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**A Revisit to Estimating Phillips Curve and NAIRU in Pakistan**

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| **ARTICLE INFO** | **ABSTRACT**  |
| ***Article History:***Received: January 27, 2024Revised: May 24, 2024Accepted: May 25, 2024Available Online: May 28, 2024 | This paper investigates the conventional Philips curve within the unique economic context of Pakistan, traditionally employed to analyze the intricate interplay between inflation and unemployment. Utilizing the Autoregressive Distributed Lag (ARDL) methodology, the research integrates annual data spanning from 1991 to 2022 on core inflation, unemployment, and supply shocks to estimate the Philips curve. Two distinct specifications of the Philips curve—the new Keynesian and the Triangle model—are employed to capture nuanced relationships. Moreover, the study establishes a constant Non-Accelerating Inflation Rate of Unemployment (NAIRU) derived from the estimated Philips curve, with precision assessed using Delta and Fieller methods. The empirical results robustly affirm the presence of a long-term trade-off between inflation and unemployment, offering fresh insights into Pakistan's economic dynamics. The ARDL error correction model reveals that short-term inflation dynamics are primarily influenced by inertia. At the same time, long-term trends are dictated by unemployment and the import price index, with the industrial productivity index deemed insignificant. The calculated sacrifice ratios of 0.57 and 0.51, alongside NAIRU estimates of 5.7 and 5.0 for the New Keynesian and Triangular models, respectively, signal a need for caution in implementing anti-inflationary policies. Addressing the significant impact of demand gaps and supply shocks on inflation calls for policies to reduce supply-demand disparities. Maintaining an optimal equilibrium of inflation and unemployment (NAIRU) necessitates a combination of stabilization and adverse supply shock control policies. These findings underscore the stabilizing role of commercial policy and advocate for reforms to bolster Pakistan's industrial sector. |
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## Introduction

In the wake of the post-pandemic era, global economies are grappling with the formidable challenges of rising inflation and soaring unemployment rates (Divergences, 2023). Pakistan, facing the severity of these issues, perceives them as a looming threat to its sustainable long-term growth (Bank, 2022; Survey, 2022-2023). The pursuit of stable prices and high employment is a cornerstone of economic policy, and the intricate relationship between inflation and unemployment plays a central role in shaping effective monetary policies (Zanzalari & Fiore, 2022). A sound empirical investigation of the issues at the nexus of inflation and unemployment is a prerequisite to formulating effective and appropriate policies. Most academic and practical exercises that measure the relationship between inflation and labor or output market slack revolve around the Philips curve theory. Most academic and practical exercises measuring the relationship between inflation and the labor and output markets slack revolve around the Philips curve theory (Guirguis & Suen, 2022). While the theory has been widely explored globally, the research in this area needs to be more robust in the case of Pakistan. The present study aims to fill this void by employing advanced econometric techniques, specifically the Autoregressive Distributed Lag (ARDL) model and the Newey-West method, to estimate two main specifications of the Phillips curve—the New Keynesian Phillips Curve (NKPC) and the Triangular Model Phillips Curve (TMPC). This paper further derives the Non-Accelerating Inflation Rate of Unemployment (NAIRU) from the estimated Phillips curve. NAIRU refers to the level of unemployment below which inflation is expected to speed up. It is an important theoretical concept to understand the highest sustainable level of employment and its correlation with a nation's potential output. The precision of NAIRU is rigorously tested using the Fieller and Delta methods. The empirical findings not only contribute novel insights into the trade-off between inflation and unemployment in Pakistan but also provide feedback for policy measures to address the current economic challenges faced by the country. However, the amount and frequency of data available limits the scope of this study.

Cyclic unemployment and inflation can have significant economic consequences as they affect the lives of millions of individuals. High inflation rates can lead to a relocation of income and wealth among different groups and create falsifications in the relative prices and outputs of various goods (Chien & Dunn, 2022). To prevent high inflation rates, an economy needs to maintain the natural unemployment rate or NAIRU, which represents the lowest level of unemployment that can be sustained while still achieving a nation's potential output. The natural rate hypothesis suggests that changes in inflation rates are primarily a labor market phenomenon that can be approximated by measuring labor market slack, such as the unemployment gap (Stiglitz, 1997). The Phillips curve proposition claims an inverse relationship between inflation and unemployment and offers a basis for estimating NAIRU (Engemann, 2020; McAdam & Mc Morrow, 1999).

Pakistan is currently going through one of the worst economic crises in its history. The situation is the result of various internal and external factors, such as the rise in global oil prices, depreciation of the Pak-Rupee, damage caused by recent floods, and political instability. Inflation has become a significant concern, with the target set at 11.5 percent for the previous fiscal year, but it rose to 36.4 percent in April 2023 from 13.4 in April 2022. The rates for food inflation are even higher, with 46.8 percent in urban areas and 52.2 percent in rural areas. To address the 5F crisis of food, fuel, fertilizer, feed, and finance, it is essential to stabilize both international and domestic prices (George, 2023; Survey, 2022-2023). Unemployment is another significant challenge faced by the country, affecting both individuals and society. With millions of people unemployed, the problem is becoming more widespread each year due to population growth and lack of employment opportunities. The government reports that the percentage of unemployed labor force is nearly seven percent. Pakistan has the fifth-largest population and top ten largest labor force in the world, making it a significant challenge to create sufficient employment opportunities to accommodate so many people. Both economic development and social well-being depend on a country's human resources, and Pakistan must find ways to generate enough employment opportunities for its massive labor force (Survey, 2022-2023).

The paper has been structured as follows: It begins with an introductory section, followed by a literature review on the theoretical framework, Phillips curve specifications and NAIRU estimation in section two. Section three details the research data, methodology, and empirical results. Finally, section four concludes the paper, provides a summary of the main findings, and offers recommendations for policymakers and future research.

## Literature Review

The research examines the relationship between inflation and unemployment in Pakistan using the NKPC and TMPC versions of the Phillips curve. A.W. Phillips established the original Philips curve, which demonstrates an inverse relationship between inflation and unemployment. He studied wage inflation and unemployment data from 1861-1957 in the United Kingdom (Engemann, 2020). In the mid-1960s, Paul Samuelson and Robert Solow noted a similar relationship between price inflation and unemployment in the United States. The traditional Phillips curve says that as the unemployment rate decreases, the demand for labor increases, leading to higher wages. To compensate for rising labor costs, companies increase their product prices. This relationship is typically represented by equation (1).

$Π\_{t}=a-bU\_{t}$ (1)

Where a and b> 0 are parameters, $Π\_{t}$ and $U\_{t}$ represent the rates of contemporaneous inflation and unemployment, respectively (Ihrig, Peneva, & Wolla, 2021; Ruberl, Ball, Lucas, & Williamson, 2021). A large body of literature uses a more convenient version of the Phillips curve, which replaces the unemployment and output gaps. This approach relies on the relationship between the output gap and the unemployment rate, known as Okun's law (Ball & Mankiw, 2002; Gordon, 2011).

The Phillips curve initially showed that there is a negative relationship between wage growth and unemployment rate in the short run. However, the work of Rivot resulted in the development of the expectation augmented Phillips curve. This new theory introduced the concept of a long-run structural equilibrium, which is the unemployment rate associated with a steady inflation rate. According to this theory, inflation is affected by the expected inflation rate and the gap between the actual unemployment rate and the equilibrium rate. This relationship is commonly expressed in equation (2) and is a fundamental aspect of most standard theories.

$Π\_{t}=Π\_{t}^{e}+b(U\_{t}- U^{\*})$ (2)

In equation (2) $Π^{e}$ represents the expected inflation while $U^{\*}$ is a parameter that is known as the natural rate of unemployment or NAIRU. The NAIRU is the equilibrium unemployment rate towards which the economy moves in the long term. It is the rate at which inflation will be stable, meaning that actual inflation will be equal to expected inflation. In the long run the Freidman-Phelps Phillips Curve is vertical and settles at the natural rate of unemployment (Ball & Mankiw, 2002).

In order to implement the expectation-augmented Phillips Curve, it is necessary to understand how expectations about inflation are formed. The adaptive expectations approach suggests that expected inflation is the past inflation weighted average. Empirical evidence confirms the rationality of this approach (Ball & Mankiw, 2002). The simplest version of this approach is to assume that expected inflation is equal to the last period’s inflation, meaning that $Π^{e}=Π\_{t-1}$. The adaptive expectation version of the Phillips Curve is traditionally represented by equation (3).

$Π\_{t}=Π\_{t-1}+b\left(U\_{t}-U^{\*}\right)+ν\_{t}$ (3)

Where $ν\_{t}$ represents the supply shock, and U\* is termed NAIRU. The NAIRU represents the unemployment rate at which inflation doesn't increase, assuming there are no unexpected shocks in the market. Supply shocks refer to sudden and unforeseen changes in the cost of inputs such as wages, raw materials, and oil prices. They can have either a positive or negative impact on output and can be temporary or long-lasting (Nguyen Jr, 2021).

According to Gordon (2011), since 1975, the Phillips curve progress has branched into two divergent groups, the New Keynesian Phillips curve (NKPC) and Triangular Model Phillips Curve (TMPC). In a seminal paper by Sargent (1971) NKPC model was originated. Unlike the expectations-augmented Phillips ccurve, NKPC assumes rational expectations of inflation instead of adaptive. It is based on the inflation dynamics based on the optimizing behavior of firms. The firms follow time-reliant rules for price adjustment. The desired price of a firm depends on the unemployment gap and the overall price level. When firms set their new price, they equate it to average price anticipation till the next price revision. However, they change prices less frequently. Thus, an average of all prices set by a firm in the past becomes its actual price. The first-order optimization conditions suggest that firms' pricing decisions are influenced by expected future market conditions. The standard NKPC is derived by solving this model of a firm’s price-setting behavior. The derivation yields an NKPC model that relates inflation rate ($Π\_{t}$) to anticipated future inflation ($E\_{t}Π\_{t+1}$)and the output (or unemployment) gap cited in equation (4).

$Π\_{t}=aE\_{t}Π\_{t+1}+b\left(U\_{t}-U^{\*}\right)+ν\_{t}$ (4)

A standard approach to proxy expected future inflation ($E\_{t}Π\_{t+1}$)uses instrumental variables. This approach leads to the first-stage equation for estimating NKPC by two stages least squares. That equation is expressed as equation (5).

$E\_{t}Π\_{t+1}=\sum\_{i=1}^{4}λ\_{i}Π\_{t-i} +ϕ\left(U\_{t}-U^{\*}\right)$ (5)

Replacing $E\_{t}Π\_{t+1}$ from equation (5) in equation (4) generates equation (6).

$Π\_{t}=a\sum\_{i=1}^{4}λ\_{i}Π\_{t-i} +(aϕ+b)\left(U\_{t}-U^{\*}\right)+ν\_{t}$ (6)

Thus, the reduced form equation (6) demonstrates that, in practice, NKPC could be estimated by simply regressing the inflation rate on the unemployment gap and a few lagged terms of inflation (Gordon, 2013). Several variants of the NKPC approach have been suggested and estimated. One popular variant is Hybrid NJPC model presented by Galı and Gertler (1999)  and (Gali, Gertler, & Lopez-Salido, 2005). This model adds explicit lagged inflation terms and the forward-looking expectation term to equation (4). Galı and Gertler (1999) reported that ‘forward-looking behavior’ dominates NKPC estimation in which labor's income share replaces the unemployment gap. J.B. Rudd and K. Whelan (2005) argue that the estimation technique used in 2SLS does not differentiate between forward-looking and backward-looking behavior. As a result, the NKPC hybrid approach has not provided any evidence to support the notion that expectations are forward-looking. Suppose more extended inflation lags and commodity prices used as instruments at the first stage in equation (4) are significant for inflation. In that case, there is no reason to omit these variables from equation (3) and equation (5) Gordon (2013).

The present study is focused on estimating the form of NKPC proposed by Roberts (2004). This backward-looking Phillips curve is considered the best way to understand policy discussions about inflation and unemployment rates, and it is a critical analytical apparatus in many macroeconomic forecasting models (Stock & Watson, 2009). Roberts’ equation is identical to equation (6) in two respects: the sum of coefficients on lagged inflation is assumed one, and the NAIRU is constant. Thus, the Roberts version of the NKPC equation can be expressed as given in equation (7).

$Π\_{t}=\sum\_{i=1}^{4}a\_{i}Π\_{t-i}+c+b\left(U\_{t}-U^{\*}\right)+ν\_{t}$ (7)

In this equation constant NAIRU is implicit as $-c/b$, where c is a constant term.

TMPC is mainly the outcome of research to explain contradictory empirical findings of an insignificant or positive relationship between inflation and unemployment. The puzzle was resolved by reconciling the macroeconomic inflation-unemployment model and microeconomic model. In that model, the price and quantity of a commodity are related negatively or positively depending upon the relative magnitude of demand and supply shifts. The inflation-unemployment relationship could be negative (positive) if demand shocks are more (less) intense than supply shocks (Gordon, 2013). Gordon (1997) “Triangle Model” of the Phillips curve posits that inflation rate is determined by a " triangle" consisting of expected inflation, demand conditions (represented by output or unemployment gap), and supply-side shocks. The predicted inflation is replaced by long lags termed the ‘inertia’ effect. The sources of this inertial effect include implicit and explicit long-term price and wage contracts and input-output supply chains (Gordon, 2011)[[1]](#footnote-1). TMPC includes supply shock variables in the inflation equation, rather than being included in the disturbance term like NKPC. A general representation of this model is given in equation (8).

$Π\_{t}=a(L)Π\_{t-1}+b\left(L\right)ED\_{t}+d\left(L\right)SS\_{t}+ν\_{t}$ (8)

Where L is a lag operator polynomial, the dependent variable $Π\_{t}$ is the inflation rate as in the NKPC approach, inertia is represented by a series of lags on the inflation rate conveyed by $Π\_{t-1}$, excess demand index is expressed by $ED\_{t}$, supply shock variables are defined by $SS\_{t}$. In equation (8), excess demand index and supply shock variables are normalized so that their zero values indicate their absence, and $ν\_{t}$ is a serially uncorrelated error term. The constant term in the equation is omitted to indicate that, in the absence of demand and supply shocks, the current inflation and the previous period’s inflation have the same value. If the sum of coefficients estimated on lagged inflation values equals one, the natural rate of the demand variable ($ED\_{t}^{N}$) consistent with a constant inflation rate can be identified.

The most used measures of excess demand in TMPC are the “output gap” and “unemployment gap”. The output gap is the logarithm of the actual real GDP to potential real GDP ratio. On the other hand, the difference between the actual unemployment rate and the natural rate of unemployment (NAIRU) yields the unemployment gap. TMPC considers several variables that can impact the supply. These variables encompass fluctuations in import prices, changes in the relative prices of food and energy, variations in the terms of trade, shifts in the real effective exchange rate, changes in productivity growth, and policy measures designed to regulate prices such as the Nixon wage and price controls implemented in the USA (Gordon, 2013; Staiger, Stock, & Watson, 1997). Including a constant term, TMPC is expressed by equation (9).

$Π\_{t}=c+a(L)Π\_{t-1}+b\left(L\right)U\_{t}+d\left(L\right)SS\_{t}+ν\_{t}$ (9)

where $c=b\left(L\right)U^{\*}$. The constant NAIRU estimate is -c/b(L), assuming the sum of the lagged inflation coefficients unity.

The interpretation of estimated NAIRU requires the measurement of its precision. Because NAIRU is a ratio (nonlinear combination) of estimated coefficients of the Phillips curve, measurement of its confidence limits is complicated. Fieller and Delta approaches are commonly used methods for deriving CI for ratios. The Delta method is a traditional approach to constructing CI. It approximates a linear relationship between parameters and ratio using a first-order Taylor-series expansion. For estimation of CIs and tests of hypothesis for nonlinear functions of regression parameters, this method is a standard approach. Fieller (1954) proposed an alternative method for constructing CIs for ratios. The Fieller iterative method uses repeated significance testing on the intercept to accept or reject trial values for the true parameter. In several applications, this approach has proved superior to the Delta method. When Delta and Fieller methods yield different results, the Fieller CI aligns more closely with the theoretical interval than the Delta interval. Moreover, unlike Delta intervals, Fieller intervals are not required to be symmetric. A limitation of the Fieller approach is that it may not result in a finite CI for some values of the level of significance. Applying Delta and the Fieller methods requires normal distribution or asymptotically normal distribution of parameter estimates. This assumption relies on additional implicit assumptions in specifying functional forms and error generation (Lye & Hirschberg, 2018). Though few studies have measured the precision of NAIRU estimates, some research, such as Staiger et al. (1997), found that the Fieller method is significantly better than the Delta method in finding confidence intervals for NAIRU. Others, like McAdam and Mc Morrow (1999), preferred the Delta method.

The literature on the Phillips curve presents a range of techniques utilized for its estimation. Two main strands of this literature are the single equation estimation (reduced-form Phillips curve) and system estimation. A comparison of different methods indicates that the reduced-form Phillips curve is the most appropriate model to estimate the relationship between inflation and unemployment (Nason & Smith, 2008b). It directly links inflation and unemployment rates and aligns with various structural approaches (Gordon, 2011; Katsouli & Pallis, 2006; Roberts, 2004).

A dominant approach applied in single equation estimation is ordinary least squares (OLS). Most studies do not explicitly provide evidence for the stationarity and exogeneity of the involved variables (Vogel, 2008). However, several classical studies discuss non-stationarity and endogeneity while reporting the OLS estimation of reduced form Phillips curve. Gordon (1981, 1990) and Roberts (2004) are included in this category. The ARDL approach is utilized to estimate the Phillips curve involving nonstationary time series. This technique is employed when some of the indicators of inflation, excess demand, and supply shock are stationary (I(0)) and others are integrated of order one (I(1)). Using OLS, Guirguis and Suen (2022) estimated linear and nonlinear models of the Philips curve for the US economy. They demonstrated that the Convex Phillips curve successfully explains and forecasts more than 90% of the underlying inflation gauge from 1995:05 to 2019:03. Similarly, Hooper, Mishkin, and Sufi (2020) assessed the performance of the expectations-augmented Phillips curve for both wages and prices using historical national-level data as well as panel data for US cities and states. National data provides strong evidence of negative and nonlinear slopes for the 1950s and 60s, with a positive link between the magnitude of the slope and the tightness of labor markets. For the price Phillips curve, this evidence of slope and nonlinearity fades substantially for macro data since the 1980s but does not change for the wage Phillips curve. Rahman and Mustafa (2017) estimated the traditional Phillips curve for US data from 1930 to 2016 using an ARDL bound testing approach. Egede, Aminu, Hamma, and Ademola-John (2023) utilized the same technique to explore the inflation-unemployment tradeoff for Nigeria. Reichel (2004) used this approach to estimate the inverted Phillips curve for US data.

The techniques that have been applied to estimate the multiple equation Phillips curve model include the Full Information Maximum Likelihood Method (FIML), Generalized Moment Method (GMM), Vector Error Correction (VEC) model, Unrestricted Vector Error Correction (VAR) model, and State Space models. Amongst many others, Gali et al. (2005) estimated hybrid NKPC for the US economy using GMM. Saeed and Riaz (2011) applied this technique to estimate hybrid NKPC in the case of Pakistan. J. Rudd and K. Whelan (2005) as well as Dees, Pesaran, Smith, and Smith (2009) argue that identification problems and weak instrument bias are common issues with the GMM approach to the hybrid NKPC. The FIML approach used by Lindé (2005) and the structural VAR approach applied by Nason and Smith (2008a) to estimate hybrid NKPC suffers the same identification problems (Vogel, 2008).

Another vital base for the classification of Phillips curve literature is the existence and non-existence or gradual demise of this curve. The studies that establish the significant fact of the Phillip curve include Guirguis and Suen (2022); Hooper et al. (2020), a series of papers by Engemann (2020); Fisher (1926); Gordon (1981, 1990, 1997, 2011, 2013); Vogel (2008), to name a few. On the other hand, in their empirical investigation, Lucas Jr (1972) and Sargent (1971) demonstrated that the long-run Phillips tradeoff could not be estimated using conventional econometric methods at that time. These findings were revisited by several studies, including (Alogoskoufis & Smith, 1991; Lucas & Sargent, 1997; Niskanen, 2002; Reichel, 2004).

Most of the Phillips curve and NAIRU research has been done concerning developed economies; most of which belong to the US economy. Research on the Phillips Curve is immensely limited in developing countries, specifically Pakistan. The history of empirical investigation of the Phillips curve in Pakistan goes back to the study executed by Hasan and Khan (1988). This research estimates the expectations-augmented Phillips using the single equation instrumental variable technique (SIV) and the full information maximum likelihood generalized errors-in-variables (FGEV) method. The findings of this research provide significant evidence for the presence of inertia in prices. It also establishes the existence of both long-run and short-run inflation-unemployment tradeoffs in the case of Pakistan from quarter-I 1972 to quarter-IV 1984. Some of the variables’ annual series were interpolated to obtain quarterly data in this study, which could result in large standard errors and biased coefficients. Moreover, it needs to be made clear which inflation measure has been used in this paper.

A study by Satti, Malik, and Saghir (2007) estimated standard NKPC using GMM to explain the Pakistan’s inflation dynamics from 1976 to 2006. They found the output gap insignificant and real marginal cost significant as determinants of inflation in Pakistan. It is established that future inflation expectations instead of inertia play a significant role in inflation determination. According to this research, the degree of price inflexibility is high in Pakistan, while relatively small percentage of firms follow backward-looking rules for price setting. This study used a GDP deflator-based inflation rate that undermines the role of the foreign sector in inflation dynamics. Moreover, the marginal cost variable estimation procedure is unclear in this work.

The sector-wise (agriculture, manufacturing, and services) hybrid NKPCs for Pakistan are estimated by Hyder and Hall (2020). This study used three indicators of economic activity: real marginal cost (based on the Dynamic Translog Cost Function), labor shares of income, and the output gap. In most of the models, estimated coefficients of NKPC are found to be consistent with economic theory. The findings of forecast performance within-sample and other diagnostic tests show that the NKPC with a real marginal cost outperforms other specifications that use output gap or labor share of income. It is suggested that a model with additional inputs and intermediate cost may perform better the NKPC model with restrictive Cobb-Douglas production technology that only takes labor input into account. According to a study, the manufacturing sector in Pakistan is the most futuristic, followed by services and agriculture. This study used sector specific deflator for measuring inflation in each sector. Hence, it suppressed the role of the foreign sector in determining inflation. Furthermore, the data source period of the variable ‘compensation to employ’ and the study period do not match.

Some studies on the Phillips curve are focused on the estimation of NAIRU in Pakistan. Zaman, Khan, Ahmad, and Ikram (2011) employed VECM to examine the causal relationships between inflation and unemployment for the period 1975-2009. Both the short- and long-term relationship between inflation and unemployment research is negative and non proportional. Non-parametric estimated values of NAIRU for Pakistan are 6.01, 3.21, and 9.01 percent for 1975-87, 1988-98, and 1999-2009, respectively. For the entire period 1975-2009, the estimate of NAIRU is 7.80 percent, substantially higher than the average unemployment rate of 4.99 percent. This study needs an explanation of inflation indicators and the non-parametric estimation procedure of NAIRU. To our knowledge, a single study for Time-Varying NAIRU (TV-NAIRU) in the case of Pakistan is by Shaheen, Haider, and Javed (2011) over the period 1973-74 to 2007-08 employing the Kalman filter. They used TMPC with Oil prices as a proxy for supply shock. The study shows that TV-NAIRU increased from 5.3% (1990-91) to 8.12% (2004-05), then fell to 6.17% in 2007-08, remaining above the actual unemployment rate. Gondal, Hussain, and Khan (2014) estimated NAIRU based on the traditional Phillips curve and TMPC for some SAARC countries, including Pakistan. They employed the Pooled OLS technique on a panel dataset from 1971 to 2012. The energy inflation, terms of trade, and exchange rate are supply shocks in this study. According to the estimation results of this research, the overall NAIRU value stands at 6.71 percent and 6.80 percent, respectively, without and with supply shocks. The estimated individual value of NAIRU for Pakistan has been determined at 6.73.

Theoretical models discussed in this section lay the ground for the present study’s data and estimation techniques. The next section presents the data description, the methodology, and the empirical findings.

## Data, Methodology, and Empirical Analysis

In the present research, the relevance of the Philips curve for Pakistan’s economy is analyzed using the annual time series data on Core inflation (ICOR), unemployment (UNEMP), and various supply shocks. Core inflation is a widely used measure for gauging the underlying inflation trends. It excludes the highly volatile categories of food and energy to derive the actual inflation rate (Guirguis & Suen, 2022). However, core inflation data is available only from the year 1991 onwards. Hence, the estimations are based on the data collected for the years 1991 to 2022. The data is collected from various Economic Surveys of Pakistan and World Development Indicators (WDI) issues. It is essential to highlight that WDI data on Pakistan's unemployment rate from 2006 to 2011 does not match that period's economic conditions. It also varies from the values reported by Economic Surveys of Pakistan.

**Table 1**

***Descriptive Statistics***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Number of observations** | **Mean** | **Standard Deviation** | **Minimum Value** | **Maximum Value** |
| ICOR | 32 | 7.45 | 2.56 | 2.25 | 11.55 |
| UNEMP | 32 | 6.24 | 0.91 | 4.78 | 8.27 |
| G\_IP | 32 | 4.68 | 4.12 | -5.75 | 17.19 |
| G\_OILPRICE | 32 | 0.07 | 0.10 | -.194 | 0.29 |
| G\_IMUVI | 31 | 0.04 | 0.11 | -.167 | 0.28 |
| G\_TOTI | 32 | -0.01 | 0.06 | -.115 | 0.12 |
| G\_NBTOTI | 31 | -0.02 | 0.08 | -.184 | 0.15 |

The supply shocks considered in this research are the industrial productivity, oil price, import price index, real effective exchange rate, net barter terms of trade index and terms of trade index (Gondal et al., 2014; Gordon, 2013; Hanif, 2012). The industry (value added) growth rate is used as a proxy for industrial productivity (G\_IP), and the change in oil price (G\_OILPRICE) is measured by the growth rate of the average retail price of petrol super. The foreign trade impact on domestic inflation is analyzed by including growth rates of import unit value index (G\_IMUVI) (a proxy for import price shock), terms of trade index (G\_TOT), and net barter terms of trade index (G\_NBTOTI). For data harmonization, Fiscal year values obtained from Economic surveys of Pakistan are converted to Calendar year values following the rules given by Atkinson and McGarry (2016). A descriptive analysis of all variables included in this research is given in Table 1.

The basic plot analysis given in Figure1 could be a helpful start for analyzing inflation unemployment nexus. This plot demonstrates that though the inflation-unemployment tradeoff dominates, it does not prevail throughout. From 1998 to 2002 a rise in unemployment is accompanied by a decrease in inflation and vice versa from 2002 to 2005, a behavior that is per Phillips curve doctrine. For the rest of the period, a positive correlation between unemployment and inflation is also detected, and the lead of inflation to unemployment is obvious; NKPC cannot explain that. Analyzing the inflation-unemployment trends in several countries, macroeconomists conclude that inflation is determined by both demand and supply factors. TMPC is based on these findings and provides an empirical tool to test this hypothesis (Ball, 1994; Ball & Mankiw, 2002; Gordon, 2013).



**Figure 1. Core Inflation Rate Vs Unemployment Rate**

The NKPC and TMPC models estimated in the present research are presented in equations (10) and (11), respectively.

$ICOR\_{t}=a(L)ICOR\_{t-1}+b\left(L\right)UNEMP\_{t-1}+ν\_{t}$ (10)

$ICOR\_{t}=a(L)ICOR\_{t-1}+b\left(L\right)UNEMP\_{t-1}+γ\left(L\right)SS\_{t}+ε\_{t}$ (11)

Where $SS\_{t}$ is a supply shock variables’ vector, $ν\_{t}$ and $ε\_{t}$ are serially uncorrelated error terms, lagged values of core inflation express inertia. Following Gordon (2013), all supply shock variables included in TMPC are normalized so that their zero value indicates a nonappearance of supply shocks. The models include lagged unemployment to avoid the endogeneity concerns about contemporaneous unemployment and to account for the possible delayed impact of tight demand on inflation (Ruberl et al., 2021; Staiger et al., 1997).

Stationarity analysis is a prerequisite for selecting an appropriate regression technique that is ignored by most empirical studies on the Phillips curve (Fanelli, 2008; Vogel, 2008). The present research analyzes the data series’ stationarity graphically and through unit root testing. The time series’ graphs are given in Appendix Figure A.1. Table 2 reports the outcomes of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (Meagher, Watson, Suh, & Virk, 2022). These tests are employed to detect unit roots in time series data. The results of both tests demonstrate that the core inflation and unemployment series are integrated of order one (I(1)), while all other series have zero order integration (I(0)). Based on the evidence of hybrid integration order (I(1) & I(0)) of variables, the ARDL approach is employed in this paper for the estimation of NKPC and TMPC. ARDL is considered an appropriate approach in a single-equation time series setup to model the relationship between variables. The ARDL technique provides a reparameterization in error correction (EC) form, making it appealing for cointegrating nonstationary time series. From this EC representation, the inference on the existence of a long-run (cointegration) relationship can be drawn by the bounds testing procedure. This procedure is independent of the information that series are integrated of order zero or one or a mixture of both orders (Kripfganz & Schneider, 2023). For the selection of the ARDL model’s lag length, the Schwarz (Bayes) information criterion (SIC) is employed because it is a consistent model selector and decides on more parsimonious models (Kripfganz & Schneider, 2023; Ogunlesi & Bokana, 2018). For TMPC, various combinations of supply shock variables are tried. Final selection is

**Table 2**

***Augmented Dickey–Fuller and Phillips–Perron Tests’ Statistics***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | **Model** | **ADF Statistic (Probability)** | **PP Statistic (Probability)** | **Order of Integration** |
| ICOR | Random walk with no drift | -2.053 (0.2640) | -2.304 (0.1760) | 1 |
| ΔICOR | Random walk with no drift | -3.744 (0.0035) | -3.762 (0.0033) | 0 |
| UNEMP | Random walk with no drift | -1.691 (0.4356) | -1.741 (0.4101) | 1 |
| ΔUNEMP | Random walk with no drift | -4.517 (0.0002) | -4.365 (0.0003) | 0 |
| G\_IP | Random walk with no drift | -4.174 (0.0007) | -3.990 (0.0015) | 0 |
| G\_OILPRICE | Random walk with no drift | -3.758 (0.0034) | -3.638 (0.0051) | 0 |
| G\_IMUVI | Random walk with no drift | -5.455 (0.0000) | -5.533 (0.0000) | 0 |
| G\_TOTI | Random walk with no drift | -5.234 (0.0000) | -5.182 (0.0000) | 0 |
| G\_NBTOI | Random walk with no drift | -5.764 (0.0000) | -5.795 (0.0000) | 0 |

Based on the overall goodness of fit, significance of parameters, and validation of diagnostic tests. All the diagnostic tests and findings for NKPC and selected TMPC are given in Appendix Table A1, and recursive Cusum plots for these models are exhibited in Appendix Figure A.2. Using the Newey-West procedure, the chosen models’ cointegration equations are re-estimated for the robust standard errors. Table 3 cites the estimated Cointegration equations (Newey-West) and ARDL EC representations of NKPC and TMPC.

The ARDL bound test statistics for each NKPC and TMPC confirm the presence of cointegration among variables at a five percent significance level. Similarly, in both models, the negative and significant adjustment coefficients witness that an error correction mechanism exists in these models. It is depicted by the values of error correction terms that in NKPC, almost 54 percent and in TMPC, nearly 51 percent of deviation from long-run equilibrium is restored in a single period. The signs of estimated coefficients of the unemployment gap in both models and supply shocks in TMPC are per the economic theory. In NKPC, the long-run impact of unemployment is significant, and it does not have any short-run effect on inflation. The absence of short-run unemployment impact on inflation does not indorse the results of Hasan and Khan (1988) and (Zaman et al., 2011). In NKPC, only the previous period’s change in inflation significantly affects the current inflation in the short run.

Similarly, the error correction representation of TMPC demonstrates the significant presence of the long-run effect of unemployment and the absence of its impact on inflation in the short-run. These findings support the Keynesian argument of the long-run inflation-unemployment tradeoff. The result implies that long-run stabilization policies could be effective in Pakistan. The short-run analysis of TMPC shows that only lagged change in inflation significantly impacts current inflation. In this model, the supply shock variables have long-run impact; however, does not reveal any short-run effect. The impact of the import price index is statistically significant with a positive effect at a confidence level of five percent. At the same time, the impact of industrial productivity is positive but insignificant. These findings show the significance of the foreign sector and the ineffectiveness of the domestic industrial sector in determining long-run inflation trends in Pakistan. It provides a rationale for stabilizing role of commercial policy and urges for reforms to improve the industrial sector in Pakistan’s economy.

**Table 3**

***ARDL Model Estimation Results for Two Specifications of Phillips Curve***

|  |  |  |  |
| --- | --- | --- | --- |
| **ARDL Model** |  **Regressors** | **NKPC** | **Triangular Model** |
| Cointegration Equation | Constant | 9.8371\*\*\*(2.4489) | 9.7125\*\*\*(1.4052) |
| UNEMPt-1 | -0.9479\*\*\*(0.2926) | -0.9852\*\*\*(0.1731) |
| ICORt-1 | 1.1114\*\*\*(0.1565) | 1.2078\*\*\*(0.0789) |
| ICORt-2 | -0.6528\*\*\*(0.1679) | -0.7138\*\*\*(0.1109) |
| G\_IP | ---------- | 0.0748(0.1972) |
| G\_IMUVI | ---------- | 0.4371\*\*(0.1945) |
| Adj. R-squared | 0.8039 | 0.8801 |
| Root MSE | 1.0975 | 0.8687 |
| Log Likelihood (SIC) | -40.1769 | -31.1188 |
| Error Correction Model | Adj. Coefficient | -0.5414\*\*\*(0.1365) | -0.5060\*\*\*(0.1159) |
| Long Run: |  |  |
| UNEMPt-1 | -1.7509\*\*\*(0.4413) | -1.9470\*\*\*(0 .3778) |
| G\_IP | ---------- | 0.1478(0.3880) |
| G\_IMUVI | ---------- | 0.8642\*\*(0.3850) |
| Short Run:ΔICORt-1 | 0.6528\*\*\*(0.1610) | 0.7138\*\*\*(0.1289) |
| Bound Test Stats(Unrestricted intercept, no trend) | F= 8.257\*\*t= -3.967\*\* | F= 8.812\*\*t= -4.366\*\* |
| Estimated Value of NAIRU | 5.6181\*\*\*(1.1377) | 4.9883\*\*\*(0.9226) |
| Note: Significance levels are shown as follows; \* denotes 10%, \*\* denotes 5%, and \*\*\* denotes 1%. Data in parentheses shows standard errors. |

The overall estimation statistics of the Cointegration equations of NKPC and TMPC demonstrate the goodness of fit for both models. These equations illustrate the equilibrium relationship among the models’ variables. According to the estimated R-squared value of NKPC, almost 80 percent variation in inflation is explained by the lagged inflation and unemployment, whereas for TMPC it is 88 percent. In NKPC and TMPC, both the first and second-lagged terms of inflation are highly significant, providing empirical evidence of inertia in the inflationary trend of the economy. The coefficient of lagged unemployment is negative with a high significance level demonstrating a noteworthy inflation-unemployment tradeoff. These findings accord with the conclusions of previous studies. The estimated coefficients of supply shock variables in the cointegration equation reveal the same tendency as is depicted by the long-run part of the error correction representation.

By utilizing the long-run coefficients of unemployment, the value of the sacrifice ratio is estimated as 0.57 and 0.51 from NKPC and TMPC, respectively. It shows the cost of one percent disinflation in terms of the increased unemployment rate. These values are lower than the estimated average sacrifice ratio of 0.8 for annual data from nine developed countries reported by Ball (1994). The probable factors could be the more flexible labor contracts, the shorter duration of these contracts, and the high speed of disinflation in Pakistan (Ball, 1994). The values of constant term and long-run coefficient of lagged unemployment are employed to determine the NAIRU. The estimated value of NAIRU is nearly 5.62 percent and 5.00 percent from NKPC and TMPC, respectively. This value is lower than the values of constant NAIRU in Pakistan estimated in previous studies discussed in the literature review. However, it is not comparable because of differences in the estimation period, and estimation techniques. A comparison of Delta and Fieller’s 95 % percent CI for estimated NAIRU is exhibited in Figure 2. It depicts that the estimated values of NAIRU are not very precise. Ball and Mankiw (2002); Jacob and Wong (2018), and several other studies pointed out that NAIRU’s estimation tends to be imprecise due to its unobservable nature. Another source of NAIRU’s imprecision might be the relatively small sample available for the present study. The asymmetric nature of Fieller’s CI is evident in both plots. It can also be observed that the lower bounds of Fieller and Delta CI estimates are close, indicating the low variances of estimated coefficients (Lye & Hirschberg, 2018). The NAIRU estimate of TMPC is relatively precise compared to that of NKPC.

|  |  |
| --- | --- |
|  |  |
| **Figure 2: Fieller & Delta 95 % Confidence interval for NAIRU** |

A plot of actual unemployment and estimated values of NAIRU is portrayed in Figure 3 to analyze the nature of the unemployment gap in Pakistan. This plot depicts that for most of the period, actual unemployment is above NAIRU indicating a positive unemployment gap. According to the Phillips curve theory, a positive unemployment gap leads to the deceleration of inflation. The prevailing stagflation in Pakistan suggests that the acceleration of inflation is mainly caused by a cost push not by a demand pull (Khan & Ahmed, 2020). Stagflation is a distinctive economic phenomenon that combines sluggish growth, high unemployment, and accelerating inflation. It is a mix of the worst aspects of the economic disorder (Liu, 2023). The sky rising prices of energy resources, increasing indirect taxes, sharp devaluation of the currency, uncertain environment for investment, global oil price rise, and the worldwide supply chain disruption due to local and international calamities (COVID, Ukrin war, floods) are the possible reasons for cost push inflation (Survey, 2022-2023). Stabilization policies would be effective with adequate policy measures to control these adverse supply shocks (Hanif, 2012).

|  |  |
| --- | --- |
|  |  |
| **Figure 3. Unemployment Gap Based on Various Estimates of NAIRU** | **Figure 4. Actual and Predicted Values of Core Inflation** |

A comparison of estimated models shows that TMPC performs better than NKPC in capturing the inflation dynamics. This conclusion is based on the overall goodness of fit criteria, the coefficients’ significance and smaller standard errors, and the estimated NAIRU’s shorter precision. However, the difference in the performance of the two versions of the Phillips curve is not substantial in the perspective of Pakistan, a finding that is different from the evidence provided by the research on most of the developed countries (Gordon, 2011, 2013; Vogel, 2008). Figure 4 compares actual inflation and estimated inflation from NKPC and TMPC. It also depicts that TMPC predicts the inflation series better than NKPC.

## Conclusion and Recommendation

The main learning of the present study establishes empirical evidence that both variants of the Phillips curve NKPC and TMPC could significantly explain the subtleties of inflation in Pakistan’s economy. TMPC performs better than NPKC in analyzing inflation dynamics, demand gap, and supply shocks. The ARDL bound test confirms the presence of a long-run cointegration relationship and a short-term error correction mechanism between inflation, unemployment, and supply shock variables. According to the estimation results, short-run inflationary dynamics are managed by inertia, whereas long-run inflationary trends are determined by unemployment and supply shock variables. The import price index's significant long-term effect highlights the foreign sector's role in deciding the long-run inflation. A comparison of two versions of Phillips curve reveals that TMPC provides more precise estimates of the regression coefficients and NAIRU. The wider confidence intervals of NAIRU obtained from Delta and Fieller methods indicate its imprecise estimation. This imprecision might be attributed to the unobservable nature of NAIRU or the relatively small sample size. A positive unemployment gap in recent years implied by the estimated value of NAIRU and prevailing stagflation infers that the cost-push factor is dominant in determining the recent inflation acceleration.

Based on the inferences of the present research and the prevailing stagflation in Pakistan, it is recommended to formulate a stabilization policy with a combination of policies that can counter adverse supply shocks. Paul Krugman, a Keynesian economist suggests that besides trying to restrain the rising unemployment and accelerating inflation, governments must control the supply shocks (Heskin & Corsi, 2023). It is recommended to exercise inflation control policies cautiously, considering the estimated sacrifice ratio of 0.51 and 0.57 (Ball, 1994). The significance of the import price index in determining inflation suggests using appropriate commercial policy to control domestic inflation. The insignificance of the industrial productivity index calls for reforms in the industrial sector of Pakistan. The significant impact of the demand gap and supply shock on inflation recommend policies that can lessen the supply-demand disparities. Or else, inflation-restraining policies would be effective temporarily and lifting will lead to an inflationary surge (Labonte, 2022).

For future research, estimating the Phillips curve using better measures for handling probable endogeneity is recommended. It is suggested to develop an appropriate model for determining time-varying NAIRU. Identification of determinants of NAIRU is another critical area to be explored in the case of Pakistan. The unavailability of fine-grain data on both supply and demand indicators at the quarterly or monthly levels is a significant limitation to digging deeper into the inflation-unemployment tradeoff. It is recommended that the Pakistan Bureau of Statistics provide the data on all vital demand and supply variables at least quarterly.

**Author’s Contribution:**

Tahira Tauseef: PhD dissertation research part.

Amtul R. Chaudhary: supervised and reviewed the research process.

Tahira Tauheed: provided help in data handling and applying econometric techniques.

**Conflict of interest/ Disclosures:**

The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

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# Appendix



**Figure A.1 Line Graphs of Phillips Curve Variables’ Time Series**

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| --- | --- |
|  |  |
|  |  |
| **Figure A.2 Recursive Cusum plots for Estimated ARDL Models of Philips Curve** |

**Table A1**

**Diagnostic Analysis of Estimated ARDL Models of Philips Curve**

|  |  |  |  |
| --- | --- | --- | --- |
| **Hypothesis** | **Test** | **NKPC** | **Triangular Model** |
| **Test Statistics(Probability)** | **Test Statistics (Probability)** |
| Homoscedasticity | Breusch–Pagan test | 0.08(0.7712) | 1.18(0.2781) |
| White Test | 7.15(0.6219) | 20.45(0.4304) |
| No Serial correlation | Breusch–Godfrey LM test | 0.029(0.8642) | 0.741(0.3894) |
| Durbin's alternative test | 0.024(0.8767) | 0.564(0.4526) |
| Normality | Skewness and kurtosis tests | 2.19(0.3345) | 2.55(0.2793) |
| Shapiro–Wilk W test | 0.567(0.2854) | 0.173(0.4311) |
| No Structural Break, Parameter Stability | Cumulative sum test | 0.5353(0.8499)\* | 0.5061(1.2238)\* |
| No Structural Break | Supremum Wald | 1.1809(0.8240) | 1.1630(0.8299) |
| Average Wald | 0.3107(0.7303) | 0.3545(0.6873) |
| Exponential Wald | 0.1705(0.7370) | 0.1924(0.6993) |
| Supremum LR | 1.4020(0.7532) | 1.5261(0.7154) |
| Average LR | 0.3728(0.6706) | 0.4707(0.5909) |
| Exponential LR | 0.2081(0.6744) | 0.2620(0.5998) |

\*These are the critical values at 10 % level of significance.

1. For a detailed discussion of the inertial impact of implicit and explicit long-term price and wage contracts, see “I Discovered the Phillips Curve: “A Statistical Relation between Unemployment and Price Changes” by Fischer (1973). See “Aggregate and Individual Price Adjustment” by Blanchard, Gordon, and Sims (1987) for input-output supply chains’ impact on the sluggishness of inflation. [↑](#footnote-ref-1)