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Abstract:

The paper explores the existence and the stability of Phillips curve for North Cyprus, a small developing economy, using time series data. ADF unit root test is employed to check for stationarity. ARDL and DOLS approaches to cointegration have been used to explore the long run relation and ECM to understand short run dynamics. The predictive properties DOLS are better than those of the conventional methods. The estimates point to the existence of Phillips curve both in the long and the short run. CUSUM and CUSUMsq tests confirm a stable relation.

Key Words: Inflation, Unemployment, ADF, Cointegration, DOLS

JEL Classification: E31, E24, C22

I. Introduction

The observed inverse relationship between nominal wages changes and unemployment rates with the British data over the period 1861-1957, first discovered by Phillips (1958) has come to be known as the Phillips Curve. Since then, a sizeable theoretical and empirical literature have backed up a stable trade off between these series [Lipsey (1960), Phelps (1967), Leijonhufvud (1968), Samuelson and Solow (1970), Solow (1970) and Gordon (1971)]. The possibility of a trade off offers policymakers a tool to deal with macroeconomic disequilibrium. However, the failure to explain economic crises of the 1970s had cast serious doubts about the validity of the relation. In particular, Phelps (1967), Friedman (1968), Lucas (1976) and Okun (1975) argued against the hypothesis. A few papers lent support to a stable non linear relation [Onder (2004), Kustepeli (2005), Furuoka (2007), Tang and Lean (2007), Schreiber and Wolters (2007), Dammak and Boujelbene (2009)]. Others found an unstable relation between unemployment and inflation [Lucas (1972, 1973, 1976); Okun (1975); Turner (1997); Atkeson and Ohanian (2001); Niskanen (2002); Demers (2003) and Reichel (2004)]. These studies used cross sectional, time series and panel data sets.

The topic deserves closer scrutiny because macro models invoke fixed non-accelerating inflation rate of unemployment (NAIRU) as the long-run approach. All NAIRU models postulate a vertical long-run Phillips curve implying no trade off in the long-run. Persistently rising unemployment rate among European nations has rendered a fixed NAIRU unrealistic. However, the search for a relation using sophisticated econometric techniques with time-varying coefficients as in Gordon (1997) continued. The question of endogeneity from mutual dependence of the variables led to fresh attempts at reinventing the relation. Against the backdrops, researchers began to check for reverse causality.

Akerlof et al. (1996, 2000), Karanassou et al. (2005), and Holden (2004) discuss models in which long-run trade-off between output and inflation can exist if the inflation rates are low. Karanassou et al. (2003) provides support to a long-run inflation-unemployment trade-off for some EU countries; and Franz (2005) for German. Thus whether or not a long-run inflation-unemployment trade-off exists should be left to empirical tests using appropriate tools. This may help clarify some of the mysteries that underline the relationship between inflation and unemployment (Mankiw, 2001).

The objective of the paper is to explore the existence of Phillips curve and examine its nature and stability for north Cyprus. Much of the earlier literature on Phillips curve has examined the developed nations. The focus on the developing nations is relatively recent [see literature review]. In an increasingly globalized world, sound macroeconomic policy is considered critical for pursuing economic growth. This is more relevant for small open economies which are vulnerable to major shocks. From that perspective the choice of North Cyprus in this paper seems relevant. Figure 1 justifies further empirical exploration of a Phillips curve for North Cyprus. The authors are not aware of any study purporting to explore existence and stability of Phillips curve for North Cyprus. The research thus fills a gap in knowledge and thus contributes to the literature. In this paper we implement a variety of econometric tools to annual data from 1978–2007. To examine the long run relation between inflation and unemployment rates the paper applies the ARDL bounds testing approach to cointegration by Pesaran et al (2001). Given the size of the sample ARDL appears appropriate. Dynamic ordinary least squares (DOLS) and OLS have also been applied to explore the nature of the Phillips curve over time. The Error Correction Model (ECM) captures the short run dynamics. Stability of the Phillips curve has been checked by CUSUM and CUSUMsq recursive regression residuals based tests.

Figure 1 about here

The rest of study is organized as follows. Literature review is discussed in Section II. Section III describes data sources and the empirical framework. Findings are discussed in section IV. Conclusions and policy implication are drawn in Part V.

2. Literature Review

Although the Phillips relation was viewed simply as an empirical phenomenon, Lipsey (1960) was the first to offer a theoretical foundation. Lipsey's idea was subsequently extended which came to be known as the augmented Phillips curve wherein Lucas added an expected inflation component to the original specification. This model was tested using the rational expectations hypothesis. This work later spearheaded the formation of a group of economist under the banner of 'new classical economists'; and also opened up a debate over the shape of the 'aggregate supply curve for the economy'.

The possibility of a trade-off between inflation and unemployment was deemed important from policy perspectives and drew substantial academic interest. This culminated in the proliferation of a bourgeoning literature [see Santomero and Seater, 1979 for review of earlier research]. Solow (1970) and Gordon (1971) showed Philips relation for the US economy which is known as the "Solow-Gordon confirmation of the Phillips curve."

The Philips curve fell from grace of the academicians during the 1980's. Okun (1975) notes that in the US, since the 1970s Phillips curve has become "an unidentified flying object" (p. 353). The topic staged a comeback in the 1990's as sophisticated econometric tools became available. For example, Alogoskoufis and Smith (1991) found support to Lucas (1976). Using US post-war macroeconomic data, King and Watson (1994) did not find a relation[1]. Hogan, (1998) found low inflation rates with declining unemployment rate concomitant with a lower level of NAIRU. The resulting low inflation might have been from reduced import cost due to strong dollar which acted as a price shock.

DiNardo and Moore (1999) employed panel approach to OECD countries using OLS and GLS methods and found the Philips relation, which is also corroborated by Malinov and Somthers (1997), and Turner and Seghezza (1999). The later paper used Seemingly Unrelated Estimation (SURE) method. Eliasson (2001) specified linear Phillips curve for Sweden, Australia, and the United States and checked for parameters stability. They did not find the Phillips curve for Australia and Sweden, but found one for the US.

Niskanen (2002) points out that in its common form the Phillips curve is misspecified and that the long-run Phillips curve is positively sloped which may be due to lack of indexed

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[1] King and Watson (1994) conclude that Phillips curve will be in long-run and short-run if noises for both periods are removed from the series of data.

tax code. Batini et al. (2000, 2005) analysis indicates that not only structural changes but also labor markets and favorable supply shocks seem to affect inflation in the long run. In the short run, changes in unemployment rate explain variations in inflation for UK. Gali et al. (2001, 2005), and Rudd and Whelan (2005) used GMM approach but failed to find strong Phillips relation. Reichel (2004) applied cointegration method to the industrialized economies but found trade-off only for the US and Japan. Using quarterly data Dua and Gaur (2009) found a forward-looking Phillips (not backward looking) for Japan, Hong Kong, Korea, Singapore, Philippines, Thailand, China and India.

Lipsey (1960) found an inverse relation for Britain for 1914-18, but not after the War. Turner (1997) argues that structural break since the 1970s in Britain may have caused the instability of the Phillips curve. He emphasizes more on the stability, than its existence. Atkeson and Ohanian (2001) also support Turner. Hansen and Pancs (2001) found inverse relation between the series for Lativa. Bhanthumnavin (2002) finds the Phillips curve for Thailand, but only in the post 1997 Asian flu. Graham and Snower (2002) demonstrate a stable Phillips curve for Chile. They argue that the trade off in long run is due to inter-relation between money growth and rise in nominal wages. Furuoka (2007)[2] found relation between inflation and unemployment for Malaysia, which was later confirmed by Tang and Lean[3] (2007). The authors used Stock-Watson procedure. Schreiber and Wolters (2007) applied VAR cointegration approach and found a long run relation for German. Islam et al. (2003) revisit the US Philips relation using 1950-99 data but did not find a strong relation.

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[2] Uses unemployment gap as proxy of unemployment
[3] Uses consumer price index (CPI) for inflation

Furher (1995) notes that the Phillips relation has been robust and remained stable over the past 35 years. Demer, (2003) uses Markov-switching model to Canada but did not find a significant relation. Hart (2003) argues that Phillips curve has been vital in explaining economic theory and empirical results. He used British hourly wage rate as proxy for inflation. Scheibe and Vines 2005 found a trade off relation after reforms in China. They use quarterly data, adjusted for structural change and found a vertical long-run Phillips[4] curve. They recommend exchange rate liberalization in China. Ogbokor, (2005) finds stagflation in Namibia over the period of 1991–2005.

Cruz-Rodriguez (2008) found Phillips curve for Dominican Republic. However, the link with output gap is positive, which may be due to world oil prices and exchange rate. Whatever the effect, it was small. Del Boca et al. (2008) found Phillips curve for Italy for 1861-1998. The paper captures the effects of structural changes and asymmetries on the estimates of the trade-off relation. In Italy a trade-off exists only during low inflation and stable aggregate supply. Russell and Banerjee (2008) investigate vertical Phillips curve assuming non-stationarity in the series. They find positive relation between inflation and unemployment rate in short run for the United States.

Onder (2004) and Kustepeli (2005) find Phillips curve for Turkey. Subsequently, Onder (2009) used structural break and Markov-switching models to examine the nature of Phillips curve and finds a non-linear relation. The results point to absence of symmetry in the inflation response to output gap. Dammak and Boujelbene (2009) find linear tradeoff

[4] Output gap, the exchange rate, and inflation expectations play important roles in inflation

for Tanzania. Paul[5] (2009) argues that droughts, oil shocks and liberalization-policy of the early 1990s may be the reason for the absence of a Phillips curve in India. After adjusting for the shocks he finds the Phillips curve suggesting a short-run tradeoff between inflation and industrial output for India.

To complete the literature review, we bring in the latest strand in understanding the inflation and unemployment relation. One branch of the literature models inflation dynamics and estimates the unemployment rate as being compatible with inflation stability. However, the other branch determines the real economic factors that drive the natural rate of unemployment. Proponents of the new Keynesian Phillips (NPC) curve argue that frictional growth--the interplay between lags and growth--generates an inflation unemployment tradeoff in the long run. They propose a framework, e.g., the chain reaction theory (CRT) and argue that evolution of inflation and unemployment can be jointly determined. The CRT approach also provides a synthesis of the traditional structural macroeconometric models and the (structural) vector autoregressions.

There are two main types of dynamic macro models. First, the monetary macroeconomic models with its main focus on inflation dynamics. Second, the labor macroeconomic models which seek to explain the evolution of unemployment. The old school argues that inflation-unemployment dynamics is part of short run Phillips curve but in the long run they are unrelated, rationalized within the classical dichotomy, where monetary policy does not affect the real variables. This is consistent with the so-called natural rate of unemployment (NRU) hypothesis. The NPC invokes “the presence of nominal frictions

[5] Uses real GDP proxy for unemployment for India

and growing nominal variables (such as money, prices and wages), the real and monetary sides of the economy cannot be compartmentalized in the long run." Karanassou et al. (2010, p. 2). "(They) argue that the phenomena of long-run economic growth and business cycles cannot be compartmentalized either, as is done in the prevailing literature where growth and cycles are analysed independently of one another. The interplay between frictions (lagged adjustments) and growth we call *frictional growth*." (ibid, p. 2)

3. Data and Methodology

The paper uses annual inflation and unemployment data to explore a long run relation for the North Cyprus economy. The data covering 1978-2007 has been extracted from the Social and Economic Indicators (2007) of the Turkish Republic of North Cyprus.

Researchers have included variables such as real GDP and marginal cost of production in estimating Phillips curve. Gordon (1981) recommends using real gross national product for unemployment rate. Proxy variables have been used for both unemployment rate and inflation [Brouwer and Ericsson, 1998), Salman and Shukur, 2004]. Khalaf and Kichian (2005) use output gap or real output as proxy for unemployment rate. To measure inflation both CPI and PPI have been used. A limitation with the former is that it ignores the producer side. Overall inflation rate is a better measure for inflation rate[6] for an economy. All variables are transformed in logarithms.

[6] For variable and model specification, see Paul (2009), Alexis, (2008), Tang & Lean, (2007) Furuoka (2007), Ogbokor (2005), Liew, (2004), Whelan (1997) and Lütkepohl (1991)

Before implementing cointegration technique, Augmented Dickey Fuller (ADF) method is employed to test for stationarity of the series using Equation-1.

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{t=1}^{m} \Delta y_{t-1} + \varepsilon_t \qquad (1)$$

where, ε_t is a white noise process. Following the standard notations, we define: $\Delta y_t = (y_t - y_{t-1})$, $\Delta y_{t-1} = (y_{t-1} - y_{t-2})$, $\Delta y_{t-2} = (y_{t-2} - y_{t-3})$

In our search for a long run relation, we use cointegration approach. When variables are cointegrated, the long-run relations are estimated by cointegrating vectors focusing on the order of integration of each series. Johansen (1988a, 1991) derived distribution when the cointegrated system is parameterized as a vector error correction model (VECM). For a set of I(1) variables and a single cointegrating vector, Stock and Watson (1993) can be applied. In this we regress any of the variables on the remaining contemporaneous levels of the series and leads and lags of their first differences, and a constant. The method has come to be known as the "dynamic OLS" (or GLS, as the case may be). The resulting "dynamic OLS" (respectively GLS) estimators are asymptotically equivalent to the Johansen estimator. In finite sample, these estimators perform better, relative to other asymptotically efficient estimators, when simple short-run dynamics is involved.

The DOLS procedure requires partial knowledge of the series expected to cointegrate and the orders of integration. With DOLS the problems associated with simultaneity, endogeneity and serial correlation are resolved by including leads and lags in small sample. The DOLS procedure is helpful if the series has different orders of lags (Stock-Watson, 1993). In the case of normal distribution the estimators have desirable properties as compared to Phillips and Perron (1988), Phillips and Loretan (1991) and Phillips and Moon (1999, 2001). In particular, the Engle–Granger's approach may not be satisfactory if in a multivariate case more than one cointegrating vector is present (Seddighi et al. 2000). Engle-Granger estimator suffers from a non-standard asymptotic distribution. Inferences on the parameters of the cointegrating vectors using DOLS estimator are efficient. Monte Carlo studies by Agrawal (2001) favor DOLS in estimating the long run relation. Predictive properties DOLS are better than the standard Engle-Granger (1987), Johansen (1988, 1991); Johansen-Juselius (1990) and Phillips & Hansen (1990) procedures. As such we also apply the DOLS using the following model.

$$LINF = \gamma_1 + \gamma_2 LUNP + \sum_{i=\pm p}^{k} \gamma_3 \Delta LINF_{t-i} + \sum_{j=\pm p}^{k} \gamma_4 \Delta Lunp_{t-j} + \varepsilon_t \qquad (1)$$

In Equation-4, γ_1 refers to a constant and γ_2 to the long run parameter. The number of lags is denoted by *p; k* refers to lag length of the leads terms. The ε refers to the error term. The selection of lags and leads is based on AIC.

In traditional approaches to cointegration, structural break in time series can be checked by Chow test. In ARDL, the CUSUM and CUSUMsq tests provide diagnosis for such information. For example, in Fig I and II, if the blue lines cross the red lines then structural break is likely. Based on the results obtained of this study, such outcome is unlikely. Also ARDL bounds test approach applies notwithstanding ambiguity in the order of integration[7]. This issue is relevant because in the presence of structural break in the data generating process, the traditional approaches may not capture cointegrating

[7] The ARDL approach for cointegration has information about structural break in time series data as it's a nature of developing economies (Wahid and Shahbaz, 2009 and Shahbaz, 2009)

relation. This can potentially affect the outcome of the unit root test and the predictive powers (Leybourne and Newbold 2003; Perron, 1989, 1997)[8]. The ARDL approach is implemented by the following unrestricted error correction method (UECM) form (See Pesaran et al. 2001, page-292)

$$\Delta LINF = \alpha_1 + \alpha_2 t + [\alpha_3 LUNP_{t-1} + \alpha_4 LINF_{t-1}] + \left[\sum_{i=0}^{p} \lambda_1 \Delta LUNP_{t-i} + \sum_{i=1}^{p} \lambda_2 \Delta LINF_{t-i} \right] + \eta_t \quad (3)$$

In Equation-3, α_3 and α_4, the long run parameters show partial impact on the dependent variable. The λ_1, λ_2 refer to the short run parameters, α_1, α_2 and refer to intercept and the coefficient of time trend respectively, and η is the error term. The null hypothesis of no cointegration is $H_\circ : \alpha_3 = \alpha_4 = 0$ against the alternate $H_a : \alpha_3 \neq \alpha_4 \neq 0$. The restrictions on UECM identify the long run relation, if any, between the series. The F-statistic tests for joint significance for cointegration. The lower or upper bounds in small sample is not provided in Pesaran et al. (2001), but are available in Narayan (2005).

The ARDL model calculates $(p+1)^k$ number of regressions based an appropriate number of lags. The *p* indicates the number of lags in ARDL bounds testing and *k* is the number of actors in the model. In selecting lags, the minimum of AIC and SBC is used. The model has been subjected to sensitivity analysis to tests for serial correlation, functional form, normality, White heteroscedisticity, model specification and ARCH. CUSUM and CUSUMsq check for the stability of long and short run parameters.

4. Discussion of the Findings

[8] Structural changes can happened for several reasons e.g., IMF mandated conditionalities and structural reforms as a result of economic crises, political instability, policy regime shifts, war etc.

The Table-1 presents the descriptive statistics and pair wise correlation between inflation and unemployment. The reported correlation is negative for North Cyprus.

Table-1 about here

We treat inflation and unemployment as potentially I(1); and test for non-stationarity. Noting that the boundedness of the unemployment rate series cannot remain I(1) forever, we recognize that use of samples in the future may produce different test results. The same is also true for the inflation rate to some degree.

Pesaran et al (2001) critical bounds test assume that variables are stationary, *I(0)* or *I(1)*; and that none is integrated of order *I(2)* or higher. Formally, we apply the Augmented Dickey-Fuller (ADF) test to check for the order of integration. Results reported in Table-2 suggest that both the series are I(1). We choose 2 lags based on AIC and SBC. Given the sample size, we note that the ARDL F-statistics is very sensitive to the lag. An intercept and time trend are included following Pesaran et al., (2001).

Table-2 about here

Table-3 about here

The lag length is numbered on the first differences in the 'conditional error correction' version of the ARDL model. The unrestricted vector auto-regression (UVAR) is used to choose the maximum number of lags through Akaike information criteria (AIC). With a selected lag length of 2 as noted earlier, the number of estimated regressions in the ARDL model in Equation-3 is $(2+1)^2 = 9$. The ARDL F-statistics are reported in Table-4. The calculated F-statistics 4.329 exceeds the upper bounds at the 10 percent level when the unemployment is the forcing variable. The same is also true when the inflation is the forcing variable. The result suggests that the series are cointegrated, which confirms a long run relation between the series.

Table-4 about here

4.1 Long Run Estimates from OLS, Dynamic OLS (DOLS)

The OLS estimate of (-0.7489) for the coefficient of unemployment is significant at the 1 percent level. This indicates that a trade off exists for North Cyprus. A 1 percent increase in unemployment rate leads to an expected 0.75 percent decrease in inflation.

$$LINF = 4.2840 - 0.7489 LUNP$$

(27.1608)* (-4.9050)*

R-squared = 0.4621 R-squared Adj = 0.4429

F-statistics = 24.0591 Durban Watson = 1.6191

The impact of lead and lag differenced terms of unemployment affect inflation rate inversely at the 1 percent level. Inflation is influenced positively and negatively by lead and lagged differenced terms of inflation series. The impact of lead term is positive but insignificant. Inflation is inversely linked to its lagged term and significant at the 10 percent level.

$$LINF = 4.2605 - 0.7467LUNP - 0.5416\Delta LUNP_{t+1} - 0.5770\Delta LUNP_{t-1} + 0.1675\Delta LINF_{t+1} - 0.1375\Delta LINF_{t-1}$$

(44.3742)* (-5.3889)* (-2.9928)* (-5.1757)* (1.1670) (-1.9406)***

R-squared = 0.8383 R-squared Adj = 0.7999

F-statistics = 21.7873 Durban Watson = 1.5869

[The notations *, ** and *** refer to significance at 1%, 5% and 10% level respectively.]

4.2 Short Run Regression

We examine the short run impact of unemployment rate on inflation. The term **(ecm_{t-1})** tells us about the short run adjustment to the long run equilibrium. A significant negative value (**ecm_{t-1}** < 0) confirms the existence of a long run relationship.

$$\Delta LINF = -0.0257 - 0.3823\Delta LUNP - 0.6904ecm_{t-1}$$

(-0.1981) (-2.5153) ** (-2.9132)*

R-squared = 0.2786 R-squared Adj = 0.2231

F-statistics = 5.0221 Durban Watson = 1.8764

The coefficient of unemployment suggests that 1 percent increase in this variable reduces the inflation by 0.3823 percent on an average, confirming trade off in the short run. The coefficient of ECM[9] is negative and significant at the 1 percent level, also confirms a long run relation. This result also suggests convergence to the long run from the short run

[9] The coefficient of **ecm** is -0.6904 appears high for an annual inflation.

deviations. The coefficient, although high, suggests that the adjustment from the short run to long run in inflation is corrected to the tune of 69.04 % for each year. The sensitivity tests reported in Table 2 suggest the absence of modeling problem in the short run.

4.3 Stability Tests

Following the suggestion of Pesaran et al. (2001), cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) tests are performed to examine the stability of the long-run and short run parameters. If the plots of the statistics for both tests lie within the critical bounds set for the 5 percent level, the hypothesis, "the regression equation is correctly specified" is not rejected (Bahmani-Oskooee and Nasir, 2004, p. 485)

Figure-1 about here

Figure-2 about here

Out results indicate that the plots of both CUSUM and CUSUMsq (Figure 1 and 2) lie within the 5% critical bounds suggesting the model is stable and correctly specified.

5. Conclusions and Policy Implications

The paper estimates a Philips Curve for North Cyprus using ARDL bounds testing and DOLS approaches. ADF unit root test is applied to check the order of integration. Results establish cointegration between unemployment and inflation for North Cyprus suggesting a long run relationship over the study period. The results from OLS and DOLS confirm the tradeoff between the macroeconomic variables. The implication is that the policy makers can use the tradeoff relation in choosing appropriate strategy. The CUSUM and CUSUMsq tests suggest stability of the parameters.

The finding that Phillips curve exists for Cyprus and is stable opens opportunities for the central bank to determine how best to stabilize the price level by controlling inflation and at the same time living within an unemployment rate consistent with inflation, given that both are undesirable outcomes. Central bank should be careful in adopting a monetary policy that would keep inflation at a politically acceptable level. However, the stability of Phillips curve is one side of the coin. On the other side, lies the tough choice that must be made: Determine the sacrifice ratio for a given Phillips relation for the North Cypriots. In terms of economic theory, the ratio must be consistent with the social welfare function. As noted earlier, the time series properties may change over time as shocks tend to alter behavior of economic agents. This implies that the findings hold for the period of study. In the future, policy regime changes need to be based on further studies and other economies bearing similar characteristics to arrive at an acceptable basis for policy.

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Figure 1

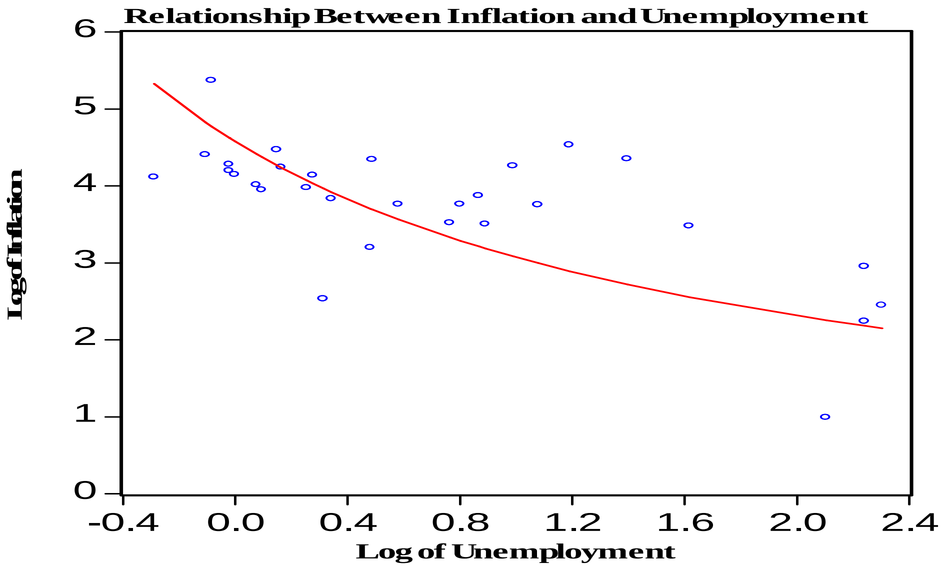

Relationship Between Inflation and Unemployment
Log of Inflation
Log of Unemployment
6
5
4
3
2
1
0
-0.4
0.0
0.4
0.8
1.2
1.6
2.0
2.4

Table-1: Descriptive Statistics and Correlation Matrix

Variables	Mean	Median	Max	Min	St.Dev	Skewness	LINF	LUNP
LINF	3.7547	3.9607	5.3706	0.9932	0.8442	-1.3336	1.0000	-0.6798
LUNP	0.7066	0.4855	2.3025	-0.2876	0.7662	0.8613	-0.6798	1.0000

Table-2: Unit Root Test

Variables	ADF Test at Level		
	T. calculated	Prob. Value	Lag
LINF	-1.5212	0.7977	1
LUNP	-0.4795	0.9785	1
ADF at 1st Difference			
ΔLINF	-4.2252	0.0129	1
ΔLUNP	-4.7519	0.0039	1

Short run Diagnostic Tests

Serial Correlation LM Test = 1.5764 (0.2273)

ARCH Test = 0.7484 (0.3948)

Heteroscedisticity Test = 0.5363 (0.7103)

Jarque-Bera Test = 1.2680 (0.5304)

Ramsey Test = 0.9710 (0.3338)

Table-3: Lag Length Criteria

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-50.9392	NA	0.2012	4.0722	4.1690	4.1001
1	-29.3242	38.2419	0.0520	2.7172	3.0075	2.8008
2	-22.4278	11.14045*	0.0419*	2.4944*	2.9783*	2.6337*
3	-20.6647	2.5767	0.0506	2.6665	3.3439	2.8615
4	-19.7199	1.2355	0.0662	2.9015	3.7725	3.1523

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

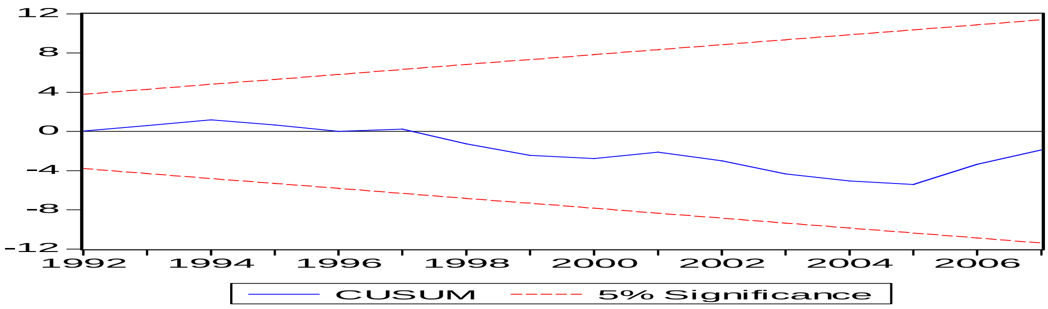
Table-4: Cointegration Test: Bounds test

Model for Estimation	*F*-Statistics		Lag
$F_{LINF}(LINF/\mathit{LUNP})$	*4.329****		2
$F_{LUNP}(LUNP/\mathit{LINF})$	*5.654***		2
Critical Bounds	Lower bound	Upper bound	
1%	4.428	5.898[a]	
%5	3.368	4.590	
10%	2.893	4.008	

Note: [a] The critical values are from Narayan (2005) p.1990. The lag selection is based on AIC and SBC.

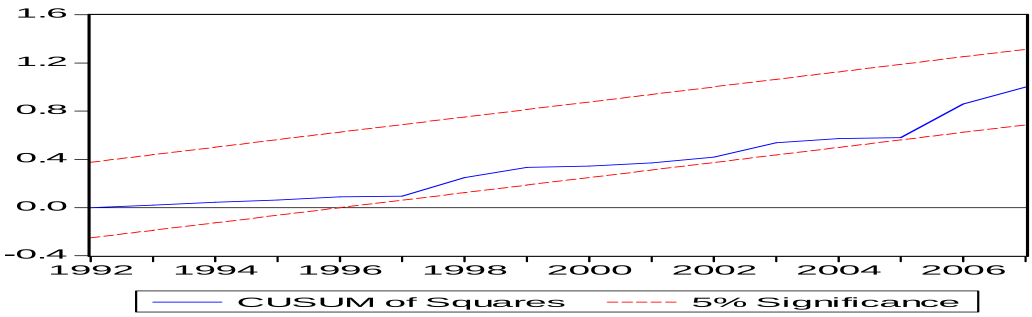
** and *** denotes the significant level at 0.05 and 0.10, respectively.

Figure-1: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

Figure-2: Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.