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# **Unemployment and Inflation: Evidence of a Nonlinear Phillips Curve in the Eurozone**

Ho, Sin-Yu and Njindan Iyke, Bernard

University of South Africa, Deakin University

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# Unemployment and Inflation: Evidence of a Nonlinear Phillips Curve in the Eurozone

## Abstract

The classical Phillips curve shows a negative relationship between inflation and unemployment. However, various studies have documented temporal positive and negative relationships between inflation and unemployment, leading to strong criticisms against the Phillips curve. In particular, the triangle approach indicates that the nature of the inflation-unemployment nexus is contingent on the source of the shocks, the length of lagged responses, and the policy response. Similarly, the strong linearity assumption on which the Phillips curve rests may have led to its empirical failure. Prior studies have modelled the possibility of threshold effects in the Phillips curve but no study has established the thresholds of when the relationship switches from negative to positive in the eurozone. This paper addresses this limitation using 11 eurozone countries for the period of January 1999 to February 2017. The paper also estimates both short- and long-run Phillips curves for these countries. We found that, by assuming linearity, there exists a Phillips curve in the short and the long run. We also established that the linearity assumption in the classical Phillips curve might be too strong since there is evidence of threshold effects. The thresholds in unemployment were 5.00% and 6.54%. By estimating the Phillips curve using these thresholds, we found that the relationship between inflation and unemployment is only negative when unemployment is lower than 5.00%. The negative relationship turned positive when unemployment was between 5.00% and 6.54%. Inflation and unemployment are unrelated once a threshold of a 6.54% unemployment rate is surpassed. These findings do not only highlight the importance of threshold effects in the Phillips curve, they also shed light on the need to fight unemployment in the eurozone.

**Keywords:** Inflation; Unemployment; Nonlinearity; Phillips Curve; Eurozone.

**JEL Codes:** E24; E31.

## 1. Introduction

Unemployment remains one of the most pressing challenges facing humanity and as a result has been one of the main foci of economic policies around the world. Over time, researchers have developed various frameworks explaining the evolution of unemployment and the factors that drive it (Davis, 1998; Kreckemeier and Nelson, 2006; Helpman et al., 2010). In their study, Smith and Zoega (2007) observed that long swings (decade-to-decade changes) in unemployment tend to dominate shorter business cycles, and that two principal components appear to account for a large part of the variance of unemployment between and within countries. The first captures the oil price shocks of the early 1990s and the second the transient elevations of unemployment coupled with the performance of the US economy in the mid- and late 1970s.

One of the consequences of business cycles is the variation in unemployment rates. This variable tends to shrink during expansion phases, while reversing in periods of recession. The latter behaviour leads to more poverty and inequality. Eurozone member countries have experienced a persistent rise in unemployment, particularly with regard to youth unemployment in recent times which is largely attributed to the protracted crisis in the euro area. For example, in 2013, unemployment was at 12.2% for the whole euro area, peaking around 26.6% and 27% in Spain and Greece respectively (Canale and Liotti, 2015).<sup>1</sup> And as shown in recent studies (Canale and Liotti, 2015), the rising unemployment rates in these countries could persist. In fact, Guerrieri (2013) reported that a quarter of young Europeans had no job and faced daunting prospects in 2013. This situation may have worsened in 2017. Guerrieri (2013) found that although the gap in unemployment between the relatively richer North and the struggling South is persistent, it has consolidated slightly. Figure 1 shows the trends in the eurozone and world unemployment rates. It is evident that the unemployment rate is higher on average in the eurozone than the world average. Although the variable has risen after 2008, both at the world and eurozone level, the rise has been faster in the latter countries.

In the wake of this worsening situation, it is imperative that powerful policy institutions continue to relentlessly find measures to fight unemployment. Failure to find robust solutions may pose a danger to the already struggling European Union. A growing number of studies have also identified the causes and provided recommendations for arresting unemployment in the eurozone (Nickell, 2006; Andersson et al., 2015; Canale and Liotti, 2015; De Grauwe, 2016; Verdugo, 2016). In this paper, we will not attempt to identify the sources of or solutions to unemployment in the eurozone. Instead, we will re-examine an old inconclusive debate – the relationship between unemployment and inflation. This relationship was first established by Phillips (1958) who found a stable negative relationship between inflation and unemployment in the UK. This relationship has been coined the Phillips curve. The evidence of a Phillips curve was later documented by Samuelson and Solow (1960) for the US.

However, the simultaneous existence of high inflation and high unemployment in the 1970s in the US and other economies raised questions regarding the stability of the Phillips curve. In their lecture, Lucas and Sargent (1979) noted that the failure of the Phillips curve extends to economics in general. King et al. (1995) documented the instability of the Phillips curve for the US in their study. They noted that “a single correlation coefficient will do a poor job summarizing the relationship between the two series” (King et al., 1995 p. 3). In fact, they found that during normal periods, the relationship between inflation and unemployment appeared to be positive, while it is negative during business cycles. In other words, the Phillips curve is a business cycle phenomenon. This revelation suggests that there is a threshold in the relationship between inflation and unemployment. Our aim in this paper is to establish whether such a threshold exists in countries in the eurozone. So far, not much has been done to estimate a potential threshold in the relationship between unemployment and inflation. Examples of studies focusing on this issue are Eliasson et al. (2001), Enders and Hurn (2002), Önder (2009), and Correa and Minella (2010). We are not aware of any studies estimating a threshold relationship between inflation and unemployment in the eurozone. Musso et al. (2009) came closer to this objective but they focused on the time-varying mean of inflation. We will add to

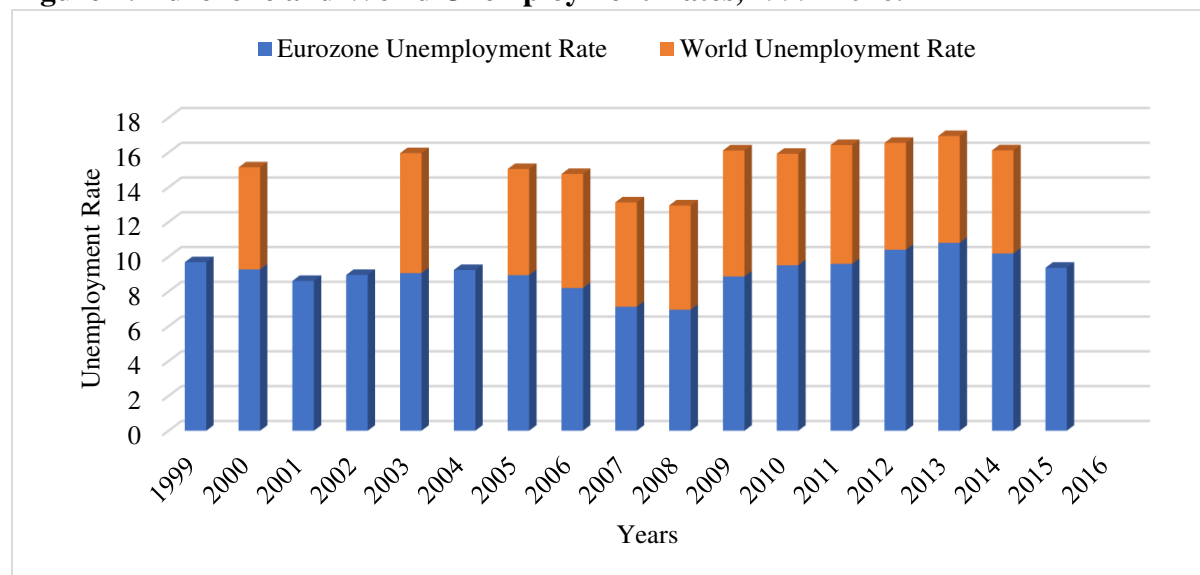
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<sup>1</sup> These figures can be found at [http://ec.europa.eu/economy\\_finance/ameco/user](http://ec.europa.eu/economy_finance/ameco/user).

the literature by explicitly estimating a threshold in the Phillips curve for these countries. Apart from this, we will also estimate the curve in the short and the long run.<sup>2</sup>

The remainder of the paper is organised as follows. The next section reviews the literature. Section 3 presents the methodology and data. Section 4 presents the results and the findings. Section 5 concludes the paper.

**Figure 1: Eurozone and World Unemployment Rates, 1999–2016.**



**Source:** World Development Indicators (WDI) available at:

<http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

**Notes:** Observations on world unemployment rates are not available for 1999, 2001, 2002, 2004, and 2016. Observations on eurozone unemployment rate are not available for 2016. Unemployment is the share of the labour force that is without work but available for and seeking employment, according to the data source. Definitions of labour force and unemployment differ by country.

## 2. Review of the Relevant Literature

The relationship between unemployment and inflation was first documented by Phillips (1958) who found a negative and stable relationship between unemployment and wage inflation in the UK during 1861–1957. Similar relationship was found in the US by Samuelson and Solow (1960). However, the hypothesis of a stable inflation-unemployment trade-off was challenged by both theoretical and empirical sides. Theoretically, Friedman (1968) and Phelps (1968) contended that it is unreasonable to assume that nominal variables have permanent effect on real variables. In particular, they argued that no policy can permanently lower unemployment below its natural rate. Empirically, the coexistence of high inflation and high unemployment during 1970s in some economies due to the oil-price shocks cast doubt on the stability of the Phillips curve.

<sup>2</sup> Note that we are mainly concerned with the classical Phillips curve. We will thus not consider other variables, apart from inflation and unemployment. There are studies focusing on the extension of the Phillips curve – the New Keynesian Phillips curve. See for example McAdam and Willman (2004), Rumler (2007), and Fanelli (2008). The interested reader may look at these studies.

The instability of the Phillips curve could be due to the business cycle or the structural change of inflation dynamics in the forms of the mean, persistence and volatility of inflation (see King et al., 1995; Musso et al., 2009). King et al. (1995), for example, found the instability of the Phillips curve in the US to be the consequence of business cycles. They noted that the relationship between inflation and unemployment is positive during normal periods, but negative during business cycles. In the eurozone, Corvoisier and Mojon (2005) identified three breaks (i.e. 1972, 1985 and 1993) for inflation rate. In addition, Angeloni et al. (2006), when controlling for breaks in the mean of inflation, showed evidence of a permanent decline in the persistence of inflation after mid-1990s.

In addition to the instability in the Phillips curve relationship, other studies investigated the nonlinearity of the relationship based on micro-founded theories. The capacity constraint model, by assuming rising marginal costs and fixed production capacity in the short run, showed that it was costly for a firm to increase output and hence employment in the times of excess demand. As a result, the Phillips curve is convex in shape (see Dupasquier and Ricketts, 1998; Yates, 1998). The costly adjustment model suggested by Ball et al. (1988) also showed that the Phillips curve is convex in the short run. They argued that the presence of menu costs and the wage contracts between firms and workers made it costly for firms to change prices in response to a demand shock. However, as the level of inflation increased, firms are more willing to change prices, thereby becoming more responsive to demand shocks. Hence, the relationship between output and inflation varied with the level of inflation. Apart from the convexity, the nonlinearity of the Phillips curves could be due to the asymmetries in price adjustment. The downward nominal wage rigidity model illustrated that workers are more reluctant to accept a decrease in their nominal wages than a decrease in their real wages due to money illusion (Stiglitz, 1984; Fisher, 1989). This implied that excess demand would have a significant effect on inflation than excess supply, thereby resulting in asymmetries with respect to the output gap. Similarly, based on the downward nominal wage rigidity assumption, Palley (2003) presented a theory of backward-bending Phillips curve, which explained that there is a trade-off between inflation and unemployment when the level of inflation is low. However, the relationship reversed when the level of inflation is too high. Apart from the microfoundation based models, Ferri et al. (2000), using a regime-switching model, found nonlinearities in the Phillips curve based on the concept of non-accelerating inflation rate of unemployment (NAIRU).

In sum, the extant studies suggest that the relationship between inflation and unemployment may be unstable and non-linear. In spite of this, there are limited studies estimating the nonlinearities or thresholds in the relationship between unemployment and inflation. Some of the few studies focusing on this issue are Eliasson et al. (2001), Enders and Hurn (2002), Önder (2009), and Correa and Minella (2010). Eliasson et al. (2001) tested the linearity of the Phillips curves for Australia, Sweden and the US using a smooth transition regression model. They found evidence of non-linearities in Australia and Sweden. Enders and Hurn (2002) examined the Phillips curve in Australia using a threshold autoregressive specification and found significant asymmetries. Önder (2009), using Markow-switching models, found evidence of nonlinearities in the Turkish Phillips curve. Correa and Minella (2010) examined the existence of nonlinearities in the Phillips curve and the role of exchange rate pass-through to inflation. They found evidence of nonlinear mechanism in the short-run pass-through. None of these studies attempted estimating a threshold relationship between inflation and unemployment in the eurozone. Musso et al. (2009) came closer to this objective but they focused on the time-

varying mean of inflation. They found that there is no significant evidence of non-linearity between time-varying mean of inflation and the output gap in the eurozone. We contribute to the literature by estimating the thresholds in the Phillips curve for countries in the eurozone. We also estimate the Phillips curve in the short and the long run.

### 3. Methodology and Data

#### 3.1. Theoretic Model

Theoretically, the Phillips curve suggests a stable negative relationship between inflation and unemployment. Early evidence of the Phillips curve was documented by Phillips (1958) for the UK and later by Samuelson and Solow (1960) for the US. Formally, the standard Phillips curve can be stated as follows:

$$\pi_t = \pi_t^e + \gamma(\mu_t - \bar{\mu}_t) \quad (1)$$

where  $\pi_t^e$  and  $\bar{\mu}_t$  refer to inflationary expectations and the natural rate of unemployment, respectively. In empirical applications, the treatment of inflationary expectations and the natural rate of unemployment are always problematic since these are not observed. Moreover, there is potential reverse causal flow between inflation and unemployment since the two are likely jointly determined (Fuhrer and Moore, 1995; Crosby and Olekalns, 1998; O'Reilly and Whelan, 2005; Cogley and Sbordone, 2008). The rational and adaptive expectation hypotheses imply inflation persistence. Similarly, in line with the hysteresis in unemployment documented in the literature (Blanchard and Summers, 1987; Jaeger and Parkinson, 1994; Camarero and Tamarit, 2004; Camarero et al., 2006; Chang, 2011), equilibrium unemployment tends to depend on historical rates of actual unemployment. Hence, a suitable reformulation of Eq. (1) into a model with lags and first-differences could overcome these issues (King et al., 1995; Crosby and Olekalns, 1998). A typical formulation is examined in the next section.

#### 3.2. Empirical Specification

##### 3.2.1. Distributed Lag Model to Estimate Short- and Long-Run Phillips Curve

In order to estimate the Phillips curve for the eurozone, we reformulated Eq. (1) into a distributed lag model as follows:

$$\Delta\pi_{it} = \phi_i(\pi_{it-1} - \theta_i'\mu_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta\pi_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}' \Delta\mu_{it-j} + \tau_i + \varepsilon_{it}. \quad (2)$$

Eq. (2) is a suitable reparameterization of a distributed lag model of the form:

$$\pi_{it} = \sum_{j=1}^p \lambda_{ij} \Delta\pi_{it-j} + \sum_{j=0}^q \delta_{ij}' \mu_{it-j} + \tau_i + \varepsilon_{it} \quad (3)$$

$\tau$  and  $\varepsilon$  are the individual fixed effects and the *iid* error term respectively;  $\lambda_{ij}$  and  $\delta_{ij}$  are the scalars and coefficient vectors respectively. Similarly,  $\phi_i = -(1 - \sum_{j=1}^p \lambda_{ij})$ ;  $\theta_i = \sum_{j=0}^q \delta_{ij} /$

$(1 - \sum_k \lambda_{ik})$ ;  $\lambda_{ij}^* = -\sum_{m=j+1}^p \lambda_{im}$ ,  $j = 1, 2, \dots, p - 1$ ;  $\delta_{ij}^* = -\sum_{m=j+1}^q \delta_{im}$ ,  $j = 1, 2, \dots, q - 1$ .  $\phi_i$  is the error-correction term; this represents the speed at which the variables revert to equilibrium after drifting apart in the short run. Hence, the variables are cointegrated if the estimated value of  $\phi_i$  is negative and statistically significant. Finally,  $\theta_i'$  is the cointegrating vector, indicating the number of cointegration relationships in the model.

The importance of formulating the Phillips curve this way can be found in the fact that we are able to model various theoretical issues. Firstly, we can model the persistence and the adjustment to equilibrium paths of inflation and unemployment. Secondly, we can capture the contemporaneous feedback causal flow from unemployment to inflation. Lastly, we can model cross-sectional heterogeneities in the consumption-uncertainty nexus by allowing the parameters in Eq. (2) to vary.

Three commonly used estimators to estimate Eq. (2) are the mean group (MG), dynamic fixed-effects (DFE), and pooled mean group (PMG) estimators. In this paper, we utilise the PMG estimator because it is flexible and performs better than both the MG and DFE estimators (Pesaran et al., 1999). Specifically, if the slope coefficients in Eq. (2) are heterogeneous, the DFE estimator yields inconsistent results. Similarly, the MG estimator also yields inconsistent results if the long-run coefficients are homogeneous. The PMG estimator is able to overcome these issues. Its unique feature is that it permits us to model the potential common cross-sectional long-run relationship between inflation and unemployment, while capturing the potential short-run heterogeneous adjustments of the markets to equilibrium across countries (Ho and Iyke, 2017).

### 3.2.2. Panel Threshold Model to Examine Threshold Effects in the Phillips Curve

The finding that the relationship between inflation and unemployment appears to be positive in normal times and negative during business cycles (King et al., 1995) suggests that there may be threshold effects in the Phillips curve. Beyond estimating the relationship between inflation and unemployment for the eurozone, we also attempted to examine this possibility of threshold effects. To do this we employed the fixed effects threshold regression proposed by Hansen (1999). For simplicity, we present a one-threshold parameter or two-regime model as follows:

$$\pi_{it} = \tau_i + \beta_1' \mu_{it} I(q_{it} \leq \gamma) + \beta_2' \mu_{it} I(q_{it} > \gamma) + \varepsilon_{it} \quad (4a)$$

where  $I(\cdot)$  is the indicator function. Alternatively, Eq. (4a) can be written as:

$$\pi_{it} = \begin{cases} \tau_i + \beta_1' \mu_{it} + e_{it}, & q_{it} \leq \gamma \\ \tau_i + \beta_2' \mu_{it} + e_{it}, & q_{it} > \gamma \end{cases} \quad (4b)$$

$\tau$  and  $\varepsilon$  are the individual fixed-effects and the *iid* error term, respectively;  $\beta_1'$  and  $\beta_2'$  are parameters in regime one and two.  $q_{it}$  is the threshold variable. The unemployment rate is countercyclical, i.e. unemployment shrinks during expansion phases, while reversing in periods of recession. Hence, unemployment can be utilised as a leading indicator of business cycles or a threshold variable.

Hansen (1999) has shown how to test the presence of threshold effects, estimate the threshold parameter  $\gamma$  and estimate Eqs. (4a) and (4b). Various studies have applied these techniques (Henry et al., 2004; Bick, 2010; Law et al., 2013). We will therefore not discuss them in this

paper. Since our focus is to establish a potential threshold or turning point in unemployment for which the Phillips curve may or may not exist, we used the actual observations on these variables instead of their first differences (King et al., 1995).

### 3.3. Data

In order to have a longer time span, only countries which met the eurozone convergence criteria in 1999 are included in our sample. These countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The sample spans the period of January 1999 to February 2017. Inflation ( $\pi$ ) is the percentage change in the consumer price index (CPI)<sup>3</sup> and unemployment ( $\mu$ ) is the unemployment rate in these countries. The data are obtained from the International Financial Statistics (IFS) database compiled by IMF. Table 1 shows the summary statistics of these variables.

**Table 1: Descriptive Statistics**

Statistics	$\pi$	$\mu$
Mean	1.8627	8.1749
Median	1.8059	7.6000
Maximum	28.3489	27.1000
Minimum	-29.8627	1.7000
Standard Deviation	5.5807	4.0420
Skewness	0.0053	1.8168
Kurtosis	6.1467	7.6611
Jarque-Bera	989.3818	3490.010
Probability	0.0000	0.0000
Sum	4466.679	19603.35
Sum Squared Deviation	74651.70	39161.69
Observations	2398	2398

## 4. Empirical Results

### 4.1. Short- and Long-run Phillips Curves in the Eurozone

We begin our analysis by first estimating the short- and long-run Phillips curves for the eurozone countries. The dynamic distributed lag approach utilised in this paper does not require pre-testing the variables for unit roots (Pesaran et al., 1999). Therefore, we did not test for unit roots in unemployment and inflation. Besides, since estimating the threshold in the Phillips curve is our main concern, we will not consider differencing the variables. As inflationary expectations and the natural rate of unemployment are difficult to model, the dynamic distributed lag approach was used to overcome this problem.<sup>4</sup> This approach also models the potential reverse causal flow between inflation and unemployment.

<sup>3</sup> This is calculated as annualised inflation =  $1200 * \ln(CPI_t / CPI_{t-1})$  following King et al. (1995).

<sup>4</sup> See Crosby and Olekalns, 1998 for a similar treatment.



The short- and long-run estimates are shown in Table 2. The error-correction term is negative, significant and lies within a unit circle, indicating that the inflation-unemployment model is stable in the eurozone. Economically, this shows that inflation and unemployment tend to move closer to one another in the long run if they drift apart in the short run. Looking at the coefficients of the lagged first difference terms of inflation, it is evident that past rates of inflation tend to determine the current rate. In other words, inflation is highly persistent in the eurozone. This finding is generally consistent with the inflation persistence literature (Fuhrer and Moore, 1995; Erceg and Levin, 2003; O'Reilly and Whelan, 2005; Altissimo et al., 2006; Batini, 2006; Benati, 2008; Cogley and Sbordone, 2008). Specifically, since we found that lags of up to 12 influence the current rate of inflation, our finding corroborates Batini's findings (2006) and who found that "it takes over a year before monetary policy actions have their maximum effect on inflation both in the euro area and in individual countries and that a lag of this length has existed in Europe at least since the collapse of the Bretton Woods system, despite the numerous changes in European monetary policy regime thereafter" (p. 977). The degree of persistence may vary at the country level as found by Batini (2006). However, we will not delve further into this.

Now, considering the coefficient of unemployment both in the short and the long run, it is clear that there exists a negative and statistically significant relationship between the variable and unemployment. In particular, the estimated coefficient in the short and long run are, respectively, -1.4198 and -0.2436. This suggest that the Phillips curve is supported both in the short and the long run. This finding is in line with studies documenting support for the Phillips curve in the eurozone (McAdam and Willman, 2004; Rumler, 2007; Fanelli, 2008; Musso et al., 2009). The pitfall of these dynamic estimates of the Phillips curve is that they rely on the assumption that threshold effects are non-existent. What if there is a turning point of unemployment for which the negative inflation-unemployment nexus vanishes? The empirical failure of the Phillips curve has been widely documented. For example, King et al. (1995) have documented instability of the Phillips curve for the US. They observed that during normal periods, the relationship between inflation and unemployment appeared to be positive, while it is negative during business cycles. Hence, one cannot completely rule out the possibility of threshold effects in the eurozone Phillips curve. The main thrust of this paper is on examining this possibility. This is done in the next section.

**Table 2: Pooled Mean Estimates (PMG) of the Phillips Curve.**

Dependent variable: $\pi$	Coefficient	Std. Error	t-Statistic	P-value
	<b>Long-Run Equation</b>			
$\mu$	-0.2436	0.0640	-3.8059	0.0001
	<b>Short-Run Equation</b>			
e <sub>c</sub> m(-1)	-0.5482	0.0587	-9.3347	0.0000
$\Delta\pi(-1)$	-0.3926	0.0605	-6.4834	0.0000
$\Delta\pi(-2)$	-0.3974	0.0634	-6.2710	0.0000
$\Delta\pi(-3)$	-0.3971	0.0645	-6.1608	0.0000
$\Delta\pi(-4)$	-0.4292	0.0666	-6.4424	0.0000

$\Delta \ln f(-5)$	-0.4756	0.0570	-8.3384	0.0000
$\Delta \pi(-6)$	-0.3505	0.0686	-5.1061	0.0000
$\Delta \pi(-7)$	-0.3747	0.0625	-5.9964	0.0000
$\Delta \pi(-8)$	-0.4108	0.0539	-7.6183	0.0000
$\Delta \pi(-9)$	-0.4394	0.0557	-7.8839	0.0000
$\Delta \pi(-10)$	-0.4727	0.0530	-8.9173	0.0000
$\Delta \pi(-11)$	-0.4457	0.0603	-7.3947	0.0000
$\Delta \mu$	-1.4198	0.4619	-3.0735	0.0021
Constant	2.0699	0.2258	9.1662	0.0000
Mean dependent variable	0.0051	S.D. dependent variance		7.7175
S.E. of regression	3.4059	Akaike info criterion		5.0436
Sum squared residuals	26018.53	Schwarz criterion		5.4173
Log likelihood	-5892.217	Hannan-Quinn criterion		5.1795

#### 4.2. Are there Threshold Effects in the Eurozone Phillips Curves?

In this section, we will look at the possibility of threshold effects in the eurozone Phillips curves. We determined the number of thresholds by estimating Eq. (4a) or (4b) permitting zero, one, two and three thresholds. Table 3 summarizes the tests for thresholds. The test for a single threshold yielded an F-statistic of 15.83 which is statistically significant at the 1% level. The same applies to the double threshold which yielded an F-statistic of 12.91. The triple threshold yielded an F-statistic of 6.58 which is insignificant at all conventional levels. Hence, there are two thresholds in the eurozone Phillips curve. The estimated thresholds are 5.00% and 6.54%. Technically,  $q_{it} \leq 5.00\%$ ,  $5.00\% < q_{it} \leq 6.54\%$ , and  $q_{it} > 6.54\%$  denote, respectively, low, medium, and high unemployment.

**Table 3: Testing for Threshold Effects.**

Threshold	F-statistic	10%	5%	1%
Single	15.83	6.6349	8.2545	13.6560
Double	12.91	7.2104	8.4001	12.3185
Triple	6.58	8.7163	10.3614	15.0754

**Note:** The significance levels are 10%, 5%, and 1%.

**Table 4: Estimated Thresholds.**

Model	Threshold	Lower Bound	Upper Bound
$\gamma_1$	5.0000	4.9000	5.1000
$\gamma_2$	5.0000	4.9000	5.1000
$\gamma_3$	6.5400	6.5000	6.6000

Using these thresholds, we estimated the Phillips curve for the eurozone. The results are shown in Table 5. An interesting finding emerges. The relationship between inflation and

unemployment is only negative when unemployment is in the low regime, i.e. when unemployment is lower than 5.00%. Once countries migrate from this regime to a mild unemployment regime (i.e. between 5.00% and 6.54%), this relationship turns positive. However, when the unemployment threshold of 6.54% is superseded, the relationship between inflation and unemployment vanishes. This suggests that the Phillips curve in the eurozone only exists in the lower regions of unemployment. Higher inflation rates are likely to co-exist with higher rates of unemployment. This conclusion is in line with King et al. (1995) who documented an upward-sloping Phillips curve for the US. Indeed, the triangle approach as documented by Gordon (2011) suggests that inflation and unemployment can be related positively or negatively, contingent on the source of the shocks, the length of lagged responses, and the policy response. According to Eliasson (2001), the empirical failure of the Phillips curve may be due to the presence of non-linearity in the relationship between inflation and unemployment. She found this to be true when testing the linearity assumption in the Phillips curve using Australian and Swedish data. Overall, our findings reflect these contentions.

**Table 5: Estimated Fixed Effects Threshold Regression.**

Dependent variable: $\pi$	Coefficients	Standard error	t-statistic	P-value
$\mu$				
$q_{it} \leq 5.00\%$	-.1321	.0478	-2.76	0.006
$5.00\% < q_{it} \leq 6.54\%$	.7799	.4199	1.86	0.063
$q_{it} > 6.54\%$	.1778	.1368	1.30	0.194
Constant	2.4896	.5004	4.98	0.000
sigma_u	.8385	Number of observations	2398	
sigma_e	5.5516	Number of groups	11	
rho	.0223	Minimum	218	
R-sq: Within	0.0146	Average	218	
Between	0.0164	Maximum	218	
Overall	0.0067	F(4,2383)	8.81	
		Prob > F	0.0000	

## 5. Concluding Remarks

Unemployment is a topical issue in all economies. The rising unemployment in the eurozone has brought about various secession concerns. In order to maintain stability in the eurozone, the main priority of policymakers should be finding robust solutions to arresting the rising unemployment in the member countries. The unemployment-inflation relationship is a classical economic relationship that seems to be of less interest in the latest literature. In his famous paper, Phillips (1958) found that there is a negative relationship between unemployment and inflation, and which was subsequently called the Phillips curve. This observation was later confirmed by Samuelson and Solow (1960). However, subsequent studies have documented temporal positive and negative relationships between inflation and unemployment, leading to strong criticisms against the Phillips curve. The triangle approach in particular indicates that inflation and unemployment can be related positively or negatively, contingent on the source of the shocks, the length of lagged responses, and the policy response. Moreover, the strong linearity assumption on which the Phillips curve rests may have led to its empirical failure.

Although prior studies have modelled the possibility of nonlinearities or threshold effects in the Phillips curve, to our knowledge no study has established a threshold for which the relationship between inflation and unemployment switches from negative to positive in the eurozone. We thus tested for threshold effects in the Phillips curve, estimating these thresholds and estimating a threshold Phillips curve. We also estimated both short- and long-run Phillips curves for these countries. Since our sole focus was on the classical Phillips curve, we only considered inflation and unemployment in our empirical specifications. We found that, by assuming linearity, there exists a Phillips curve in the short and the long run in the eurozone. However, when we tested for threshold effects, we established that the linearity assumption in the classical Phillips curve might be too strong. In fact, we established thresholds of 5.00% and 6.54% in unemployment. By incorporating these thresholds in the Phillips curve, we found that the relationship between inflation and unemployment is only negative when unemployment is in the low regime (i.e. when unemployment is lower than 5.00%). We found that once countries migrate from this regime to a mild unemployment regime (i.e. between 5.00% and 6.54%), this relationship turns positive. Further, we found that when an unemployment threshold of 6.54% is superseded, the relationship between inflation and unemployment vanishes. Our findings do not only highlight the importance of threshold effects in the Phillips curve, but also show the need to fight unemployment in the eurozone. Policymakers should model threshold effects when forecasting inflation or unemployment. Higher unemployment may induce higher inflation which are both unpleasant economic conditions. Hence, fighting unemployment should continue to be a key priority of policymakers. A limitation of our study is that we drew conclusions based on aggregate effects obtained via pooling countries together. Since the dynamic panel approach utilised in this study allows for heterogeneities across countries, it may not be able to account for unique country experiences. Future studies may consider using time series techniques to shed light on the importance of the threshold effects at the individual country level. In addition, to allow for a longer time span, we only included countries which met the eurozone convergence criteria at the inception of the European Union. We believe that perhaps rich dynamics may be introduced into the eurozone Phillips curve by broadening our sample. While this may be a big task at the present, future studies may consider expanding our sample to verify our findings.

## References

- Altissimo, F., Ehrmann, M., & Smets, F. (2006). Inflation persistence and price-setting behaviour in the Euro Area-a summary of the IPN evidence. ECB Occasional Paper No. 46. Available at SSRN: <https://ssrn.com/abstract=807420>
- Andersson, D. E., Andersson, Å. E., Hårsman, B., & Daghbashyan, Z. (2015). Unemployment in European regions: structural problems versus the eurozone hypothesis. *Journal of Economic Geography*, 15(5), 883-905.
- Angeloni, I., Aucremanne, L., & Ciccarelli, M. (2006). Price setting and inflation persistence: did EMU matter? *Economic Policy*, 21(46), 354-387.

- Ball, L., Mankiw, N. G., Romer, D., Akerlof, G. A., Rose, A., Yellen, J., & Sims, C. A. (1988). The new Keynesian economics and the output-inflation trade-off. *Brookings papers on economic activity*, 1988(1), 1-82.
- Batini, N. (2006). Euro area inflation persistence. *Empirical Economics*, 31(4), 977-1002.
- Benati, L. (2008). Investigating inflation persistence across monetary regimes. *The Quarterly Journal of Economics*, 123(3), 1005-1060.
- Bick, A. (2010). Threshold effects of inflation on economic growth in developing countries. *Economics Letters*, 108(2), 126-129.
- Blanchard, O. J., & Summers, L. H. (1987). Hysteresis in unemployment. *European Economic Review*, 31(1-2), 288-295.
- Camarero, M., & Tamarit, C. (2004). Hysteresis vs. natural rate of unemployment: new evidence for OECD countries. *Economics Letters*, 84(3), 413-417.
- Camarero, M., Carrion-i-Silvestre, J. L., & Tamarit, C. (2006). Testing for hysteresis in unemployment in OECD countries: new evidence using stationarity panel tests with breaks. *Oxford Bulletin of Economics and Statistics*, 68(2), 167-182.
- Canale, R. R., & Liotti, G. (2015). Structural adjustment and unemployment in selected eurozone countries. *Australian Economic Review*, 48(2), 113-121.
- Chang, T. (2011). Hysteresis in unemployment for 17 OECD countries: Stationary test with a Fourier function. *Economic Modelling*, 28(5), 2208-2214.
- Cogley, T., & Sbordone, A. M. (2008). Trend inflation, indexation, and inflation persistence in the New Keynesian Phillips curve. *The American Economic Review*, 98(5), 2101-2126.
- Correa, A. D. S., & Minella, A. (2010). Nonlinear mechanisms of the exchange rate pass-through: A Phillips curve model with threshold for Brazil. *Revista Brasileira de Economia*, 64(3), 231-243.
- Corvoisier S. and B. Mojon (2005), Breaks in the mean of inflation - How they happen and what to do with them, ECB Working Paper No. 451.
- Crosby, M., & Olekalns, N. (1998). Inflation, unemployment and the NAIRU in Australia. *Australian Economic Review*, 31(2), 117-129.
- Davis, D. R. (1998). Does European unemployment prop up American wages? National labor markets and global trade. *American Economic Review*, 88(3), 478-494.
- De Grauwe, P. (2016). The legacy of the eurozone crisis and how to overcome it. *Journal of Empirical Finance*, 39, 147-155.

Dupasquier, C., & Ricketts, N. (1998). Non-linearities in the output-inflation relationship. *Price Stability, Inflation Targets, and Monetary Policy*, 14, 131-173.

Eliasson, A. C. (2001). Is the short-run Phillips curve nonlinear? Empirical evidence for Australia, Sweden and the United States (No. 124). *Sveriges Riksbank Working Paper Series*.

Enders, W., & Hurn, S. (2002). Asymmetric price adjustment and the Phillips curve. *Journal of Macroeconomics*, 24(3), 395-412.

Erceg, C. J., & Levin, A. T. (2003). Imperfect credibility and inflation persistence. *Journal of Monetary Economics*, 50(4), 915-944.

Fanelli, L. (2008). Testing the new Keynesian Phillips curve through vector autoregressive models: Results from the Euro area. *Oxford Bulletin of Economics and Statistics*, 70(1), 53-66.

Ferri, P., Greenberg, E., & Day, R. H. (2001). The Phillips curve, regime switching, and the NAIRU. *Journal of Economic Behavior & Organization*, 46(1), 23-37.

Fisher, T.C.G. (1989). Efficiency wages: A literature survey. Working paper 89-5, Bank of Canada.

Friedman, M. (1968). The role of monetary policy. *American Economic Review*, 58, 1-17.

Fuhrer, J., & Moore, G. (1995). Inflation persistence. *The Quarterly Journal of Economics*, 110(1), 127-159.

Gordon, R. J. (2011). The history of the Phillips curve: Consensus and bifurcation. *Economica*, 78(309), 10-50.

Guerrieri, P. (2013). The Rise of Unemployment in the Eurozone: The Worst of the Crisis is Not Over. *The G-20 and Central Banks in the New World of Unconventional Monetary Policy*, 51.

Jaeger, A., & Parkinson, M. (1994). Some evidence on hysteresis in unemployment rates. *European Economic Review*, 38(2), 329-342.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of Econometrics*, 93(2), 345-368.

Helpman, E., Itskhoki, O., & Redding, S. (2010). Inequality and unemployment in a global economy. *Econometrica*, 78(4), 1239-1283.

Henry, Ó. T., Olekalns, N., & Thong, J. (2004). Do stock market returns predict changes to output? Evidence from a nonlinear panel data model. *Empirical Economics*, 29(3), 527-540.

Ho, S. Y., & Iyke, B. N. (2017). Consumption and Exchange Rate Uncertainty: Evidence from Selected Asian Countries. MPRA Paper 80096, University Library of Munich, Germany.

- King, R. G., Stock, J. H., & Watson, M. W. (1995). Temporal instability of the unemployment-inflation relationship. *Economic Perspectives*, 19(3), 2-13.
- Kreickemeier, U., & Nelson, D. (2006). Fair wages, unemployment and technological change in a global economy. *Journal of International Economics*, 70(2), 451-469.
- Law, S. H., Azman-Saini, W. N. W., & Ibrahim, M. H. (2013). Institutional quality thresholds and the finance–growth nexus. *Journal of Banking & Finance*, 37(12), 5373-5381.
- Lucas, R. E., & Sargent, T. J. (1979). "After Keynesian macroeconomics," in *After the Phillips Curve: Persistence of High Inflation and Unemployment*, Federal Reserve Bank of Boston, Conference Series, No. 19, 1979.
- McAdam, P., & Willman, A. (2004). Supply, factor shares and inflation persistence: Re-examining Euro-area New-Keynesian Phillips curves. *Oxford Bulletin of Economics and Statistics*, 66(s1), 637-670.
- Musso, A., Stracca, L., & van Dijk, D. J. (2009). Instability and nonlinearity in the euro area Phillips Curve. *International Journal of Central Banking*, 5(2), 181-212.
- Nickell, S. (2006). *A picture of European unemployment: success and failure. Structural Unemployment in Western Europe: Reasons and Remedies*, The MIT Press, Cambridge, United States.
- O'Reilly, G., & Whelan, K. (2005). Has Euro-area inflation persistence changed over time? *The Review of Economics and Statistics*, 87(4), 709-720.
- Önder, A. Ö. (2009). The stability of the Turkish Phillips curve and alternative regime shifting models. *Applied Economics*, 41(20), 2597-2604.
- Palley, T. I. (2003). The backward–bending Phillips Curve and the minimum unemployment rate of inflation: Wage adjustment with opportunistic firms. *The Manchester School*, 71(1), 35-50.
- Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621-634.
- Phelps, E. (1968). Money-wage dynamics and labour market equilibrium. *Journal of Political Economy*, 76, 678-711.
- Phillips, A. W. (1958). The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861–1957. *Economica*, 25(100), 283-299.
- Rumler, F. (2007). Estimates of the open economy new Keynesian Phillips curve for euro area countries. *Open Economies Review*, 18(4), 427-451.

Samuelson, P. A., & Solow, R. M. (1960). Analytical aspects of anti-inflation policy. *The American Economic Review*, 50(2), 177-194.

Smith, R., & Zoega, G. (2007). Global unemployment shocks. *Economics Letters*, 94(3), 433-438.

Stiglitz, J. E. (1984). Price rigidities and market structure. *The American Economic Review*, 74(2), 350-355.

Verdugo, G. (2016). Real wage cyclicality in the eurozone before and during the Great Recession: Evidence from micro data. *European Economic Review*, 82, 46-69.

Yates, A. (1998). Downward nominal rigidity and monetary policy. Working paper Bank of England.