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Empirical Analysis of the Phillips Curve and Okun's Law Through Simultaneous Equation Modeling: A Case Study of Pakistan

Introduction

Unemployment is an acute problem existing globally which reflects the underutilization of labor by a nation. High unemployment not only leads to resource wastage but also shrinks the economy. At present days this grave problem is faced by each state, whether be it a highly industrial one, having a strong development portfolio, or a deprived country (developing). Unemployment naturally exists in an economy when too many people are facing a lurch to find out the most appropriate jobs matching up to their level of interest. Economists belonging to a different school of thought conceived this core issue from a different perspective. Neo-classical economists propose that unemployment occurs when rigidities are imposed from outside forces while Keynesian economics postulates that unemployment is existing owing to the inefficiency of the markets and ineffective demand for goods and services. As in the latest report of IMF (2018), "unemployment is considered as a percentage of labor force periodically that could not find a suitable job for themselves". The International Labor Organization (ILO) reported (2018) that unemployment is a situation having people aged 16 or above and being out of a job or keeping strong will for doing the job and incessantly pursuing it in the preceding four weeks but couldn't find a suitable job. Those people who are willingly not interested in doing a job are not considered to be

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unemployed, e.g. full-time enrolled university students, retired government officials, medically retarded people and children. Thus, all people who are without a job, struggling to access work by any means, are included in unemployed group.

Let us summarize the existing trend of unemployment in Pakistan. Like in many other developing countries, Pakistan's employment pattern has deteriorated in recent years. The employment extension capacity of the economy has decreased. Concerning population growth, according to the 2018 survey, the total population of Pakistan was 217.3 million that was equivalent to 2.8% of the total world population. According to the latest economic survey of 2018–19, the literacy rate is 58%, with 72.5% among males and 27.5% among females. The current inflation rate is 10.1% which is too high and has gradually increased over the past decade, whereas GDP growth rate is 2.3% and it has progressively declined since the last decade. As a developing country, Pakistan is facing several problems on the social ground, with unemployment being one of the major ones. In 2018–19, the unemployment rate has dropped to 5.8%. In the case of Pakistan, many factors affect the unemployment trend. Being an important issue of joblessness in the context of Pakistan, the independent variables that come under the umbrella of this research work are inflation rate, the growth rate of GDP per capita, and population growth. Two dependent variables, i.e. unemployment rate and GDP per capita, are also used in a cross relationship to be captured in order to estimate the parameters of the Phillips curve and Okun's law through simultaneous equations models via Indirect Least Square (ILS) technique to find out the relationships between these variables. This would be helpful for the strategy makers to develop a more efficient strategy for national growth acceleration.

The rest of the paper is organized as follows: the literature review which comprises theoretical review and empirical review, the methodology used, empirical results, and lastly the conclusion.

1. Literature review

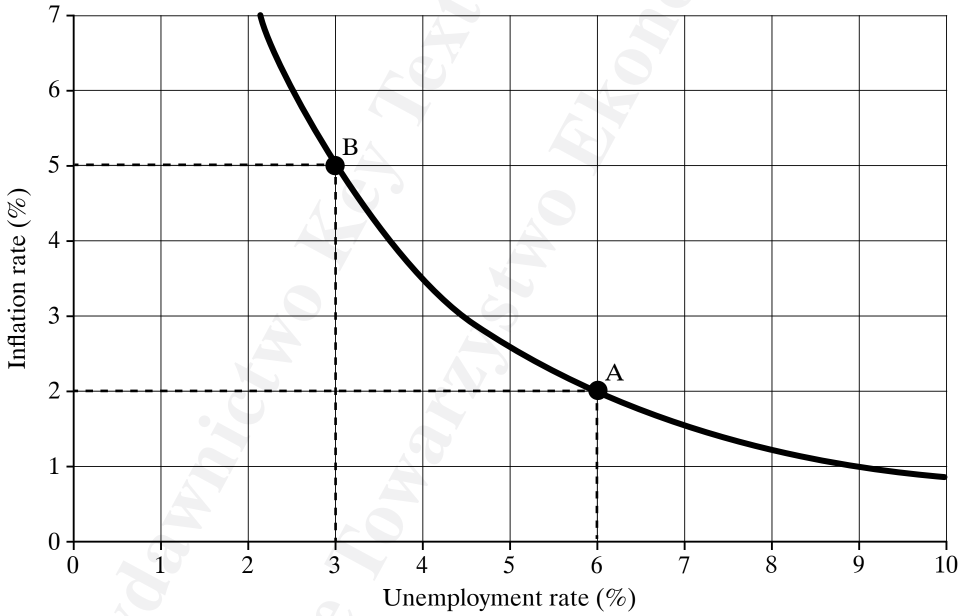
The literature review in this paper divides into two sections, namely theoretical review, and empirical review. The theoretical review is on the theoretical literature about the concepts of the Phillips curve and Okun's law, while the empirical review is on the existing empirical research concerning the topic of the paper.

1.1. Theoretical review

The Phillips curve: the inflation – unemployment trade-off

Owing its name to A.W Phillips, the New Zealand-born economist, the Phillips curve is a diagram (curve) showing the relationship between the rate of change of money wage rate and the level of unemployment. According to Barnier (2020), the Phillips curve is an economic concept which states that inflation and unemployment have a stable and inverse relationship. Therefore, higher inflation is associated with lower unemployment and vice versa (University of Miami, 2020). However, from the early beginning, it developed into a relationship between inflation rate and rate of unemployment. Furthermore, Phillips has detected an inverse curve linear relationship between inflation rate and the rate of unemployment in a statistical study of the observed annual figures for unemployment and money wage rate for fifty years from 1861 to 1913. Other studies were from 1913 to 1948 and 1948 to 1957. Phillips' approach was to draw a curve of best fit through the scatter diagram of the observed combination of unemployment and money wage rate for the United Kingdom. The resulting curve exhibited a negative shape, much like a demand curve as illustrated below:

Figure 1
The Phillips Curve



Source: www.economicsheslp.org

Figure 1 shows a theoretical Phillips curve, the trade-off between unemployment and inflation. From the figure, point B illustrates an inflation rate of 5% and an unemployment rate of 3%. If the government attempts to reduce inflation to 2%, then it will experience a rise in unemployment to 6%, as shown at point A. Therefore, the government should either tolerate a low rate of inflation with a high rate of unemployment or a low rate of unemployment with a high rate of inflation. The Phillips curve is made up of the following equation:

$$\pi = \pi_e - \alpha(u - u^n) + v,$$

where π is the rate of inflation, π_e is the expected rate of inflation, α is a parameter that measures the response of inflation with relation to cyclical unemployment, $(u - u^n)$ is the cyclical unemployment, and v is the supply shocks. The equation shows that unemployment is related to inflation and movements in the inflation rate.

The basic tenant of the Phillips curve

The basic tenant of the Phillips curve is that a stable inverse relationship exists between unemployment and inflation rate as approximated by money wage rate changes. The continued existence of this observed stable relationship was deemed to have far reaching implications for policy makers for it represented a menu of policy choices between inflation and unemployment rate. This feature of the Phillips curve means that policy makers could choose between inflation and unemployment in the course of macroeconomics management (a low unemployment rate could only be obtained by tolerating a high inflation rate). The existence of this trade-off reflects the 'twin evil of macroeconomics' with which we must choose between unemployment and inflation.

A second tenant of the Phillips curve is that apart from the impossibility of the simultaneous attainment of both objectives being in conflict, the attainable combination of both variables is known. Hence the diagram shows that zero rate of inflation can be obtained only at the cost of an unemployment rate of 5.5%. On the other hand, an effort to attain a 7.5% rate of wage inflation would only be compatible with a 1% rate of unemployment. In general, the relevant policy trade-off, i.e. the rate of exchange between policy goals at the disposal of the authorities, is reflected in the slope of the curve. Since the existence of the trade-off could be traced to the existence of inherent conflict among policy objectives, efforts to solve one of the policy problems necessarily exacerbate the other. For example, the inability to simultaneously achieve the goals of the employment and price stability means that efforts to move the economy closer to one of them, say full employment, will necessarily drift it further away from the price stability. The rate of trade-off (the cost of attaining a little lot more of one of the objectives as reflected in the magnitude of the loss in the other that must be tolerated) is measured by the slope of the curve. Thus, the steeper the curve the lower will be the decrease in employment that will be brought about by a large increase in the rate of inflation. On the other hand, the flatter the curve the larger will be the fall in unemployment that will be attained by a small increase in the rate of inflation. The trade-off relationship implied by the Phillips curve means that policy makers can determine the opportunity cost of a lower inflation rate in terms of employment forgone. It is their task, therefore, to optimize this relationship by selecting the inflation – unemployment combination that maximizes social benefit (or minimize social cost).

Okun's law

Owing its name to A. Okun, the US-born economist, the Okun's law describes a statistical relationship between the unemployment rate and economic growth rate. Following the Okun's law original statement, a 2% increase in output corresponds to a 1% decline in the rate of cyclical unemployment. Therefore, economic growth is a necessary condition for reducing the rate of unemployment and a 1% increase in the growth rate of the economy will lead to a 0.5% reduction of the unemployment rate. So, Okun's finding is on how economic growth and unemployment are related. However, according to the economics research arm of the Federal Reserve Bank of St. Louis (2020), Okun's law "is proposed to disclose to us the amount of a nation's gross domestic product might be lost when the unemployment rate is over its characteristic rate." It proceeds to clarify that the rationale behind the Okun's law is basic. Output relies upon the measure of labor utilized in the production, so there is a positive connection between output and employment. So there is also a negative connection between output and unemployment. The mathematical formula of the Okun's law can be stated as follows:

$$\frac{Y^* - Y}{Y^*} = \beta(u - u^*),$$

where Y is the actual output (GDP), Y^* is the potential growth domestic product, u is the actual unemployment rate, u^* is the natural rate of unemployment, and β is the factor relating changes in unemployment to changes in output.

1.2. Empirical review

Our study examines the empirical relationship of unemployment with inflation, the growth rate of GDP per capita income, and population growth rate in Pakistan for the period 1985 to 2017. The relevant works of different researches on the subject are as follows:

Qayyum (2007) scrutinized various aspects of unemployment and its important determinants, foundation, and degree to which it is extending in diverse segments of Pakistan's economy. The statistics have been taken from the labor force review from 2003 to 2004 where the related model for such a self-sufficient variable gave considerable outcome for the impact on youth unemployment.

Gilini (2011) examined the co-relationship among crime rate and different financial indicators like poverty, unemployment, and increasing prices in Pakistan from 1976 to 2007using autoregressive distributed lag (ARDL) model and causality test via the Toda–Yamamoto technique, where the result showed that the crime rate is caused by unemployment, poorness, and rise in the general prices level in the country.

Shaheen et al. (2011) have conducted a research to find out the envisages during the time-varying non-accelerating inflation rate of unemployment in Pakistan. Because it is considered as unobservable stochastic factors for Pakistan economy during the period of 1973–74 to 2007–08, using the Kalman filter both as a sum of trend and a cyclical component gave a result that a trend component is regarded as a benchmark for the natural rate of unemployment at equilibrium, where cyclical estimates suggest that TB-NAIRU in Pakistan is currently around 6.7% according to this result, and in 2007-08 and also in 2011, the TV-NAIRU increased to 10.2%. The results of the study suggest that the unemployment gap should be the factor considered when assessing inflating pressure.

Zaman et al. (2011) analysed the correlation between unemployment and inflation in Pakistan from 1975 to 2009 to find the validity of the Phillips curve in the country. The Granger causality test was used to discover the short- and long-run bond. The results show that the negative relationship between unemployment and inflation exists which is called Phillips curve where a 2% increase in inflation rate causes a 2% decrease in unemployment.

Akram and Khan (2012) have identified the causes of unemployment and its effects on Pakistan's economy where the main endeavor of the study was to find the unemployment and its social and economic impact on the youth. The findings revealed that the main causes of unemployment are economic crisis, insufficient care on the part of government, and political instability in a country. Furthermore, the study shows that due to many non-favorable reasons of employment, our economy faces the problem of structural and friction unemployment because of lack of jobs opportunities for youth available in the market, and the education system is not fully developed to enhance the skill and ability of youth to fulfill the market demand. In order to overcome the problem, the whole economy must be placed on firm footing, free of corruption.

Hussain and Wajid (2013) analysed data on unemployment, GDP growth, urban population, and foreign direct investment in Pakistan using a log-linear model. The study revealed that a larger contribution of the urban sector toward GDP growth significantly increases unemployment in the economy in the long run. On other hand, the impact of the foreign direct investment was insignificant in long run but the impact of urban population was significant in the short run. The study concluded that the government should initiate a new investment policy to increase loan opportunities in order to reduce unemployment.

Aurangzeb and Khola (2013) examined determinants of unemployment in the context of cross-country analysis for Pakistan, China, and India from 1980 to 2009 to demonstrate the association between unemployment, inflation, exchange rate, GDP, and population growth. The study revealed a long-run association among all the variables of the three countries. Furthermore, the results obtained from the Granger causality test show that there is no duplex causality among the indicators. The study suggested that redistribution of income is required to enhance the positive effect of growth on the employment rate.

Maqbool (2013) studied the factors of unemployment over the period of 1976–2012 to specify the empirical relationship of certain variables such as unemployment, population, FDI, GDP, and inflation in Pakistan. This study used the autoregressive distributed lag (ARDL) model. The findings revealed that these variables are significantly related to unemployment and further it stated that 1% increase in inflation causes a 0.34% decrease in unemployment, thus confirming the existence of the Phillips curve in Pakistan.

Mosikari (2013) analysed the impact of the unemployment rate on PCI in South Africa from 1971 to 2006 using the autoregressive distributed lag (ARDL) model. The study investigated the joint dynamics of yield and unemployment rate both in the short-run and long-run analysis, finding the unemployment rate being associated with per capita GDP and a two-way causality between the variables.

Cheema (2014) studied the determinants of unemployment for the period of 1973–2010 using the autoregressive distributed lag (ARDL) model to analyse the empirical relationship among the variables such as unemployment and production gap, productiveness, economic precariousness, total rigid investment, and trade openness. The research finding is that there is a significant direct correlation between unemployment, production gap, productiveness, and economic precariousness, and a statistically significant inverse relationship with total rigid investment and openness of trade.

Abbas (2014) conducted a study on the relationship between unemployment and economic growth in Pakistan for the period from 1990 to 2016 using the autoregressive distributed lag (ARDL) model. The results revealed the existence of a considerable inverse correlation between output growth and unemployment level in the long-run where a 1% boost in economic growth reduced the unemployment level by 1.7% in the long run. The study stated that poor economic performance of Pakistan is responsible for the high level of unemployment and poverty.

Arsalan and Zaman (2014) conducted a study with the aim of finding the factors which determined unemployment in Pakistan in the period of 1999–2010 using a simple linear regression model. The input variables included unemployment, foreign direct investment (FDI), gross domestic product (GDP), and inflation. The obtained results reveal that inflation and GDP have an inverse association with the unemployment rate. Population growth is the main variable shaping unemployment and it has a positive relationship with unemployment.

Acero (2017) investigated some factors of unemployment assuming that all the factors responsible for a job availability will not be heightened by neo-classical outlook. The study further analyses changes in the occupational pattern caused through vertical mobility. If this alteration takes an extensive time due to heterogeneity of labor and bright career prospect, absence of ideal information, and outlay of training, then it can pose serious problems.

Mehmud and Khalid (2017) explored the long-run relationship between fiscal policy and unemployment in Pakistan for the period from 1980 to 2010 using the Johannsen co-integration test and vector error correction model (VECM). The results showed that government expenditures and inflation have a positive impact on unemployment, growth, and foreign direct investment. However, taxes have a negative impact on unemployment. Also, foreign direct investment contributes to unemployment.

Xuen et al. (2017) analysed the data for the period of 1982–2014 for China to assess the macroeconomic variables affecting unemployment where variables such as foreign direct investment, gross domestic product, and population were taken into account. The findings revealed an inconsequential connection between unemployment rates and gross domestic product.

Kraft and Assad (2017) analysed a variety of factors of being without a job in Egypt. Every year, the labor market of Egypt was starving from the span of overall employment at peak level, and employment was thriving with an unvarying rate. The well-informed female segment was being much more exaggerated than that the male segment of the labor market.

Simmons (2018) presents some results about the relationship between inflation and unemployment at the Washington DC level. The report shows that 4% increase in inflation at a general level will result in 4% reduction in unemployment, but on the other hand, a 4% decrease in the inflation rate from the normal level makes the worst result of increasing by 4% unemployment in the economy. From another angle, if the inflation rate decreases by 5% and employment remains the same, the employment starts to decrease at an increasing rate. For the whole process, the Philips curve shows the trade-off between unemployment and the inflation rate. Finally, the report generalizes that we cannot control both and also that the economy of any city or country should be growing at the natural and desirable rate of 4%, and in this way unemployment will be reduced.

2. Methodology

The core purpose of this part of the paper is to find out the empirical relationship among unemployment, inflation rate, population growth rate, and the growth rate of GDP per capita in the light of two important laws, i.e. Phillips curve and Okun's law.

2.1. Data and its sources

This paper has used annual time series data on inflation rate (*INF*), unemployment rate (*UN*), the growth rate of GDP per capita income (*PCI*), and population growth rate (*PR*) for the period 1985 to 2017. All the variables are in percentage, hence, there is no need to take their logarithms. The choice of the variables used is based on the objectives of the paper and the research in the area. The data of the variables were taken from the World Bank Development Indicators (2019).

2.2. Estimation techniques

The analysis started by estimating the descriptive statistics of the series under investigation for understanding the statistical characteristics of the series. The second thing is the graphical representation of the series so as to observe the trend of the series. Third, is the execution of unit root test, namely the augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests for examining the stochastic properties of the series. The reason of employing three different unit root tests is to enable comparison. In deciding the test to choose for judging in a situation where three tests produce

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a conflicting result, Imam et al. (2016) conduct research by comparing power and type I error of ADF, KPSS, and PP unit root tests using simulation; the study concluded that PP is the best one over all the conditions considered for the models, sample sizes, and orders. Moreover, in terms of type 1 error PP is still the best. Hence, in this research work, in a case where the tests produced a conflicting result, that of the PP is used. Fourth, is the estimation of the coefficients of both the Phillip's curve and Okun's law, which was executed using simultaneous equations models (SEM) with the dependent variables, i.e. unemployment and the growth rate of GDP per capita, that are also simultaneously the functions of one another, where the estimation of the SEM coefficients was carried out using indirect least square (ILS) method when all the equations of the SEM are exactly identified.

Simultaneous equations models (SEM)

The structural form of the model is:

$$UN = B_1 + B_2 PCI + B_3 INF + V_1 \tag{1}$$

$$PCI = \ltimes_1 + \ltimes_2 UN + \ltimes_3 PR + V_2 \tag{2}$$

where B_1 and $\ltimes_1$ are constant terms in both equations (1) and (2) respectively; B_2, B_3, $\ltimes_2$, and $\ltimes_3$ are the respective coefficients for *PCI*, *INF*, *UN*, and *PR* in both equations; V_1 and V_2 are the respective error terms of the equations. However, since it is a cross-relationship among the two variables as both variables unemployment and the growth rate of GDP per capita income are used as a dependent and independent variable in the system of equations, therefore, their covariance with the error term is not equal to zero. Solving this, first, we check the identification for both equations (1) and (2).

Step1. Identification of the structural form of model

Check identification of equation (1):

$$K - R = M - 1$$

where K is the exogenous variables in the whole system, R is the exogenous variables in one equation, and M is the endogenous variable in one equation.

From equation (1):

$$K = 2\,[INF, PR] \qquad 2 - 1 = 2 - 1$$
$$R = 1\,[INF] \qquad 1 = 1$$
$$M = 2\,[PCI]$$

Similarly, from equation (2):

$$K = 2\,[INF, PR] \qquad 2 - 1 = 2 - 1$$
$$R = 1\,[PR] \qquad 1 = 1$$
$$M = 2\,[UN]$$

It can clearly be seen that both equations are exactly identified and a unique solution exists through the indirect least square (ILS) method.

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Step 2. Deriving reduced form equations from the structural form of the model

Now we put equation (2) in (1) and solve through the substitution method; as a result we get:

$$UN = \left[\frac{B_1 + B_2\ltimes_1}{1 - B_2\ltimes_2}\right] + \left[\frac{B_3}{1 - B_2\ltimes_2}\right] INF + \left[\frac{B_2\ltimes_3}{1 - B_2\ltimes_2}\right] PR + \left[\frac{B_2V_2 + V_1}{1 - B_2\ltimes_2}\right],$$

$$UN = \pi_{11}INF + \pi_{13}PR + V_{it}. \tag{3}$$

We get thus the reduced form equation for structure equation (1) where the obtained reduced form parameters are:

$$\pi_{11} = \frac{B_1 + B_2\ltimes_1}{1 - B_2\ltimes_2} \qquad \pi_{12} = \frac{B_3}{1 - B_2\ltimes_2},$$

$$\pi_{13} = \frac{B_2\ltimes_3}{1 - B_2\ltimes_2} \qquad V_{it} = \frac{B_2V_2 + 1}{1 - B_2\ltimes_2}.$$

Similarly, putting equation (1) in (2) and substituting will result in:

$$UN = \left[\frac{\ltimes_1 + B_1\ltimes_2}{1 - B_2\ltimes_2}\right] + \left[\frac{B_3\ltimes_2}{1 - B_2\ltimes_2}\right] INF + \left[\frac{\ltimes_3}{1 - B_2\ltimes_2}\right] PR + \left[\frac{\ltimes_2V_1 + V_2}{1 - B_2\ltimes_2}\right],$$

$$PCI = \pi_{21} + \pi_{22}INF + \pi_{23}PR + V_{\ltimes t}. \tag{4}$$

We get thus the reduced form equation for structure equation (2) where reduced form parameters are:

$$\pi_{21} = \left[\frac{\ltimes_1 + B_1\ltimes_2}{1 - B_2\ltimes_2}\right] \qquad \pi_{22} = \left[\frac{B_3\ltimes_2}{1 - B_2\ltimes_2}\right],$$

$$\pi_{23} = \left[\frac{\ltimes_3}{1 - B_2\ltimes_2}\right] \qquad \pi_{\ltimes t} = \left[\frac{\ltimes_2V_1 + V_2}{1 - B_2\ltimes_2}\right].$$

Step 3. Obtaining structure co-efficient from the reduced-form equations

Now putting equation (4) in (1), we get:

$$UN = (B_1 + B_2\pi_{21}) + (B_2\pi_{22}INF + B_3INF) + (B_2\pi_{23}PR) + (B_2V_{2t} + V_1),$$

$$UN = \pi_{11} + \pi_{12}INF + \pi_{13}PR + V_{it}, \tag{5}$$

where the obtained structure parameters from the reduced form equations are as follows:

$$\pi_{11} = B_1 + B_2\pi_{21} \qquad B_1 = \pi_{11} - B_2\pi_{21} \tag{6}$$

$$\pi_{12} = B_2\pi_{22} + B_3 \qquad B_3 = \pi_{12} + B_2\pi_{22}. \tag{7}$$

Also

$$\pi_{13} = B_2\pi_{23} \qquad B_2 = \frac{\pi_{13}}{\pi_{23}}. \tag{8}$$

Now putting equation (3) in (1), we get:

$$PCI = (\ltimes_1 + \ltimes_2\pi_{11}) + (\ltimes_2\pi_{12})INF + (\ltimes_2\pi_{13} + \ltimes_3)PR + (\ltimes_2 V_{it} + V_2),$$

$$PCI = \pi_{21} + \pi_{22}INF + \pi_{23}PR + V_{\ltimes t} \tag{9}$$

where structure parameters from the reduced form are as follows:

$$\pi_{21} = \ltimes_1 + \ltimes_2\pi_{12} \qquad \ltimes_1 = \pi_{21} - \ltimes_2\pi_{11} \tag{10}$$

$$\pi_{22} = \ltimes_2\pi_{12} \qquad \ltimes_2 = \frac{\pi_{22}}{\pi_{12}} \tag{11}$$

$$\pi_{23} = \ltimes_2\pi_{13} + \ltimes_3 \qquad \ltimes_3 = \pi_{23} - \ltimes_2\pi_{13}. \tag{12}$$

Step 4. Identification of reduced form equation

Structural parameters	Reduced form co-efficient
B_1, B_2, B_3 [*equation*#1]	$\pi_{11}, \pi_{12}, \pi_{13}$, [*equation*#3]
$\ltimes_1, \ltimes_2, \ltimes_3$ [*equation*#2]	$\pi_{21}, \pi_{22}, \pi_{23}$, [*equation*#5]

Thus, the whole model illustrates that for six structural coefficients there are six reduced form coefficients, thus the number of structural coefficients = number of reduced form coefficients. Therefore, we can say that both equations of *UN* and *PCI* are exactly identified and the unique solution of the model is possible through a simultaneous equation model.

Indirect least square (ILS) model

With the confirmation that the model is identified, one can proceed with the estimation of the parameters of the structural coefficients, and if all the equations of the *SEM* are exactly identified, indirect least square model (ILS) can be applied which is a method for estimating the structural parameters of a single equation in a simultaneous equation's models. It involves estimating the parameters of the system in the reduced form using the ordinary least squares (OLS) technique and solving for the structural parameters in terms of the reduced form parameters.

3. Empirical results

Our research work was intended to estimate the coefficients from cross-relationship of the Okun's law and Phillips curve simultaneously in the context of the economy of Pakistan in order to check whether these laws hold in Pakistan economy or not, as reflected in annual time series. This part of the paper presents the empirical findings. It comprises: (a) descriptive statistics, (b) graphical representation of the series, (c) unit root tests, namely augmented Dickey–Fuller (ADF), Phillips–Perron (PP) , and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests, and (d) the estimation of the coefficients of both Phillips curve

Table 1
Descriptive statistics

	INF	*UN*	*PCI*	*PR*
Mean	9.454545	4.460909	5.237273	2.423030
Median	8.300000	3.900000	5.570000	2.510000
Maximum	26.70000	7.690000	8.710000	3.030000
Minimum	2.500000	1.700000	1.700000	1.800000
Std. dev.	5.163943	1.538141	1.897497	0.378859
Skewness	1.592858	0.017394	0.066589	–0.233508
Kurtosis	5.747059	1.983666	2.003830	1.874246
Jarque–Bera	24.33078	1.421949	1.388875	2.042461
Probability	0.000005	0.491165	0.499355	0.360151
Sum	312.0000	147.2100	172.8300	79.96000
Sum sq. dev.	853.3218	75.70807	115.2159	4.593097
Observations	33	33	33	33

Source: Authors' computation.

and Okun's law using simultaneous equations models (SEM) via indirect least square (ILS) technique.

Table 1 shows the descriptive statistics of the variables consisting of the mean, median, maximum and minimum values, standard deviation, skewness, kurtosis, and Jarque–Bera. From the table it can be observed that the mean inflation rate (*INF*), unemployment rate (*UN*), growth rate of GDP per capita income (*PCI*), and population growth rate (*PR*) are 9.454545, 4.460909, 5.237273, and 2.423030 respectively, which means the series with highest rate is *INF* and the one with the lowest is *PR*. Looking at the maximum and minimum values of each series it can be seen that *INF* is the series with the highest disparity between its values while the one with the least one is *PR*. The series with the highest standard deviation is *INF* and *PR* is with the lowest, which means that *INF* exhibits higher variability than the other three series while *PR* is one with lower variability. The skewness of *INF, UN,* and *PCI* is positive while that of *PR* is negative. However, all the four series except *INF* are close to a normal distribution, since their respective skewness is almost zero, but since that of *INF* is not zero, it means that the inflation rate is volatile. The kurtosis statistic shows that *UN*, *PCI*, and *PR* are platy-kurtic with kurtosis of less than 3 in numeral values except for *INF*; while *INF* is lepto-kurtic which implies that its distribution is peaked relative to a normal distribution and is greater than 3; it means that inflation rate is volatile. Moreover, the *p*-value of the Jarque–Bera statistic of all the series except *INF* indicates normality of the series in terms of distribution at 5% level while the distribution of the *INF* series is explosive.

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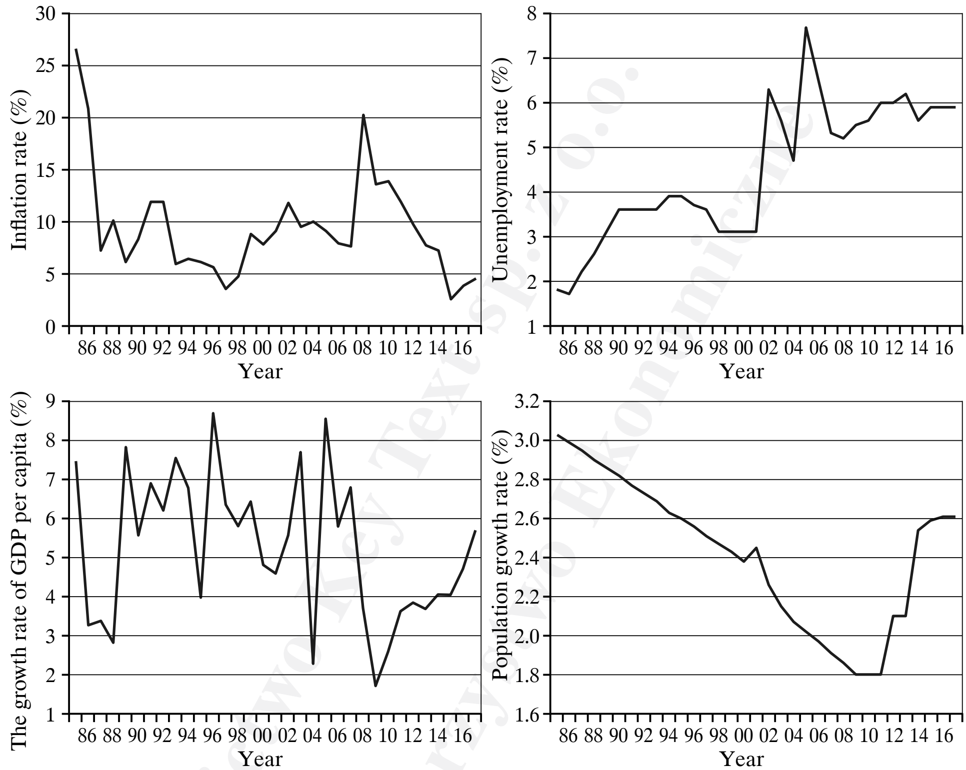
Figure 2

Graphical representation of inflation rate (*INF*), unemployment rate (*UN*), the growth rate of GDP per capita (*PCI*), and population growth rate (*PR*) from 1985 to 2017



Source: Researchers' depiction.

Figure 2 displays a graphical representation of the four series, namely *INF*, *UN*, *PCI*, and *PR* respectively, which show considerable fluctuations over a period of 1985 to 2017 where each of them presents a different form, but with constant ups and downs throughout the period.

Table 2 presents the results of the augmented Dickey–Fuller (ADF) unit root tests, both at the level and first difference. At level, the test rejects the null hypothesis of unit root for all the series except of *PR*, where the rejection is at 1% for both *INF* and *PCI* but at 10% for *UN*, which means that all the variables except of *PR* are stationary at level. However, at the first difference, all the variables are stationary at 1% except of *PR* which is at 5%.

Table 3 shows the results of Phillips–Perron (PP) unit root tests, both at the level and first difference. At level, the test rejects the null hypothesis of unit root for all the variables except in the case of *PR*, where the rejection is at 1% for both *INF* and *PCI* but at 10% for *UN*, which means all the variables except *PR* are stationary at level. However, at the first difference, all the variables are stationary at 1%.

Table 4 reports the results of Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests, both at the level and first difference. At level, the test accepts the null

Table 2

Unit root test results (ADF)

Null hypothesis: the variable has a unit root.					
	At level				
		INF	*UN*	*PCI*	*PR*
With constant	*t*-statistic	–4.3218	–2.0527	–4.8724	–1.9723
	Prob.	0.0018*	0.2641	0.0004*	0.2967
With constant and trend	*t*-statistic	–4.1020	–3.3827	–5.0626	–3.0876
	Prob.	0.0150**	0.0716***	0.0014*	0.1279
Without constant and trend	*t*-statistic	–2.6476	0.8862	–0.5610	–0.4382
	Prob.	0.0098*	0.8949	0.4660	0.5161
	At first difference				
		d(*INF*)	*d*(*UN*)	*d*(*PCI*)	*d*(*PR*)
With constant	*t*-statistic	–6.3196	–6.2637	–10.5308	–1.9530
	Prob.	0.0000*	0.0000*	0.0000*	0.3049
With constant and trend	*t*-statistic	–6.2928	–6.2750	–10.3373	–2.3406
	Prob.	0.0001*	0.0001*	0.0000*	0.4010
Without constant and trend	*t*-statistic	–6.3105	–5.9896	–10.7195	–1.9869
	Prob.	0.0000*	0.0000*	0.0000*	0.0464**

Note: *, **, and *** denote the order of integration at 1%, 5%, and 10% level of significance respectively based on Mackinon's critical values; Prob. is the Mackinon *P*-value.

Source: Authors' computation.

Table 3
Unit root test results (PP)

Null hypothesis: the variable has a unit root.					
	At level				
		INF	*UN*	*PCI*	*PR*
With constant	t-statistic	–4.3273	–1.9094	–5.0092	–1.6657
	Prob.	0.0018*	0.3240	0.0003*	0.4385
With constant and trend	*t*-statistic	–4.1062	–3.4054	–5.1323	–0.0181
	Prob.	0.0148**	0.0684***	0.0012*	0.9942
Without constant and trend	*t*-statistic	–2.6740	0.4820	–1.1713	–0.7244
	Prob.	0.0092*	0.8137	0.2153	0.3949
	At first difference				
		d(*INF*)	*d*(*UN*)	*d*(*PCI*)	*d*(*PR*)
With constant	*t*-statistic	–6.4347	–7.5205	–14.8790	–4.6550
	Prob.	0.0000*	0.0000*	0.0000*	0.0008*
With constant and trend	*t*-statistic	–6.3714	–7.5205	–14.6854	–5.2485
	Prob.	0.0001*	0.0000*	0.0000*	0.0009*
Without constant and trend	t-statistic	–6.4346	–7.1568	–15.2220	–4.6745
	Prob.	0.0000*	0.0000*	0.0000*	0.0000*

Note: *,**, and *** denote the order of integration at 1%, 5%, and 10% level of significance respectively based on Mackinon’s critical values: Prob. is the Mackinnon *P*-value.

Source: Authors’ computation.

Table 4

Unit root test results (KPSS)

Null hypothesis: the variable is stationary.					
	At level				
		INF	*UN*	*PCI*	*PR*
With constant	*t*-statistic	0.1877	0.6767	0.3288	0.4848
	Prob.	no	**	no	**
With constant and trend	*t*-statistic	0.1173	0.0736	0.1202	0.1467
	Prob.	no	no	***	**
Without constant and trend	*t*-statistic	═══	═══	═══	═══
	Prob.				
	At first difference				
		d(*INF*)	*d*(*UN*)	*d*(*PCI*)	*d*(*PR*)
With constant	*t*-statistic	0.1863	0.0842	0.5000	0.3283
	Prob.	no	no	**	no
With constant and trend	*t*-statistic	0.1199	0.0534	0.5000	0.1343
	Prob.	***	no	*	***
Without constant and trend	*t*-statistic	═══	═══	═══	═══
	Prob.				

Note: For KPSS, the null hypothesis is that the variable is stationary. *, **, and *** denote the order of integration at 1%, 5%, and 10% level of significance respectively based on Kwiatkowski–Phillips–Schmidt–Shin (Table 1) critical values; 'no' means not significant, Prob. is the Mackinnon *P*-value.

Source: Authors' computation.

hypothesis of stationarity for all the series except in the case of *INF*, where the rejection is at 5% for both *UN* and *PR* but at 10% for *PCI*, which means that all the variables except *INF* are stationary at level. However, at the first difference, all the variables except *UN* are stationary at 10% for *INF,* 1% for *PCI*, and 10% for *PR*.

Overall, the ADF and PP unit root tests produced the same result that the series of *INF*, *UN*, and *PCI* are stationary but *PR* is not. However, following the Imam et al. (2016) who conducted a study on the best test among *ADF*, *PP*, and *KPSS* by comparing power and type I error of the tests using simulation where the study concluded that *PP* is the best, this paper concluded that the series of *INF*, *UN*, and *PCI* are stationary but *PR* is not.

Indirect least square regression

Equation A

$$UN = \pi_{11} + \pi_{12}INF + \pi_{13}PR + \varepsilon_{1t} \quad \text{(A)}$$

Table 5

Regression for equation (A)

Dependent variable: *UN*				
Variable	Coefficient	Standard error	*t*-statistics	Prob.
INF	–0.076	0.034	–2.231	0.033
PG	–3.016	0.467	–6.458	0.000
Constant	12.492	1.201	10.399	0.000
R-squared	0.604			
Adjusted *R*-squared	0.577			
S.E. of regression	1.000			
F-statistic	22.839			
Prob (*F*-statistic)	0.000			

Source: Authors' computation.

Equation B

$$PCI = \pi_{21} + \pi_{22}INF + \pi_{23}PR + \varepsilon_{2t} \ldots\ldots\ldots . \quad \text{(A)}$$

By substituting the values in equation (A) and equation (B) we get the following:

$$UN = 12.49 - 0.076INF - 3.01PR, \quad \text{(A}^*\text{)}$$
$$PCI = 2.80 - 0.059INF + 1.23PR. \quad \text{(B}^*\text{)}$$

Finding values of β and α for the structural equation which is the main concern of analysis:

$$\beta_1 = \pi_{11} - \beta_2\pi_{21},$$
$$\beta_1 = 12.49 - 2.45(2.80).$$

Hence, $\beta_1 = 19.35$.

Table 6
Regression for equation (B)

Dependent variable: PCI				
Variable	Coefficient	Std. error	*t*-Statistic	Prob.
INF	–0.060	0.064	–0.937	0.356
PG	1.238	0.873	1.419	0.166
Constant	2.803	2.244	1.249	0.221
R-squared	0.091			
Adjusted *R*-squared	0.030			
F-statistic	1.498			
Prob (*F*-statistic)	0.240			

Source: Authors' computation.

For β_2 we get:

$$\beta_2 = \frac{\pi_{13}}{\pi_{23}}$$

$$\beta_2 = \frac{-3.01}{1.23}$$

$$\beta_2 = -2.45.$$

Now substituting the values for β_3:

$$\beta_3 = \pi_{12} + \beta_2 \pi_{22},$$

$$\beta_3 = -0.076 + (-2.45)(-0.059),$$

$$\beta_3 = -0.068.$$

Now finding the values of α for the above equations as:

$$\alpha_1 = \pi_{21} + \alpha_2 \pi_{11},$$

$$\alpha_1 = 2.80 + (0.78)(12.49),$$

$$\alpha_1 = -6.94.$$

Similarly,

$$\alpha_2 = \frac{\pi_{22}}{\pi_{12}}$$

$$\alpha_2 = \frac{-0.059}{-0.076}$$

$$\alpha_2 = 0.78.$$

Similarly,

$$\alpha_3 = \pi_{23} + \alpha_2 \pi_{13},$$
$$\alpha_3 = 1.23 + (0.78)(-3.01),$$
$$\alpha_3 = 3.58.$$

So the original structural form of the equation is given as:

$$UN = 19.35 - 2.45 INF - 0.068 PCI, \qquad (A^{**})$$
$$PCI = -6.94 + 0.78 UN + 3.58 PR. \qquad (B^{**})$$

Estimates of the structural form of the coefficients are obtained indirectly from the simple version of Okun's law and Phillips curve from the reduced form parameters while substituting both equations using the composed well-designed methodology of indirect least square (ILS) technique. In the case of equation A^{**}, the study has found that even if unemployment rate and the growth rate of GDP per capita values are zero; still unemployment is 19.35. Similarly, a one-unit increase in inflation brings about a 2.45 units decrease in unemployment. Thus, inflation and unemployment show a negative relation in the regression line. Hence, our findings reflect the presence of Phillips curve. It is due to the fact that when the price level in the economy increases so the producers get higher profits; hence, they become more motivated to produce more goods, leading to higher demand for labor, due to which the employment level increases in the economy and unemployment decreases. Furthermore, the slope gives a clear reflection of the Phillips curve that is reasonable in the situation of Pakistan. The equation A^{**} also shows a negative relationship between the growth rate of GDP per capita and unemployment. It states that a one-unit increase in the growth rate of GDP per capita brings about 0.068 decrease in unemployment.

Furthermore, we can propose that Okun's law does not hold in Pakistan owing to the fact that Pakistan is a developing country and it faces a lot of challenges through structural, frictional and cyclical unemployment. From Equation B^{**} we have found that even if unemployment and population growth rate are zero, still the growth rate of GDP per capita will be 6.94. Similarly, a one-unit increase in unemployment will lead to an increase in the growth rate of GDP per capita up to 0.78% while a one-unit increase in PR leads to reduce the growth rate of GDP per capita by 3.58%. In a nutshell, we can conclude that Phillips curve exists (directly) in the economy of Pakistan while the pattern of Okun's law is not existing directly. Thus, during the analysis, we neglected the indirect relationships of the two laws. With this, it is concluded that in the short run Phillips curve still exists in the economy of Pakistan and an increase in general price level significantly causes a decrease in the unemployment rate. But the Okun's law is not present in Pakistan due to the bad performance of the economy from the time when it got independence in 1947. Pakistan had faced three severe wars and later was scattered in two parts in 1971. These early tribulations kept our economy non-progressive and dormant.

Conclusion and recommendation

This research tried to verify empirically the existence in the economy of Pakistan of the Phillips curve, which postulates an inverse relationship between inflation and unemployment, and the working of the Okun's law, which postulates an inverse relationship between the output growth and unemployment rate. The results of this analysis show that Okun's law does not work directly and indirectly in the case of Pakistan while the Phillips curve directly exists in the case of Pakistan's economy.

The paper offers some policy recommendations as follows. First, it is vital to take the economy to that level with the active role of policy makers or economists where these important laws of Philips and Okun can be integrated. They ought to design strategies to patch the height of the prevailing labor force along with a hub on the potential of laborers. Second, training should be provided to increase the potential productivity of the laborers. Third, technical and vocational training ought to be offered in order to adjust the labor force to the needs of modern economy and assure the growth of real wages. Fourth, sessions and workshops are to be organized to bring awareness and encouragement among the people.

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EMPIRICAL ANALYSIS OF THE PHILLIPS CURVE AND OKUN'S LAW THROUGH SIMULTANEOUS EQUATION MODELING: A CASE STUDY OF PAKISTAN

Summary

According to the Phillips curve, there is an inverse relationship between inflation and unemployment. According to the Okun's law, there is an inverse relationship between potential output growth and unemployment. The paper tries to check whether these interdependencies are seen in the Pakistan's economy, thus testing the relevance of both dependencies for that economy. With this aim, the authors analyse the relationships between several macroeconomic variables, such as inflation rate, unemployment rate, GDP per capita growth rate, and population growth rate, using annual data of the period 1985–2017. By employing the respective simultaneous equation models (SEM) estimated with the indirect least square technique (ILS) and using various statistical tests, the authors conclude that the relationship postulated by the Phillips curve can be observed in the Pakistan's economy, but the results of the examination do not confirm the occurrence of the relationship postulated by the Okun's law.

Keywords: Phillips curve, Okun's law, simultaneous equations models, indirect least square technique, Pakistan

JEL: E41, E42

ANALIZA EMPIRYCZNA KRZYWEJ PHILLIPSA I PRAWA OKUNA ZA POMOCĄ MODELI RÓWNAŃ JEDNOCZESNYCH: STUDIUM PRZYPADKU DLA PAKISTANU

Streszczenie

Zgodnie z krzywą Phillipsa istnieje odwrotna zależność między inflacją i bezrobociem. Zgodnie z prawem Okuna istnieje odwrotna zależność między wzrostem potencjalnej produkcji a bezrobociem. Autorzy próbują sprawdzić, czy zależności te występują w gospodarce Pakistanu, sprawdzając tym samym adekwatność tych zależności dla tej gospodarki. W tym celu analizują zależności między kilkoma zmiennymi makroekonomicznymi, takimi jak stopa inflacji, stopa bezrobocia, stopa wzrostu PKB per capita i stopa wzrostu ludności, na danych rocznych z okresu 1985–2017. Szacując odpowiednie modele równań jednoczesnych za pomocą pośredniej techniki najmniejszych kwadratów, z wykorzystaniem różnych testów statystycznych, autorzy dochodzą do wniosku, że zależność postulowana przez krzywą Phillipsa da się zaobserwować w gospodarce Pakistanu, ale wyniki analizy nie potwierdzają występowania zależności postulowanej przez prawo Okuna.

Słowa kluczowe: krzywa Phillipsa, prawo Okuna, modele równań jednoczesnych, pośrednia metoda najmniejszych kwadratów, Pakistan

JEL: E41, E42

ЭМПИРИЧЕСКИЙ АНАЛИЗ КРИВОЙ ФИЛЛИПСА И ЗАКОНА ОУКЕНА С ПОМОЩЬЮ МОДЕЛИ ОДНОВРЕМЕННЫХ УРАВНЕНИЙ: АНАЛИЗ НА ПРИМЕРЕ ПАКИСТАНА

Резюме

Согласно кривой Филлипса существует обратная зависимость между инфляцией и безработицей. Согласно закону Оукена существует обратная зависимость между ростом потенциального производства и безработицей. Авторы статьи пытаются проверить, наблюдаются ли эти зависимости в экономике Пакистана, проверяя тем самым их адекватность для этой страны. В этих целях авторы анализируют зависимости между несколькими макроэкономическими переменными, такими как норма инфляции, норма безработицы, показатель роста ВВП на душу населения и показатель роста населения – все это за годовые периоды в 1985–2017 гг. Оценивая соответствующие модели одновременных уравнений с помощью косвенной техники наименьших квадратов и различных статистических тестов, авторы приходят к выводу, что зависимость, постулируемая посредством кривой Филлипса, в экономике Пакистана просматривается. С другой стороны, результаты анализа не подтверждают наличия зависимости, постулируемой посредством закона Оукена.

Ключевые слова: кривая Филлипса, закон Оукена, модели одновременных уравнений, косвенный метод наименьших квадратов, Пакистан

JEL: E41, E42