INTRODUCTION

Arthur Melvin Okun was an American economist. In 1962, Okun discovered a widely cited “Okun’s law.” He observed that as real GDP reduced unemployment increased in the economy, representing a negative association among GDP and unemployment. Okun’s law has been an emerging topic under study in macroeconomics because it is known as “one of the most reliable empirical regularities of macroeconomics.” While assessing Okun’s law, alleged Okun’s coefficient is also calculated. This coefficient shows how much of the country’s output may be lost when unemployment rate is above its natural rate [1].

Unemployment has become a serious problem in many developing and developed countries. Unlike others unemployment rates are soaring high in Pakistan. Increasing the army of
unemployed has diverse impacts on households, societies and economies. At household level, unemployment lowers the consumption of a household because of lack of income. At social level, individuals, who remain unemployed for longer periods, are, due to financial difficulties, impelled to join the underworld and commit crimes e.g., murder, theft, violence, drug abuse, robbery and suicide. At economic level, unemployment lowers output as well as the amount of tax collected by the government, hence increasing budget deficit. Consequently, reducing unemployment is a crucial macroeconomic goal.

There is a large body of research based on Okun's law, many researchers approach the relationship using only two variables unemployment and GDP, as stated by the law. However, recent studies have focused on the magnitude and stability of Okun's coefficient over the economic cycle [2]. Owyang et al. [3] show that unemployment appears to be more sensitive to economic growth during recessions than economic stability. Cazes et al. [4] also find that Okun's coefficient varies over time and appears to be larger during economic expansions and recessions. Nonetheless, Ball [5] suggested that a constant (not time varying) Okun's coefficient is strong, reliable, stable and a good approximation of reality, while Boussemart et al. [6] identified that the factors like productivity, capital and technology that affect GDP and unemployment rate might be considered as key elements to explain unemployment – output correlation discrepancies overtime.

Thus, in this study explanatory variables capacity utilization, capital, labor, unemployment and technology are used to estimate Okun's coefficient for Pakistan so that effective policies are implemented and unemployment rates could be pulled down.

1.1 Rationale of the Study

The objective of this study is the estimation of Okun's coefficient for Pakistan over the period of 1973 to 2017 and to determine how unemployment has affected the economy of Pakistan over that period.

1.2 Statement of the Problem

Unemployment rates are serving as a standard measure of "economic pain" in the economy since long. Unfortunately, Pakistan is facing high unemployment. As reported by Pakistan labor force survey the total civilian labor force was 65.5 million in 2017. Out of it, 3.79 million (5.79%) were unemployed and 61.71 million (94.21%) were employed, which is a bad sign for the economy of Pakistan. Thus effective strategies are required to overcome this issue. This study evaluates how reduction in real GDP is triggering unemployment in Pakistan.

1.3 Formulation of Okun's Law

Okun’s law has several versions e.g., the difference version, the gap version, the dynamic version, and the production function version [1]. Each one of them is explained precisely below:

1.3.1 The difference version

Okun’s primary relation explains how real GDP varies simultaneously with the variations in unemployment.

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

Where:

- \( Y_t \) = Real GDP
- \( Y_{t-1} \) = First difference of real GDP
- \( \beta \) = Coefficient
- \( \alpha \) = Constant term
- \( U_t \) = Unemployment rate
- \( U_{t-1} \) = First difference of unemployment rate
- \( \epsilon_t \) = Error term
- \( t \) = Time trend

The coefficient (\( \beta \)) has a negative sign. This specifies a reduction in unemployment rate leads to a rise in real GDP, while a reduction in real GDP is linked with an increase in unemployment [1].

1.3.2 The gap version

Okun’s second link connects the actual and natural unemployment rate with the output gap. Okun tried to discover that how much the economy can produce "in full employment condition." Okun assumed full employment to be occurred when the unemployment rate is at 4% or fairly low to produce maximum output without generating too much inflationary pressure [1]. It took the form:
Okun's dynamic version suggests that the existing unemployment rate, past unemployment rate and past changes in real output has an impact on current level of output which can be expressed as follows:

\[
\Delta Y_t = \beta_0 + \beta_1 U_t + \beta_2 U_{t-1} + \beta_3 U_{t-2} + \beta_4 \Delta Y_{t-1} + \beta_5 \Delta Y_{t-2} + \epsilon_t
\]

Where:
- \(\Delta Y_t\) = Change in real GDP
- \(\Delta Y_{t-1}\) = First lag of real GDP
- \(\Delta Y_{t-2}\) = Second lag of real GDP
- \(U_t\) = Unemployment rate
- \(U_{t-1}\) = First lag of unemployment rate
- \(U_{t-2}\) = Second lag of unemployment rate
- \(t\) = Time trend
- \(\epsilon_t\) = Error term
- \(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4\) and \(\beta_5\) are parameters to be estimated.

The only drawback of this version is that it has a complex interpretation [1].

1.3.4 The production function version

Okun realized that his proposed association is limited due to the fact that the association between unemployment and real GDP is not one-to-one, but the variations in output are related with the variations in labor, capital and technology also, and unemployment rate at best is “a proxy variable for all the ways by which output is affected by idle resources” [7]. Okun's production function version typically combines a theoretical production function with Okun's law version. It is assumed that the theoretical production function is Cobb-Douglas. Thus, a hybrid specification of the model is:

\[
\ln (Y_t - Y_t^*) = \beta_0 + \beta_1 \ln C_t + \beta_2 \ln K_t + \beta_3 \ln (U_t - U_t^*) + \beta_4 \ln L_t + \tau
\]

1.4 Theoretical Framework

Okun presented simple equations that connected unemployment rate to real GDP that have been used by economists for macroeconomic analysis as a rule of thumb. Henceforth, these equations have been revised by several authors and extended to make their theoretical foundations more specific and improve statistical fit. Therefore, an additional set of papers formed an empirical version of Okun's law with a production function involving real GDP and potential factors including the size of labor force, capital and technology [7]. They assumed that equilibrium of real output is obtained when these factors reach their equilibrium level.

Thus, to estimate the production function version of Okun's law, it is important to understand how GDP works. The two basic characteristics of GDP are potential GDP and actual GDP. Potential GDP is the level of production an economy is capable to produce while operating at full capacity, it rises in the long run; while actual GDP is the total output produced by an economy during a given time period, it fluctuates in the short run. A negative actual GDP shows a contraction and positive an expansion [7]. The actual GDP fluctuates in a cyclical pattern around potential GDP, it can be seen in Fig. 1.
In the figure above, four phases of an economic cycle are presented. The difference amid actual and potential GDP is recognized as GDP gap.

- A negative GDP gap indicates a weak demand for goods and services, and the economy may not be operating at full employment.
- A positive GDP gap indicates that the economy is producing more than its sustainable limits.

This association among actual and potential GDP is interesting while analyzing Okun’s law, as it is closely related to unemployment [7]. Unemployment declines as the economy experiences an expansion in the actual GDP and rises when actual GDP is in the contraction phase. Simply put, the difference amid the actual and potential GDP includes the cyclical level of output. Similarly, the difference amid the actual and natural unemployment rate denotes the cyclical rate of unemployment [7]. The natural unemployment rate is a normal unemployment the economy experiences when it is neither in a recession nor boom. It includes frictional and structural unemployment not cyclical [7].

1.5 Objectives of the Study

This study intends to address the following objectives:

1. To ascertain whether or not the Okun’s law production function version is valid in Pakistan.
2. To study the current state of real GDP, capacity utilization, capital formation, unemployment rate and total labor force in Pakistan.
3. To determine a long run and short run relationship among real GDP, capacity utilization, capital formation, unemployment rate and total labor force in Pakistan.

1.6 Research Questions

1. Does Okun’s law, as specified, is valid in Pakistan?
2. Is there a causal relationship between real GDP, capacity utilization, capital formation, unemployment rate and total labor force in Pakistan?

1.7 Significance of the Study

Pakistan is a labor-driven country, therefore it is dependent on its laborers for the consumption and production of goods and services. These laborers can earn a living only if they are employed. However, Pakistan is facing a major problem of unemployment. Therefore, it is essential to examine how variations in output are affecting unemployment rates in Pakistan because unemployment is considered harmful for the citizens as well as for the economy. Hence,
Okun's coefficient is prime to the policy makers to stimulate economy, control unemployment rates and carrying out effective economic policies.

2. LITERATURE REVIEW

This section is split into three parts: The first part covers the origin of Okun's law, the second part covers previous researches about Okun's law in other countries and the third part covers previous researches about Okun's law in Pakistan.

2.1 Origin of Okun’s Law

Arthur Okun first time documented an inverse association between variations in unemployment and variations in real GDP [1]. The initial form of Okun's law developed by Okun [8] identified that "unemployment drops by 1% when GNP rises by 3%”. However, later form of Okun’s law proposed by Samuelson and Nordhaus [9] suggests "when unemployment rises up to 1% GDP falls by 2%”.

There are many critiques of Okun’s law because it is an arithmetical relation not structural therefore it varies remarkably across countries depending on their economic structures. However, Okun’s law has been used by the policy makers during economic slowdowns to stimulate the economy [1].

2.2 Okun’s Law in Other Countries

2.2.1 Okun’s law in developed world

Blackley [10] estimated Okun's law for twenty-six American states. He finds that to increase GNP by 3.1 percentage points, 1 percentage point reduction in unemployment is required. Moreover, he suggested that interstate variations in industrial mix, age and gender distributions and growth rate of labor force are significantly related to variations in Okun's law. Prachowyny [11] assessed Okun's law by production function (assumed Cobb-Douglas) involving productivity, labor force working hours, capacity utilization, capital and technology for American economy. He confirms the existence of Okun's law in American economy.


Arshad [14] investigated Okun’s law for Sweden. He employed gap version and Hodrick Prescott (HP) technique for the analysis on quarterly data, for the period 1993-2009. Findings show the stability of Okun's law in Sweden for short run and long run. Boussemart et al. [6] estimated Okun's law by production function version for United Kingdom. He said that Okun’s law exist in UK and economic growth is dependent on capital stock of a country, size of labor force, the rate of capacity utilization and unemployment rate. Daly et al. [15] attempted to provide a growth accounting framework by which modern economies adjust to different shocks. Firstly, they validate the presence of Okun's law in American economy. Secondly, they analyzed output drops faster than unemployment rate increases. Thirdly, in response to all the shocks, the adjustment mainly rests with the capacity utilization rate.

2.2.2 Okun’s law in emerging and developing economies

Kreishan [16] concludes that Okun’s law doesn’t exist in Jordan for the specific years 1970 to 2008. Lam [17] examined the difference version of Okun’s law for Philippine from 1961-2012. Empirical findings reveal that in Philippine Okun’s law is not stable in short run but exists in long run.

Liu et al. [18] projected a generalized Okun's law (GOL) that that joins migrant movements with unemployment rates to check the link between labor market dynamics and economic cycle, the empirical results initiate that labor market remains strong generally and Okun’s law is not fit for China. Esmeraldo et al. [19] estimated Okun’s law for Albania for the time phase soon after the collapse of Leninism in 1993 up to the most recent period in 2017. Results specify that the link between economic growth and unemployment doesn’t exist during periods of turmoil, but it is comparatively strong later.

2.3 Okun’s Law in Pakistan

Javed [20] used Engle-Granger cointegration test to check the long run connection and Error
Correction Mechanism to check the short run connection among unemployment and GDP growth using Okun's law difference version on yearly time series data over the period of 1981 to 2005. He concludes that Okun's law exists in Pakistan. Khan et al. [21] tested Okun's law using Hodrick Prescott (HP) and Ordinary Least Square (OLS) on annual time series data from 1976-2010. The results show 1% point rise in unemployment lowers GDP growth by 0.36% points.

Ahmed et al. [22] investigated Okun's law by difference and gap versions using annual time series data from 1974-2009 by applying Simple Linear Regression. They did not found the presence of Okun’s law in Pakistan. Batavia et al. [23] estimated Okun’s law by gap version using annual time series data from 1985-2010, applied linear regression (OLS). The empirical findings are not significant for the economy of Pakistan. Akram et al. [24] assessed Okun’s law by its gap, difference and dynamic versions using annual time series data for 1971-2012. Linear regression (OLS) is applied for analysis. The empirical findings are not significant for the economy of Pakistan.

In a nutshell, the literature shows that Okun’s law is stable in the developed world but in emerging and developing economies it is either vague or invalid, it is mainly due to the difference between their economic structures. The literature concerning the existence of Okun's law in Pakistan shows ambiguous results. Furthermore, it can be seen that not much research has been conducted into the relationship between macroeconomic variables e.g., capacity utilization, labor, capital formation and technology along with unemployment rate in Pakistan, so that how each variable affects real GDP with variations in unemployment can be identified. Since, little to no research has been done in this area; this study intends to bridge this gap in the literature by estimating the production function version of Okun's law by applying time series analysis for the case of Pakistan.

3. COUNTRY CONTEXT

This section provides a general background information on real GDP, capacity utilization situation, capital formation, unemployment and labor force in Pakistan.

3.1 History of Real GDP Growth in Pakistan

Gross domestic product is the most important measure of the output of the economy. Real GDP is the sum of the value-added in economy adjusted for inflation. If the GDP is increasing it shows that production and capital formation is going up and a reduction in unemployment rate. A glance at the history of real GDP in Pakistan shows an increasing trend with a little bit fluctuation. The graph below shows, the real GDP was highest at 304.95 in 2017. However, it was lowest at 6.32 in 1973.

Graph 1. Real GDP in Pakistan
3.2 Capacity Utilization Situation in Pakistan

Capacity utilization is a decent top-down macroeconomic indicator that assists in understanding final demand, consumption, inflation and labor market. It measures how much of the manufacturing and productive potential is being utilized by any economy at any given point in time [25]. Economies with a capacity ratio of less than 100% can considerably boost production while not requiring major expenditures for new capital or equipment [25].

It can be seen from the graph below that there is no significant rise in capacity utilization in Pakistan over the last 45 years. This signifies that there is a lot of space for production to expand before the economy starts feeling inflationary pressures [25].

3.3 Capital Formation in Pakistan

Capital is the most important factor of production particularly in developing economies. Capital formation is defined as an addition to country’s stock of capital goods. Thus, it is a key indication of confidence in the future of an economy [26]. The graph shows investment in Pakistan is continuously on decline since 2008, and reached all-time low at 12.52% during fiscal year 2011-12 and all-time high at 19.23% in 1993-94.

Graph 2. Capacity utilization in Pakistan

Graph 3. Capital formation in Pakistan
3.4 Unemployment Trends in Pakistan

Pakistan is facing a major problem of unemployment. However, foregoing governments have tried their best to control unemployment rates despite fairly high population growth. They introduced schemes of self-employment by granting loans to unemployed youth and launched employment programs that provided employment to the unemployed young people for a year or two which has reduced unemployment in the short run [27]. However, despite providing all these facilities, all the governments of Pakistan has failed to establish an effective education system. Particularly technical and vocational education; and upgrade the quality of higher and professional education [27]. Thus, Pakistan is low at producing human capital which is the biggest cause behind the rapidly growing unemployment in the country; other major reasons are uncontrolled and ever-growing population and political uncertainty.

3.5 Labor Force in Pakistan

An active labor force is the strength of the economy as it can increase a nation’s economic growth but low wages and unemployment would become a risk, when its quantity is too high comparative to the rest of the population. The graph below shows the labor force in Pakistan is continuously rising over the past 45 years. This indicator reached a maximum value of 65.5 million in 2017 and a minimum value of 20.12 million in 1973.
4. DATA, METHODOLOGY AND ECONOMETRIC MODELS

This study covers annual time series data from 1973 to 2017, for a total of 45 observations. To study the long run association and short run dynamics of Okun’s law in Pakistan this research opts broader production function version because it involves potential variables e.g., capacity utilization, labor and capital along with unemployment rate that have a significant impact on output. This study employs a comparative analysis between linear regression and time series predictive models, to analyze their predictive ability. Eviews software is used for the analysis of data.

4.1 Research Design

This research is descriptive in nature because it explains the relationship between variables. In this study, real GDP is the dependent variable and capacity utilization, capital formation, unemployment rate, and total labor force are independent variables.

4.2 Sources of the Data

Data on unemployment rate and total labor force are collected from Labor Force Survey of Pakistan and Pakistan Bureau of Statistics, while data on capital formation and real GDP are collected from World Bank. Since, the official estimate of capacity utilization is not released by the government or central bank of Pakistan. Therefore, it is computed by the researcher; through dividing the actual output by potential output and multiplied by 100, as:

\[
\text{Capacity Utilization} = \frac{\text{Actual Output}}{\text{Potential Output}} \times 100
\]

Moreover, the estimate of natural unemployment and potential GDP is neither directly observable nor published officially so Okun preferred a simple time trend to evaluate \( Y_t^* \) and \( U_t^* \) [7]. Therefore, in this study potential output was extracted from actual output and natural rate of unemployment was extracted from actual unemployment using Hodrick Prescott Filter [28] in Eviews.

4.3 Empirical Model

Model 1: Okun’s Law Production Function Version

In natural logarithm the production function version is written as:

\[
\ln (Y_t - Y_t^*) = \beta_0 + \beta_1 \ln (C_t) + \beta_2 \ln (K_t) + \beta_3 \ln (U_t - U_t^*) + \beta_4 \ln (L_t) + \tau_t
\]

Where, \( Y_t \) denotes real output; \( Y_t^* \) is the potential output, \( C_t \) is the rate of capacity utilization which explains the utilization of all the factors in the economy. \( K_t \) is capital formation of a country; \( L_t \) stands for labor force. \( U_t \) is unemployment rate and \( U_t^* \) is the natural rate of unemployment which exists in the economy even at full employment level. \( \tau \) is a disembodied technology factor which is based on purely organizational progress while \( \lambda \) is its elasticity parameter, because things still sitting in the residual term vary. \( \tau_t \) denotes time trend. \( \beta_0, \beta_1, \beta_2, \beta_3 \) and \( \beta_4 \) are parameters of variables with respect to output.

4.4 Hypothesis to be Tested

The following hypothesis is formulated for estimation and testing.

- \( H_0 \): The association between real GDP, capacity utilization, capital formation, unemployment rate and total labor force is insignificant.
- \( H_1 \): The association between real GDP, capacity utilization, capital formation, unemployment rate and total labor force is significant.

4.5 Linear Regression Analysis

Linear regression model also known as ordinary least square (OLS) is mostly used to investigate dependency of a predicted variable on the predictor variable through fitting a regression line [29].

The OLS log-log model for the production function version of Okun’s law is as follows:

\[
\ln (Y_t - Y_t^*) = \beta_0 + \beta_1 \ln (C_t) + \beta_2 \ln (K_t) + \beta_3 \ln (U_t - U_t^*) + \beta_4 \ln (L_t) + \epsilon_t
\]

Where, \( \ln \) is the natural logarithm, \( Y_t \) is real GDP, \( Y_t^* \) is potential GDP, \( C_t \) is capacity utilization, \( K_t \) is capital formation, \( U_t \) is unemployment rate, \( U_t^* \) is natural unemployment rate and \( L_t \) is the labor force. \( \tau_t \) denotes time trend and \( \epsilon_t \) is the error term.

This study will also test classical linear regression model conditions i.e., multicollinearity, autocorrelation and heteroscedasticity.
4.5.1 Autocorrelation

Autocorrelation refers to the link between the successive values of the error term. This indicates the regression results are less reliable and cannot be used for future predictions. This study employs Durbin Watson test for serial autocorrelation. Durbin Watson test detects a specific type of serial correlation, the AR (1) process. The Durbin Watson test has a value between 0 and 4. A value of 2 indicates no autocorrelation. A value of 0 to less than 2 indicates positive autocorrelation and values from 2 to 4 indicates negative autocorrelation [29].

\[ H_0 = \text{no first order autocorrelation} \]
\[ H_1 = \text{first order correlation exists} \]

4.5.2 Heteroscedasticity

Heteroscedasticity occurs when the variance of an unobservable error \( \mu \) is not constant. The equality of error variances is the key assumption for validity of variance analysis. If the errors do not have equal variances, the regression results are less reliable. This study employs Breusch Pagan test for Heteroscedasticity. This test has a chi-squared distribution, so if the calculated \( \chi^2 \) is greater than the critical value at 5% significance level, null hypothesis of constant variance will be discarded [29].

\[ H_0 = \text{the residuals are homoscedastic} \]
\[ H_1 = \text{the residuals are heteroscedastic} \]

4.5.3 Multicollinearity

The issue of multicollinearity arises when some of the predictor variables are interrelated among themselves. Though, predictors are usually related up to some extent. It's a matter of degree [29]. However, an essential condition for the application of ordinary least square is that the predictors are not perfectly linearly correlated.

This study employs Variance Inflation Factor to test multicollinearity. A rule of thumb for interpreting VIF is, a value of 1 specifies no multicollinearity. Values of more than 4 or 5 are regarded as moderate collinearity and values of 10 or more specifies a very high collinearity. High VIF indicates the regression results are less reliable [29].

4.5.4 Model specification

Ramsey's RESET model is used to check if the model is correctly specified. The null hypothesis is discarded if the P-value of F-statistic is less than the 5% significance level [29].

\[ H_0 = \text{no misspecification error} \]
\[ H_1 = \text{misspecification error exists} \]

4.5.5 Why OLS is not suitable for time series data

Linear regression model cannot be used in this study for several reasons:

Firstly, linear regression model assumes a random selection. However, time series data is not randomly selected as it is a stochastic process [29]. Secondly, time series data are subject to autocorrelation. This happens when data is non-stationary, lagged trends are excluded and when the errors are carried over different time periods [29].

Therefore, time series analysis is used for time series data, to avoid the above-mentioned issues. Time series model is the improvement of the linear regression model. Linear regression model can be applied to time series data only when the variables of the stochastic process are stationary at level [29].

4.6 Time Series Analysis

Time series data is collected at equally spaced time intervals for forecasting the future [29]. There are two major approaches to time series analysis:

1. The Decomposition Method: It involves a mixture of a trend, seasonality, pattern and a random error term. It employs the pattern's trends, its long run rise and fall and the fluctuations of the business cycle to predict the future.

2. The Regression Method: It takes into account special features of time series data; firstly, stationarity and cointegration tests are done to avoid spurious results. Secondly, it also features causality test to check whether one variable precedes the other [29].

This study employs the regression method of time series analysis.

4.6.1 Philips perron unit root test

Philips and Perron developed a stationarity test in 1998 that became popular in time series analysis [30]. It contains fitting the regression:
The specified ARDL model for the Okun’s law variables are stationary at level then OLS is used and if all the above series are stationary this method is used regardless of whether the long run as well as short run coefficients. Offers strong results and super reliable estimates approach got a wide acceptance because cointegration approach was proposed by [30] in 2001. Information econometrics which states the capability of one everyday use. It is a significant topic in Causality is quite different to the concept of 

\[ \Delta Y_t = \pi y_{t-1} + \beta t D_{t-i} + \varepsilon_t \]

Where, \( \varepsilon_t \) is i(0) with zero average and \( D_{t-i} \) is a deterministic trend factor. The hypothesis is tested for \( \pi = 0 \). Philips Perron unit root test modifies any serial correlation and heteroscedasticity in the residuals of regression analysis [30]. It means the mean, variance and covariance of stationary data remain the same overtime, and there should be no linkages between the variables [29]. Results obtained by a non-stationary data are spurious that is why cannot be generalized overtime [29].

### 4.6.2 Lag selection

Lag signifies the lapses of time [29]. In time series analysis it is essential to include lags in the model for three reasons.

The first reason is the economy is sticky, and it may take a while for individuals to realize the change in the economy, the second reason is it is difficult to analyze whether the change is permanent or transitory for capital addition or decision making a permanent or transitory for capital addition or change in the economy, the second reason is it may take a while for individuals to realize the change is difficult to analyze whether the change is permanent or transitory for capital addition or decision making and the third reason is contractual obligations exist in the economy e.g. labor contracts [29].

Over selection of lags may cause inclusion of irrelevant variables in the model, while under selection of lags may lead to omitted variable bias. Both are considered major problems in econometrics [29]. Therefore, to avoid such issues Information-Criterion Lag Selection Approach is used.

### 4.6.3 Autoregressive Distributed Lag (ARDL) Test

Autoregressive Distributed Lag (ARDL) cointegration approach was proposed by Pesaran, Shin and Smith in 2001 [31]. This approach got a wide acceptance because it offers strong results and super reliable estimates of the long run as well as short run coefficients. This method is used regardless of whether the series are stationary at level or first difference but if a variable is stationary at second difference or above ARDL is not appropriate [31]. Alternately, if all the variables of the stochastic process are stationary at level then OLS is used and if all the variables are stationary at first difference then VECM is used.

The specified ARDL model for the Okun’s law production function version is as follows:

\[ \Delta \ln (Y_t) = \beta_0 + \sum_{i=1}^{f_1} \beta_1 \Delta \ln (Y_{t-i}) + \sum_{i=1}^{f_2} \beta_2 \Delta \ln (C_{t-i}) + \sum_{i=1}^{f_3} \beta_3 \Delta \ln (K_{t-i}) + \sum_{i=1}^{f_4} \beta_4 \Delta \ln (U_{t-i}) + \lambda EC_{t-i} + \xi_t \]

Where, \( \Delta \) signifies change; \( f_1, f_2, f_3, f_4 \) and \( f_5 \) signify an optimal lag interval; \( \beta_1, \beta_2, \beta_3, \beta_4 \) and \( \beta_5 \) signify short term dynamics of the model and \( \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10} \) are long run elasticity parameters. If cointegration exists, an error correction model will be as:

\[ \Delta \ln (Y_t) = \beta_0 + \sum_{i=1}^{f_1} \beta_1 \Delta \ln (Y_{t-i}) + \sum_{i=1}^{f_2} \beta_2 \Delta \ln (C_{t-i}) + \sum_{i=1}^{f_3} \beta_3 \Delta \ln (K_{t-i}) + \sum_{i=1}^{f_4} \beta_4 \Delta \ln (U_{t-i}) + \lambda EC_{t-i} + \xi_t \]

Where, \( \lambda \) is the adjustment parameter speed and \( EC \) signifies the error correction term.

An ARDL bounds test measures the cointegration among the variables. It involves comparing the F-statistic against critical bounds, i.e. lower and upper bound [31]. The hypothesis setup for ARDL bounds test approach is:

\[ H_0: \sigma_1 = \sigma_2 = \ldots = \sigma_n = 0 \]
\[ H_1: \sigma_1 \neq \sigma_2 \neq \ldots \neq \sigma_n \neq 0 \]

The set of the hypothesis reads as: there is cointegration if the null hypothesis is discarded. The null hypothesis is discarded when the value of F-statistic is higher than the upper bound and fail to discard when it is lower than the lower bound and if it is in the middle of lower and upper bounds the test is indecisive [31].

### 4.6.4 ARDL stability test

The stability of the ARDL approach is gauged by the cumulative sum (CUSUM) and cumulative sum (CUSUM) of the square of recursive residuals. It explains if the estimated model of real GDP has been shifted or not overtime [31].

### 4.6.5 Granger causality test

Causality is quite different to the concept of everyday use. It is a significant topic in econometrics which states the capability of one
variable to cause the other [29]. The causality between two variables $Y_t$ and $X_t$ is as:

$$Y_t = \sum \alpha X_{t-i} + \sum \beta Y_{t-i} + \mu_i$$  \hspace{1cm} (4.5)

$$X_t = \sum \lambda_i X_{t-i} + \sum \gamma Y_{t-i} + \epsilon_i$$  \hspace{1cm} (4.6)

It is deemed that $\mu_i$ and $\epsilon_i$ are not correlated. In this equation $Y_t$ and $X_t$ are related to their lag values respectively. The null hypothesis states non-existence of causal relationships. If the null hypothesis is rejected, Granger causality exists.

5. ESTIMATION AND INTERPRETATION OF RESULTS

In this section the findings of this study are discussed under two broad headings: linear regression analysis and time series analysis.

5.1 Linear Regression Analysis

Table 1. Ordinary least square results

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<thead>
<tr>
<th>Variables</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>(-5.65)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>LN ($C_t$)</td>
<td>(1.44)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>LN ($K_t$)</td>
<td>(0.24)</td>
</tr>
<tr>
<td></td>
<td>(0.21)</td>
</tr>
<tr>
<td>LN ($U_t$)</td>
<td>(0.23)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>LN ($L_t$)</td>
<td>(2.60)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>R-Squared</td>
<td>(0.98)</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>(57.82)</td>
</tr>
<tr>
<td>P-Value</td>
<td>(0.00*)</td>
</tr>
</tbody>
</table>

* denotes significance level at 5%

OLS test results reveals that the regression model is significant since the P-value of F-statistic (0.00) is less than 5% significance level. Therefore, I reject the null hypothesis of absence of Okun’s law. Hence, this law exists in Pakistan

5.1.1 Autocorrelation

Table 1.1 Durbin watson serial correlation results

| Durbin Watson Statistic | 1.86 |

Durbin Watson test results reveals positive autocorrelation exists in the model as $1.86 < d_L = 1.29$, that is common in time series data. Therefore, I fail to discard the null hypothesis of serial correlation. Hence, autocorrelation exists in the model

5.1.2 Heteroscedasticity

Table 1.2 Breusch pagan test results

<table>
<thead>
<tr>
<th>Observed R-Squared</th>
<th>Probability of Chi-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.80</td>
<td>0.21</td>
</tr>
</tbody>
</table>

The Breusch Pagan test results shows that the $P$-value of $\chi^2$ (0.21) is greater than 0.05 level of significance, so I fail to discard the null hypothesis of constant variance. Hence, residuals are homoscedastic

5.1.3 Multicollinearity

Table 1.3 Variance inflation factor test results

<table>
<thead>
<tr>
<th>Variables</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN ($C_t$)</td>
<td>1.10</td>
</tr>
<tr>
<td>LN ($K_t$)</td>
<td>1.61</td>
</tr>
<tr>
<td>LN ($U_t$)</td>
<td>3.33</td>
</tr>
<tr>
<td>LN ($L_t$)</td>
<td>3.64</td>
</tr>
</tbody>
</table>

The Variance Inflation Factor (VIF) estimates exhibit no multicollinearity in the regression model, since VIF is less than 10
5.1.4 Ramsey RESET test

The Ramsey RESET test estimate shows that the p-value (0.86) of F-statistic is greater than the 0.05 significance level. Therefore, I cannot discard the null hypothesis of no misspecification error. Hence, the production function version of Okun’s law is correctly specified.

<table>
<thead>
<tr>
<th>Table 1.4 Ramsey RESET test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Descriptive statistics of the data series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>LN (Yt)</td>
</tr>
<tr>
<td>LN (Ct)</td>
</tr>
<tr>
<td>LN (Kt)</td>
</tr>
<tr>
<td>LN (Ut)</td>
</tr>
<tr>
<td>LN (Lt)</td>
</tr>
</tbody>
</table>

* denotes significance level at 5%

<table>
<thead>
<tr>
<th>Table 3. Philips perron unit root test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>LN (Yt)</td>
</tr>
<tr>
<td>LN (Ct)</td>
</tr>
<tr>
<td>LN (Kt)</td>
</tr>
<tr>
<td>LN (Ut)</td>
</tr>
<tr>
<td>LN (Lt)</td>
</tr>
</tbody>
</table>

Lag selection is based on Newey-West automatic using Bartlett kernel
* denotes significance level at 5%

5.2 Time Series Analysis

5.2.1 Descriptive statistics

Prior to the time series analysis a comprehensive statistical analysis is carried out for viewing the temporal properties of the variables. The results reveal that all the variables of the data set are negatively skewed except for labor force, which is positively skewed. Kurtosis indicator of the variables show that only capacity utilization and unemployment rate is leptokurtic (high peaked), while all the other variables are platykurtic (low peaked). A Jarque-Bera test concludes that the P-value of unemployment rate is less than 5% significance level. Therefore, I discard the null hypothesis of normal distribution, while the P-value of other variables is greater than 5% significance level, so I fail to discard the null hypothesis of normal distribution. Hence, they are normally distributed.

5.2.2 Philips perron unit root test

The results of Philips Perron unit root test suggests that all the variables are stationary at level I(0), except for total labor force which is stationary at first difference I(1). Due to this mixed order of stationarity ARDL cointegration approach can be proceeded with.

5.2.3 Information-criterion lag selection approach

The lag selection test shows that optimal lag length one is allowed by all criterions for ARDL approach. Therefore, lag length 1 will be used for the analysis.

5.2.4 Autoregressive Distributed Lag (ARDL) cointegration test

ARDL Bounds test result shows the lower and upper bound values for the F-statistic. Since $F_{cal}$ (13.04) is higher than the upper bound critical value of 3.49 at 5% significance level. Therefore, there is enough evidence to reject the null hypothesis of no cointegration. Hence, there exists a long run relationship between the variables.
Table 4. Lag order selection

<table>
<thead>
<tr>
<th>Lags</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SIC</th>
<th>HQIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NA</td>
<td>1.07</td>
<td>-17.98</td>
<td>-17.77</td>
<td>-17.90</td>
</tr>
<tr>
<td>1</td>
<td>251.7*</td>
<td>4.29*</td>
<td>-24.13*</td>
<td>-22.87*</td>
<td>-23.67*</td>
</tr>
<tr>
<td>2</td>
<td>27.21</td>
<td>3.32</td>
<td>-23.82</td>
<td>-21.50</td>
<td>-22.79</td>
</tr>
<tr>
<td>3</td>
<td>34.62</td>
<td>3.23</td>
<td>-24.00</td>
<td>-20.64</td>
<td>-21.83</td>
</tr>
<tr>
<td>4</td>
<td>82.97</td>
<td>3.89</td>
<td>-22.44</td>
<td>-19.66</td>
<td>-22.79</td>
</tr>
<tr>
<td>5</td>
<td>94.17</td>
<td>2.87</td>
<td>-20.55</td>
<td>-15.01</td>
<td>-20.56</td>
</tr>
</tbody>
</table>

Sequential modified LR test statistic, Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Schwarz's Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQIC)

* indicates lag order selected by each criterion.

Table 5. ARDL bounds test results

<table>
<thead>
<tr>
<th>Test-statistic</th>
<th>Value</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
<td>13.04*</td>
<td>1</td>
</tr>
</tbody>
</table>

Critical Bounds

<table>
<thead>
<tr>
<th>Significance level</th>
<th>I(0) Bounds</th>
<th>I(1) Bounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>2.2</td>
<td>3.09</td>
</tr>
<tr>
<td>5%</td>
<td>2.56</td>
<td>3.49</td>
</tr>
<tr>
<td>2.5%</td>
<td>2.88</td>
<td>3.87</td>
</tr>
<tr>
<td>1%</td>
<td>3.29</td>
<td>4.37</td>
</tr>
</tbody>
</table>

* denotes significance level at 5%

Case II Restricted Constant and No Trend introduced by Pesaran et al. (2001)

Table 5.1 ARDL Long run coefficients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>Standard error</th>
<th>T-Statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN (Cₜ)</td>
<td>0.14</td>
<td>0.06</td>
<td>2.09</td>
<td>0.04*</td>
</tr>
<tr>
<td>LN (Kₜ)</td>
<td>0.12</td>
<td>0.01</td>
<td>11.82</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Uₜ)</td>
<td>-0.06</td>
<td>0.00</td>
<td>-15.20</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Lₜ)</td>
<td>0.64</td>
<td>0.14</td>
<td>4.57</td>
<td>0.00*</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.45</td>
<td>0.13</td>
<td>-3.41</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

* denotes significance level at 5%

Table 5.2 ARDL short run coefficients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>T-Statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN (Cₜ)</td>
<td>0.99</td>
<td>0.00</td>
<td>831.5</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Kₜ)</td>
<td>0.01</td>
<td>0.00</td>
<td>8.74</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Uₜ)</td>
<td>-0.05</td>
<td>0.00</td>
<td>-14.07</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Lₜ)</td>
<td>0.02</td>
<td>0.00</td>
<td>16.04</td>
<td>0.00*</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.01</td>
<td>0.00</td>
<td>-3.36</td>
<td>0.01*</td>
</tr>
<tr>
<td>ECT</td>
<td>-0.41</td>
<td>0.00</td>
<td>-16.72</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

* denotes significance level at 5%

The long run coefficients of ARDL model indicates a significant positive impact of capacity utilization, capital formation and total labor force on real GDP in Pakistan. In the long run 1% increase in CU causes real GDP to increase by 0.14%, 1% increase in CF increases real GDP by 0.12%, while 1% increase in TLF increases real GDP by 0.64%. Contrary to this, the coefficient of unemployment rate indicates a significant negative impact on real GDP; it shows 1% increase in unemployment rate reduces real GDP by 0.06%. So I reject the null hypothesis that the relationship between real GDP, capacity utilization, capital formation, unemployment rate
and total labor force is insignificant. This shows that for increasing real GDP in Pakistan the government has to reduce unemployment, improve the quality of labor force and direct efforts towards increasing capacity utilization and capital formation.

The short run coefficients of ARDL model indicates the lagged error correction term for the estimated real GDP equation is negative and statistically significant at 5% significance level. This confirms the existence of Okun's law in the short run. The coefficient of the error term –0.41% suggest that a deviation from the long run equilibrium level of real GDP in one year is corrected by 41% over the current year in Pakistan. Furthermore, capacity utilization, total labor force and capital formation have a significant positive relationship with real GDP in the short run. 1% increase in capacity utilization causes real GDP to increase by 0.99%, 1% increase in capital formation causes real GDP to increase by 0.01% and 1% increase in total labor force increases real GDP by 0.02%. While unemployment has a significant negative relationship with real GDP, 1% increase in unemployment rate reduces real GDP by -0.05%.

5.2.5 Stability of ARDL model

Fig. 2 and 3 shows that CUSUM and CUSUM of square lie inside the interval bands. Hence, there is no structural instability in the residuals of equation of real GDP.

![Fig. 2. Plot of cumulative sum of recursive residuals](image1)

![Fig. 3. Plot of cumulative sum of squares of recursive residuals](image2)

5.2.6 Granger causality test

Table 6. Pair-wise granger causality test results

<table>
<thead>
<tr>
<th>Dependent</th>
<th>F-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN (Ct) does not Granger Cause LN (Yt)</td>
<td>7.97</td>
<td>0.00*</td>
</tr>
<tr>
<td>LN (Yt) does not Granger Cause LN (Ct)</td>
<td>2.49</td>
<td>0.06</td>
</tr>
<tr>
<td>LN (Kt) does not Granger Cause LN (Yt)</td>
<td>0.42</td>
<td>0.79</td>
</tr>
<tr>
<td>LN (Yt) does not Granger Cause LN (Kt)</td>
<td>3.38</td>
<td>0.02*</td>
</tr>
<tr>
<td>LN (Ut) does not Granger Cause LN (Yt)</td>
<td>0.87</td>
<td>0.04*</td>
</tr>
</tbody>
</table>
The results of granger causality test reveals that unidirectional causality runs from capacity utilization to real GDP. The results also show unidirectional causation among real GDP and capital formation, and the direction of causality runs from real GDP to capital formation. The estimated results reveal that unemployment does cause real GDP but real GDP does not cause unemployment in Pakistan. I further find no causation between total labor force and real GDP, no causation in case of capacity utilization and capital formation. There is no causation between capacity utilization and unemployment, and capacity utilization and labor force. There is no causation between capital formation and unemployment rate. There is no causation between total labor force and capital formation. No causation between total labor force and unemployment rate. Overall results show that to increase real GDP the government has to lessen unemployment and simultaneously increase capacity utilization and capital formation in Pakistan.

The empirical findings validate the presence of Okun’s law in Pakistan in the long run and also in the short run but the ratio between unemployment and GDP is much less than as compared by Okun’s coefficient benchmark.

6. GENERAL CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

Okun’s law attracts major research attention because the social and economic effects of increasing unemployment are very important to almost everyone. The idea behind Okun’s law was that if the more labor is used in production the more output will be generated in economy.

In this study linear regression and time series predictive models are used for the analysis to compare their predictive ability and analyze their performance to select the best. The performance analysis shows that the time series forecasting model gives more efficient results as compared to the linear regression model because there exists a problem of autocorrelation which makes the estimation less reliable as well as the explanatory power of linear regression model is very low.

I revisit Okun’s relationship using a hybrid specification of Okun’s law production function version namely, I relate the output gap on one hand and capacity utilization, capital formation, labor force and technology alongside the gap between actual and natural unemployment on the other. Hence, the empirical estimates found that Okun’s law holds true for the case of Pakistan, in the long run and also in the short run, but unemployment has a less impact on real GDP for the case of Pakistan as compared by Okun’s coefficient benchmark.

However, economic and political stability and investment oriented strategies are crucial to achieve handsome economic growth. The government should empower small and medium scale businesses through soft loans and explore the agricultural sector in order to increase exports so the share of the agricultural sector in GDP could be increased. Investment in
education and improved technical and vocational training facilities are essential requirements to lessen unemployment in Pakistan.

Furthermore, the findings of this study are almost same to the empirical findings of [20] and [21], their estimated results also confirm the presence of Okun’s law in Pakistan; whereas the results are contrasting with the findings of [23, 22] and [24]. Therefore, this study supports the view put forward by [1] that Okun’s law is not stable across time; it behaves differently as the economy moves through a cycle of expansions and contractions. However, if one takes the instability of Okun’s link into consideration, it will still be useful as a forecasting tool [1]. The factors i.e. productivity, capital and technology that affect GDP and unemployment rate might be considered as key elements to explain unemployment – output correlation discrepancies overtime [6], because Okun’s coefficient is unpredictable but it does not collapse [5].

6.1 Why Okun’s law, as Specified, is Not Valid in Pakistan

Though, Okun’s law should be practicable in all economies and also in Pakistan but mainstream studies suggests that Okun’s law is applicable in developed economies but for the developing economies, it is generally not valid [1]. There are certain reasons as to why Okun’s law is partly or not valid in Pakistan.

The economy of Pakistan is relatively more informal, the labor force survey of Pakistan (2017) states that the informal sector accounts for 71.7% of the employment. So, the labor working in that sector are likely to be less or unprotected, prone to greater income instability and poor working conditions.

According to labor force survey of Pakistan (2017) around 55.6% of workers was estimated to be in vulnerable forms of employment.

The agricultural sector is an important sector in Pakistan. According to labor force survey of Pakistan (2017) this sector absorbs 42.3% of labor force and contributes 18.1% to GDP. But unfortunately its share in GDP is continuously decreasing. Therefore, the incomes generated are not high, often enough to ensure basic food security and serve as a means of coping mechanisms to reduce poverty. Moreover, agricultural based developing countries like Pakistan face systematic volatilities arising from the international commodity prices that induce terms of trade shocks as well as hostage of rainfall, its excess and absence, causes considerable losses to the economy, temporary unemployment and business interruption.

The capital to labor ratio is also very low in Pakistan. Low investment and capital accumulation combined with greater labor supply leads to underutilization of labor and poor quality of jobs. In Pakistan, labor is oriented to domestic and even local markets; and sheltered from the impacts of macroeconomic policies.

Human capital is critical in determining the quality of labor force of countries. Pakistan tends to have a lower quality of human capital. According to World Bank report, the human capital index (HCI) of Pakistan was lower than the average in 2017, it ranked 134 out of 157 countries. Education poverty is very high in Pakistan. Public spending on education was only 2.2 percent of GDP in fiscal year 2017.

Lastly, certain sources claim that the estimate of unemployment in Pakistan is deceptive. It has been remained at 5-6% on average since 1986 [32]. If the unemployment rate was that low, then it meant that almost every newcomer in the job market was getting an employment in Pakistan. This should be a source of great joy and happiness for the people and there should be no such thing like unemployment in Pakistan because economists have declared 4% unemployment rate as full employment. Hence, the economic data in Pakistan are not politics-free [32].

Notwithstanding, developed countries are more formal and industrialized; they have a higher capital-to-labor ratio therefore their labor is likely to be more productive, oriented to domestic and international markets, exposed to macroeconomic policies, have good quality of human capital that is likely to have at least de jure protection and stable incomes.

As a result, Okun’s law is applicable in most of the developed states. To make Okun’s law valid in Pakistan taking the economy to that level is mandatory. With that, I hope Okun’s law becomes applicable in Pakistan in the nearest future.
6.2 Scope and Limitations of the Study

This study involved a large set of observations which strengthens the generalizability of the findings at least within a Pakistani context. Hence, this information can be useful in designing programs that aim to reduce unemployment in Pakistan.

However, the only limitation that should be noted is that in Pakistan the data available on real GDP, capital formation, labor force and unemployment rate is annual while quarterly data may have taken into consideration more variations.

6.3 Directions for Future Research

The aim of this study is to focus on Okun’s law production function version in Pakistan. Future research can be conducted on the difference version, gap version and dynamic version of Okun’s law with expanding time series as well as cross-country analysis, which will provide more insights into the differences between economic structures of different countries.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

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