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Has the introduction of the euro currency modified the Phillips Curve in the euro zone countries?

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Introduction

The Phillips Curve is a relationship that links the level of inflation to the unemployment gap, highlighted for the first time by the economist Alban Phillips in 1958. During the past decades, it has been used as a useful tool for the conduction of the monetary policy by central banks, as it captures some economic variables, such as expectations by economic agents and the relationship between inflation and economic slack, that are always considered as they give key information on the condition of the economy at a macro level. Given the importance for policymakers, this instrument has been widely studied and a large literature has emerged, in which is analysed the evolution of the Phillips Curve over time and countries.

The objective of this study is to verify whether one of the most relevant innovations of the twenty-first century, the introduction of the euro currency, has somehow modified the relationship between the variables of interest of the Phillips Curve, operating through channels such as the change of the formation of expectations.

The first two chapters will present a brief analysis of the literature on Phillips Curve and of the introduction of the common currency in the euro zone's countries, while the last chapter will present an empirical analysis in which we try to capture changes due to the euro introduction.

CHAPTER 1 – A review of the literature

1.1 A.W. Phillips (1958)

One of the first empirical studies on the relationship between wage inflation and unemployment is attributed to Alban Phillips. The New Zealand economist had great success thanks to his paper "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957" in 1958, in which he plotted the annual wage inflation rate against the unemployment rate, discovering a clear negative slope curve for this period.

Figure 1. Phillips (1958). Evidences on inflation-unemployment relation in UK, 1861-1913.

The relation identified by Phillips can be described as follows:

$$w_t = \beta - \alpha v_t$$ [1]

where w_t is the annual rate of change of wage and v_t is the annual unemployment rate.

[1] A.W.B. Phillips, 1958

This evident negative correlation has been widely analysed in the years that followed the publication of the paper and other economists have tried to verify whether this relation held also for other countries.

Notably, Samuelson and Solow (1960) tried to apply the evidences of the Phillips research to US data and also in that case they have found an inverse relationship. Slightly modifying the main path drawn by Phillips, the two authors selected price inflation instead of wage inflation as the dependent variable, such that starting from this point it will be the main variable we refer to when we talk about the Phillips Curve. The impact of these findings made the inflation-unemployment link identified by Phillips an essential tool in the decision-making processes of policy makers during the 1960s. If this relation held, it suggested that there was a possibility to choose among different combinations of unemployment and inflation, leading macroeconomic policies to focus on an optimal point along the Phillips Curve.

1.2 The breakout of the relationship: Phelps (1967) and Friedman (1968)

At the moment in which the relationship seemed to be accepted as an empirical rule and it worked perfectly, the first critics emerged. Within a few months each other, but arriving at the same result, Edmund Phelps and Milton Friedman, two future Nobel prize winners, criticized the Phillips Curve basing their arguments on several key points, the main ones being the relevance of the expectations and the difference between real and nominal wages.

"Only surprises matter. If everyone anticipated that prices would rise at, say, 20 percent a year, then this anticipation would be embodied in future wage (and other) contracts, real wages would then behave precisely as they would if everyone anticipated no price rise, and there would be no reason for the 20 percent rate of inflation to be associated with a different level of unemployment than a zero rate. An unanticipated change is very different, especially in the presence of long-term commitments."

Milton Friedman, 1977

As Friedman suggests, the problem in Phillips' analysis lies in the fact that there is no distinction between real and nominal wages, and the framework in which the original formulation is conceived is "a world in which everyone anticipated that nominal prices

would be stable and in which that anticipation remained unshaken and immutable whatever happened to actual prices and wages."[2]

The critiques of Friedman and Phelps suggested that the trade-off between inflation and unemployment, that in the original formulation looked to be permanent, could be exploited only in the short run, when inflation expectations are not adjusted yet. Each country, they suggest, has his own "Natural rate of unemployment", that is "a rate such that, as long as unemployment is above it, inflation can be expected to decline"[3]. For example, we can consider an economy that has a level of unemployment u_A, and a level of inflation π_A. Let's assume that the policymaker pursues an economic expansion and he cuts interest rates in order to stimulate consumption. This will shift inflation upwards to π_B (1st shift) and more workers will be hired to satisfy the growing demand, reducing the unemployment rate to u_B (2nd shift). But here is where expectations come into play! Workers will realize that prices have grown more than salaries, and will ask for a higher wage. At that point, unemployment will go back to his original level (3rd shift) (so-called NAIRU, "Non-Accelerating Inflation Rate of Unemployment") with the only consequence that inflation will be higher than the previous period.

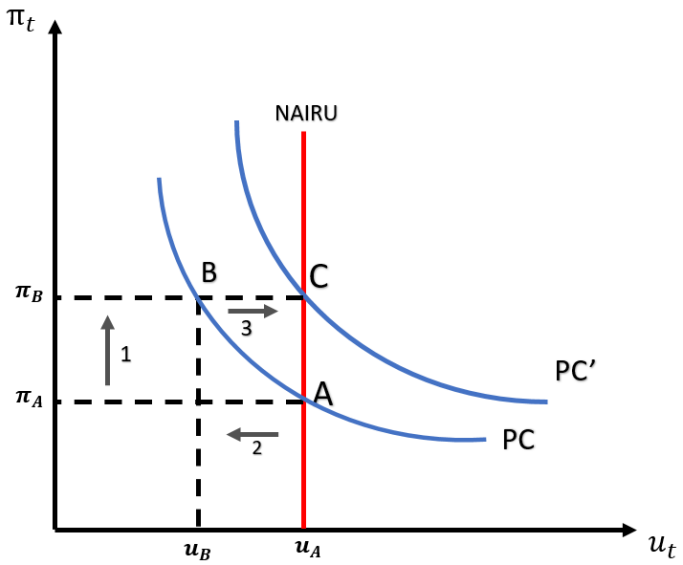


Figure 2. A representation of the "Non-Accelerating Inflation Rate of Unemployment".

[2] Milton Friedman, 1968
[3] Franco Modigliani and Lucas Papademos, 1975

Despite its simplicity, this theory was able to perfectly explain, and even forecast, what happened at the beginning of the 70's. In those years a stagflation period spread in different economies, experimenting at the same time a high rate of inflation and unemployment, making undetectable the relationship between inflation and unemployment originally formulated by Phillips in 1958. At the same time, a new relation between unemployment and variation of inflation showed up. This is because in that period expectations unanchored since central banks were sure, mistakenly, that choosing between inflation and unemployment was a feasible policy, and prices, that in the previous years were relatively stable, started to increase, influencing expectations of economic agents.

By incorporating these insights to the original model, we can now derive a new Phillips Curve accounting for expectations, known as "Accelerated Phillips Curve":

$$\pi_t = \theta\pi_{t-1} + (\mu + z) - \alpha u_t{}^4$$

where π_i is the annual inflation, π_{t-1} is the annual inflation in the previous period, μ is mark-up, z is term that indicates the level of protection of workers, u_t is the annual unemployment rate, and θ is a measure of how much inflation expectations are anchored. The terms z and μ are defined in a way such that an increase in the mark-up applied by firms or a more efficient support to workers increases wages and, hence, inflation levels. Here, a θ parameter closer to one means that economic agents expect the current inflation to be similar to the inflation observed in the previous year, while if it is close to 0 it means that people think inflation to be near to a certain value.

We can rearrange this equation highlighting the change in the inflation rate and the presence of the NAIRU:

$$\pi_t - \theta\pi_{t-1} = -\alpha(u_t - u_n)$$

where u_n is the NAIRU and is defined as $u_n = \frac{\mu+z}{\alpha}$, that is the level of unemployment at which actual inflation equal to the expected one.

[4] Olivier Blanchard, 2021

In successive estimations of the Curve, economists also regressed inflation on the output gap, since there is a relation that links unemployment and production. The equation would look like that

$$\pi_t - \theta\pi_{t-1} = \frac{\alpha}{LF}(Y_t - Y_n)$$

where Y_t is the actual output, Y_n is the potential output, and LF is the total number of labour forces.

The relation between unemployment and output can be checked in the Appendix at the end of this work.

1.3 More recent literature: The New Keynesian Phillips Curve

The earthquake caused by Friedman and Phelps in the literature has unearthed some problematics of the original Phillips formulation. In response to the challenges that several countries faced in the 70's due to oil's price surge, a lot of economists put effort in trying to elaborate a new model for the estimation of the Curve that could improve the inefficiencies of the original one. In particular, these new studies try to account also for a rational mechanism of expectations formation and nominal rigidity in prices. We refer to these models that follow this new theoretical approach as 'New Keynesian Phillips Curve' (NKPC).

Even if the improvements by Friedman and Phelps helped the original formulation to explain better the relationship between the two variables, their approach had few problems at the bottom. The expectation term introduced in the late 60's is a representation of an adaptive expectation assumption, meaning that economic agents could build their expectations only on past information and not also on news about the future, such as the announcement of a new policy adoption, that is quite absurd to believe.

It is more plausible to assume that people can base their assumptions also on available information for the future, namely using rational expectations.

The concept of rational expectations has been developed for the first time by John Muth (1961), who argued that expectations in economic models should be consistent with the actual structure of the economy, meaning that individuals and firms use all available information efficiently when forming their expectations about the future. This concept

has been later taken up by Lucas (1972), Sargent and Wallace (1975), creating two important propositions in the economic theory: the Lucas critique and the Policy Ineffectiveness Proposition. These theses substantially state, the first, that it is useless to try to predict the effects of a change in economic policy entirely on the basis of the relationships observed in historical data and, the second, that monetary policy cannot systematically manage the levels of output and employment in the economy.

Another important feature of the New Keynesian Phillips Curve is the introduction of instruments for nominal rigidity in prices in the models that try to estimate the Phillips Curve. This new feature is really useful since in the previous formulations of the Curve, it was common to assume frictionless markets and immediate adjustments of prices, that were highly unlikely to verify. This new formulation, that started with Fischer (1977) and Taylor (1980), and then followed by a lot of updates, strikes at the foundations of the so-called monetary neutrality, a classical theory that denies the effects of money supply on real variables, but only on nominal ones. From this point on, the new models that try to estimate the New Keynesian Phillips Curve will rely on the fact that monetary policy plays a paramount role 'in affecting real output', building even more accurate models.

1.3.1 A general NKPC model

Although hundreds of models have been proposed to estimate the Phillips Curve in this new theoretical framework, we can summarize these innovations in one general NKPC equation.

Stemming from the recent formulation suggested by Furlanetto and Lepetit (2024), we can generalize as follows:

$$\pi_t = \gamma\pi_{t-1} + (1-\gamma)E_t\pi_{t+1} + k(Y_t - Y_n) + u_t$$

where π_t is annual inflation at time t, π_{t-1} is annual inflation at time t-1, $E_t\pi_{t+1}$ is expected future inflation at time t+1, γ is a parameter that measures the anchoring of inflation expectations and $Y_t - Y_n$ is the output gap, whom parameter, k, measures the slope of the Phillips Curve. This equation is known in the literature as 'hybrid version' of the Phillips Curve, since it combines forward and backward-looking terms. Introduced for the first time by Galì & Gertler (1999), this formulation can be considered complete since it takes into account both the past events relating inflation and the forecasted trend.

This hybrid formulation is particularly relevant in explaining a key concept for the policymaker, that is the persistence of inflation. "The more intrinsic persistence inflation embodies, the more difficult it will be for monetary policy to move inflation around. If inflation itself is inertial, then a given monetary action that changes output will have a smaller effect on inflation." [5]

As evidenced by some papers that talk about the argument, among all Fuhrer and Moore (1995), the forward-looking models are not sufficient in explaining the persistence of inflation, that is driven not only by the changes in output gap, but also by the past inflation itself. Introducing an element that takes into consideration the past inflation can help us to build a more precise model in estimating the real relation between inflation and economic activity.

These innovations have been gradually introduced in the new estimations of the Phillips Curve and nowadays economists and policymakers use this tool to forecast and analyse the economic outlook and the formulation of the monetary policy.

1.4 Empirical evidences from the literature

1.4.1 The flattening of the Phillips Curve

The so-called event of the 'flattening of the Phillips Curve' is a phenomenon that has his roots in the early 80's and consisted in a fall of the slope that remained at low levels until the 2013 sovereign debt crisis.

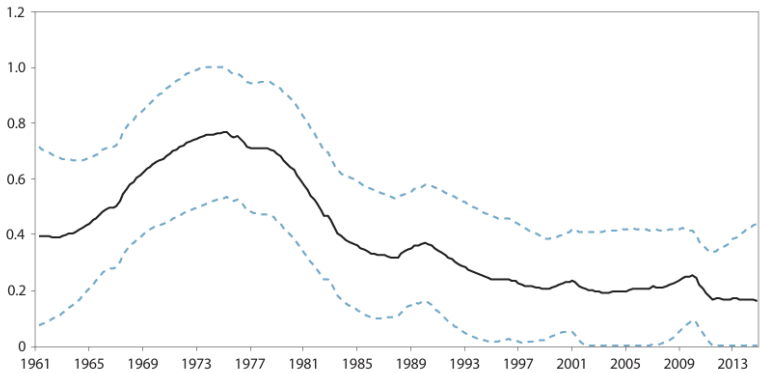


Figure 3. Blanchard, Cerutti, Summers (2015). The flattening of the Phillips Curve.

[5] Jeffrey C. Fuhrer, 2009

From an economic point of view, the decreasing slope of the Phillips Curve means that, starting from 1980 on, there's been a weaker relationship between inflation and output/unemployment gap, that has limited the menu of possible approaches for the policymaker in choosing the best combination of the two variables in the economic scenario. This phenomenon coincided with the years of the so-called 'Great Moderation'. This period was characterized by stability in the macroeconomic outlook, "where most OECD countries experienced a sharp reduction in the volatility of both output growth and inflation".[6]

In recent decades, economists have sought to explain the decline in the slope of the Phillips Curve. In a speech from February 2004 addressed to the Eastern Economic Association, Ben Bernanke, at that time Member of the Board of Governos of the US Fed, reported three possible 'classes of explanations' that could be used to explain the decrease of volatility in economic activity. Among the possible sources of the Great Moderation, we can catalogue structural changes, improved macroeconomic policies, and good luck.

The first class of explanations includes improvements in business activity, increased sophistication in financial markets and more incentives to international trades. Particularly relevant in the literature is the analysis proposed by Galì and Gambetti (2006), where they suggest as a possible explanation for the Great Moderation period, among the others, a shrinking contribution of non-technology shocks to output volatility.

Secondly, Bernanke proposes as explanation for this phenomenon a better macroeconomic policy. Historically, there has always been a strong relation between output and inflation volatility to move together, being really high in the 70's. However, several economists propose that in that period "monetary policy was in disarray"[7], and policymakers were not able to conduct properly the monetary policy. On the contrary, the Great Moderation period was characterized by a more credible and stable monetary policy that probably influenced the economic activity leading to lower volatility levels.

One last reason to explain this flattening of the Phillips Curve is commonly known as 'good luck', expression to which economists use to refer to when trying to analyse this period. The good luck hypothesis refers to the idea that the decline observed in economic

[6] Laura Gonzàlez Cabanillas and Eric Ruscher, 2008
[7] Marvin Goodfriend, 2007

volatility during the Great Moderation is primarily due to favourable shocks in exogenous variables that hit economies during those years.

1.4.2 Back to the 60's?

While the effects of the Great Moderation have caused the flattening of the Curve, in recent decades economists have also noticed a new Phillips Curve that remembers the one spotted by Phillips in 1958. While the relation between variation of inflation and output gap seems to have weakened, a new strong link between inflation and output gap has resurfaced, sweeping away the evidence of the so-called Accelerationist Curve which was characteristic of the 1970's period.

In particular, Blanchard (2015, 2016), Jørgensen and Lansing (2021) have noticed this trend of reversal in the economy. From an economic point of view, that would suggest that inflation does not heavily depend on the past inflation level, but rather it would suggest that inflation expectations are anchored.

This hypothesis finds a confirm in the empirical evidence. Jørgensen and Lansing (2021) have provided a measure of one-year ahead expected CPI inflation for two different periods, 1981 to 1998 and 1999 to 2021. In this case, the lower is the coefficient, the less expected inflation is sensitive to inflation, and data seem to prove that to be true.

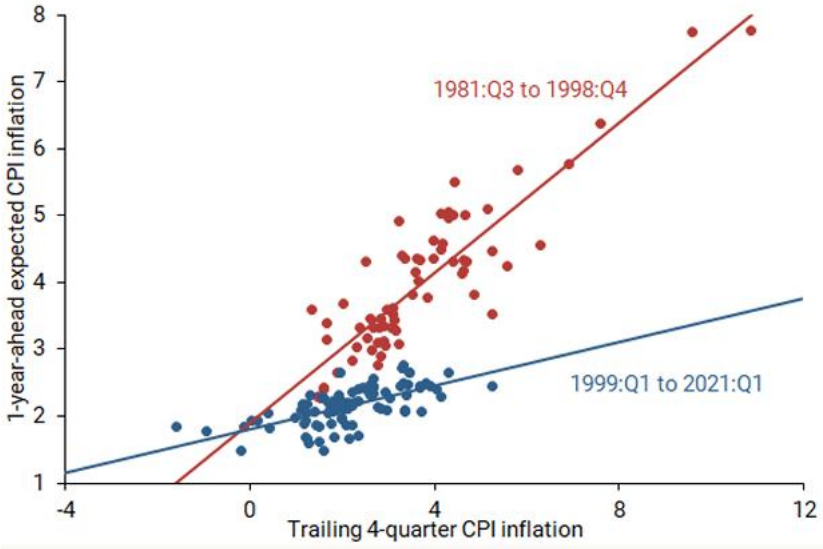


Figure 4. Jørgensen and Lansing (2021). Sensitivity of one-year ahead expected CPI inflation to incoming data of inflation itself.

The coefficients result to be, for the first period, around 0.56, and for the second around 0.16, as a prove of the sharp decline of the importance that inflation plays in influencing inflation expectations.

CHAPTER 2 - The introduction of the Euro currency

2.1 The history of the Euro introduction

A defining milestone of the past decades is the born of the Economic Monetary Union (EMU) and the introduction of the Euro currency. This is a process that started in the second post-war period with a tentative of a common economic policy for the EU countries but that took a decisive turn at the beginning of the 1990s.

The first push for the monetary union came from the so-called 'Delors Report', a document drawn up in 1989 by an ad hoc committee chaired by the European Commission president, Jacques Delors, in which it is defined a three-stages project which has as main finality the creation of the economic and monetary union.

In the first stage, an initiative for the liberalization of capital movements is carried out and concluded through a 'complete removal of physical, technical and fiscal barriers within the Community'[8], allowing for free trade in European regions. Most importantly, the first stage of the Delors Report announces a program of economic and fiscal policy coordination, aimed to a convergence of parameters that will be defined in the Maastricht Treaty, known as 'Euro convergence criteria' or Maastricht parameters. In this agreement, countries who choose to join the EMU pledged to respect four essential prerequisites, necessary for the entrance in the Union: price stability, no excessive budget deficit, stable exchange rate in the European Exchange Rate Mechanism, and low interest rates in the bond's yield.

The second stage, that goes from 1994 to 1998, is a period of transition, during which it is signed the Stability and Growth Pact, which aimed to maintain the stability of the EMU, the eleven countries who initially adopted the Euro currency are chosen, and, most importantly, the European Central Bank (ECB) is created, with the primary responsibility for the conduct of monetary policy in the Euro area. The great innovation that the ECB brings with it, however, is that, for the first time in history, European countries' central

[8] Delors Report, 1989

banks lose their power in terms of monetary authority, leaving the task of printing money to another entity.

Finally, the last step of Delors Report consisted in the introduction of the new currency into the market. While the Euro has been officially introduced in 1999, real coins started to circulate after a three-year transition period from the 1st January 2002. After the eleven original adopters and the Greece's entry during the third stage of EMU in 2001, eight more countries have joined the Eurozone since 2007, with Croatia being the most recent in 2023.

2.2 The effect of the Euro on actual, perceived and expected inflation

As we have seen in the first chapter, the inflation expectations are a key factor we have to look at when considering the Phillips Curve. When the expectations are anchored, the Curve tends to be similar to the original one identified by Phillips in 1958, while when that's not the case, a relation similar to the Accelerate Phillips Curve shows up, meaning that economic agents do not believe inflation rates to fluctuate around a precise target but, rather, to be similar to the ones observed in the previous year.

The introduction of the Euro currency has been a shock in the perception of the inflation rates. This is because citizens in a lot of countries, when Euro was introduced, used to think of the price of goods in terms of the old currency, and at any moment had to reshape their perception of value of goods, switching from local country currency to Euro.

As shown by a 2002 monthly bulletin, the European Central Bank has reported the divergence that has emerged between actual inflation, expected inflation and the perceived one. The interesting fact is that the phenomenon starts in the exact period that coincides with the adoption of the Euro from the original adopting members.

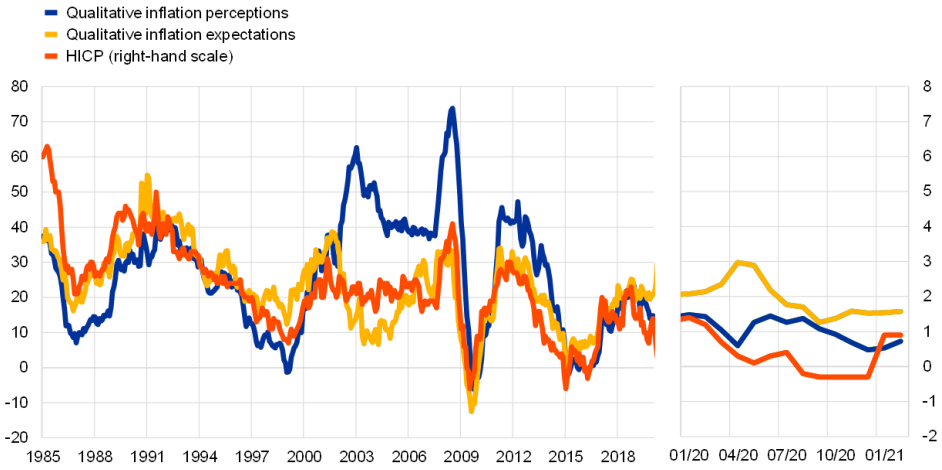


Figure 5. Changes in Euro area consumers' qualitative inflation perceptions and expectations and actual HICP inflation. Sources: European Commission DG-ECFIN and Eurostat.

According to Dziuda (2009), almost 70% of citizens believed that prices were rounded up and this influenced heavily the perception of prices in the Eurozone. This is can be explained by two arguments: by one hand, people were not able to fully understand the new prices in Euro, since they were used to think at goods' prices using the old national currency; on the other hand, it seems like prices were effectively rounded up, especially for cheap goods. This explains the divergence of inflation perception from the actual inflation even more if we consider that people mainly base their beliefs on prices looking at goods that are most frequently purchased, in particular food and clothing.

Another aspect that we have to take into account is the fact that starting from 1998, when ECB was founded, the monetary policy has been conducted exclusively by the new Frankfurt-based institution, that has set as its main objective the stabilization of inflation at a rate of 2%. Given this precise and mandatory goal, people started to expect the inflation to fluctuate around that value, making monetary policy more credible. It is highly probable that people's expectations of inflation have been influenced by the introduction of the European Central Bank in the economic landscape.

Given these changes that occurred after the introduction of the Eurocurrency, it is interesting to check whether the Euro had an influence on the relation between inflation and economic slack, and, hence, if we can observe a change in the Phillips Curve for the Eurozone's countries.

CHAPTER 3 – Effects of the Euro on the Phillips Curve

3.1 Data

In this section, our goal is to estimate whether the introduction of Euro currency at the beginning of the twenty-first century has had an impact on the Phillips Curve of the countries in the Eurozone. More precisely, we will try to verify if there is a change in the relation between annual inflation and output gap, taking into account data both from the period that precedes the Euro introduction and from the years following.

In order to do that, we collected and analysed data from the World Economic Outlook of October 2024, drawn up by International Monetary Fund. In particular, we analysed the link between variables for the period that goes from 1980 to 2023. This large temporary horizon has been selected in order to check how the relation between the variables was before 2001 and whether it changed.

The country considered in this analysis are all the ones who agreed to join the EMU from 1999 on. These countries are, in order of adoption of the common currency, displayed in the tab below.

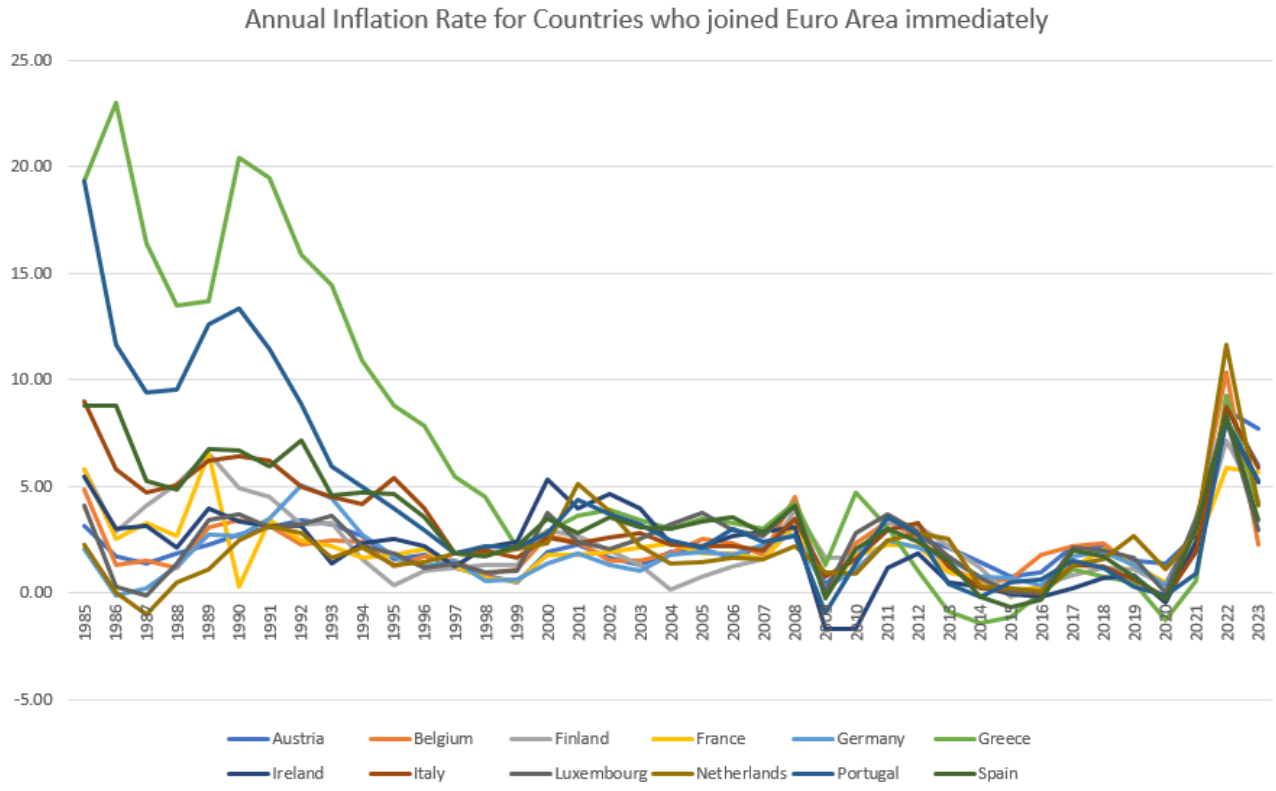
Country	Date of adoption
Austria	1st January 1999
Belgium	1st January 1999
Finland	1st January 1999
France	1st January 1999
Germany	1st January 1999
Ireland	1st January 1999
Italy	1st January 1999
Luxembourg	1st January 1999
Netherlands	1st January 1999
Portugal	1st January 1999
Spain	1st January 1999
Greece	1st January 2001
Slovenia	1st January 2007
Cyprus	1st January 2008

Malta	1st January 2008
Slovak Republic	1st January 2009
Estonia	1st January 2011
Latvia	1st January 2014
Lithuania	1st January 2015
Croatia	1st January 2023

Due to economic and political reasons, not all countries joined Euro area immediately, and some of them have not yet done so. Just think to the Sweden case for example. In 2003, a referendum for the adoption of the Euro currency was held, but the population rejected the common currency.

On the other hand, economic factors have been another obstacle to the immediate entrance of some countries in the Eurozone. After the fall of the communist regime, Baltic states have conducted an economic policy aimed to the stability, with the goal to match Maastricht Parameters and join the Euro. In the period that goes from 2011 to 2015, all the Baltic states have officially started to adopt the Euro.

While the low level of inflation is a prerequisite for the entrance in the Eurozone, it is less obvious that countries will maintain price stability in the years that follow the adoption of the common currency. However, it looks like that when countries adopt the Euro, they start to have more stability in prices with respect to the period in which they didn't use the Euro. We can compare how does the annual inflation rate change for countries who immediately adopted the Euro against those countries who started later.


Annual Inflation Rate for Countries who joined Euro Area immediately
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
Austria
Belgium
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain

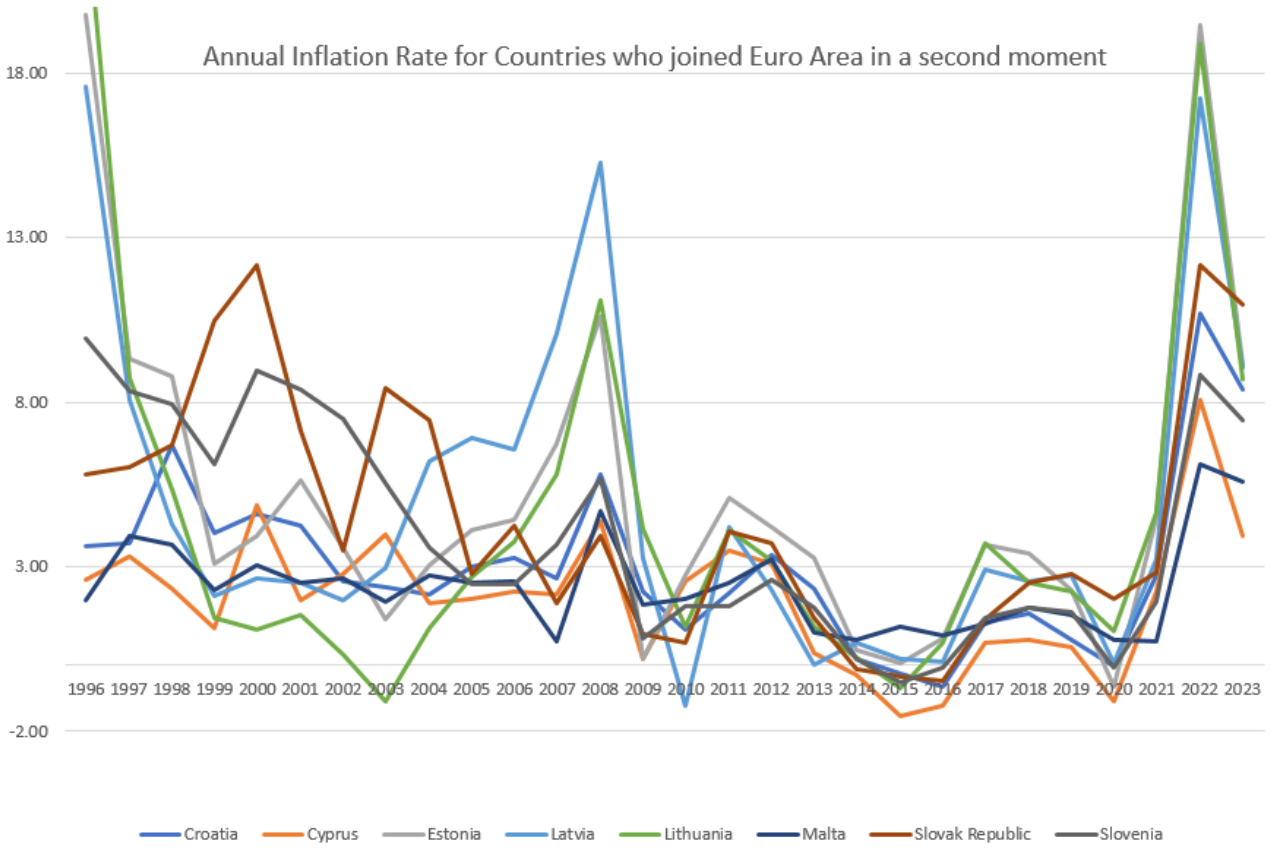

Annual Inflation Rate for Countries who joined Euro Area in a second moment
18.00
13.00
8.00
3.00
-2.00
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
Croatia
Cyprus
Estonia
Latvia
Lithuania
Malta
Slovak Republic
Slovenia

Figure 6 and 7. Comparison of annual inflation rate between countries who immediately adopted euro and countries who adopted euro later.

From these graphs it is evident that the Euro area and the ECB policies were a great breakthrough for the change in the volatility of inflation, both for early and late adopters. In fact, inflation rate remained stable after the introduction of the common currency, with the exception of the periods of deflation after the financial crisis and during the pandemic, and the surge of inflation that followed the Covid.

There are of course different events, occurred thorough years, that may have influenced the level of inflation rate, such as different economic conditions in the market or at a country level. However, it is clear that the common currency and, especially, the common monetary policy have played a significant role.

Given this stabilizing effect that the Euro had on the economies of Euro area's countries, let's now introduce the model we will use for our analysis.

3.2 Methodology

We try to estimate the new Phillips Curve for Euro area with panel data analysis, combining time series and cross-sectional data.

In the tentative to capture in the right way the effect of the introduction of the Euro, we will use the following model:

$$\pi_{i,t} = \theta\pi_{i,t-1} + \gamma D_{i,t}\pi_{i,t-1} + \alpha\left(Y_{i,t} - Y_{i,n}\right) + \varepsilon_{i,t}$$

where $\pi_{i,t}$ is the annual inflation rate for country *i* at time *t*, $\pi_{i,t-1}$ is annual inflation rate for country *i* at time *t-1*, $D_{i,t}$ is a dummy variable that equals 1 if the country *i* at the time *t* is a member of the Euro area, 0 otherwise, $Y_{i,t} - Y_{i,n}$ is the output-gap for country *i* at time *t*, and $\varepsilon_{i,t}$ is the error terms that accounts both for country and time specific errors.

The term θ captures the persistence on inflation, and helps us to understand how inflation expectations change over time. As, we have seen, a value of θ closer to one means that expectations are completely adaptive and past inflation influences the actual one. On the contrary, as the value tends to zero, a rational mechanism of expectations shows up.

The term $\gamma D\pi_{i,t-1}$ measures the effects of past inflation on current inflation only in the years that follow the introduction of the Euro currency. It will be essential in checking whether, in the years that followed the introduction of the Euro, the effect of inflation of previous year is different if compared with years before. We can refer to this variable γ as "Euro Effect on Inflation Persistence".

Finally, the error term ε_{it} both takes into account country specific, λ_i, and time specific events, λ_t. We will include in our regression country and time fixed effects in order to isolate the noise of events that may disturb our results.

3.3 Results

Results of the analysis show the changes of inflation expectations and slope of the Curve in the period 1980-2020.

	1980-1990	1990-2000	2000-2010	2010-2020
θ (Inflation expectations)	.7582448 (0.000)	.676612 (0.000)	.4033474 (0.020)	.4693962 (0.000)
α (Slope of the Phillips Curve)	.4876864 (0.042)	.1097102 (0.019)	.2051488 (0.036)	.337734 (0.000)

In the table above we can look at values of θ (Inflation expectations) and α (Slope of the Phillips Curve) every 10 years for the period considered (p-values are shown in parenthesis). All estimated coefficients are statistically significant at the 5% significance level (p-value < 0.05). We can furthermore plot the values of the observations for each year on a graph and observe the development year-to-year.

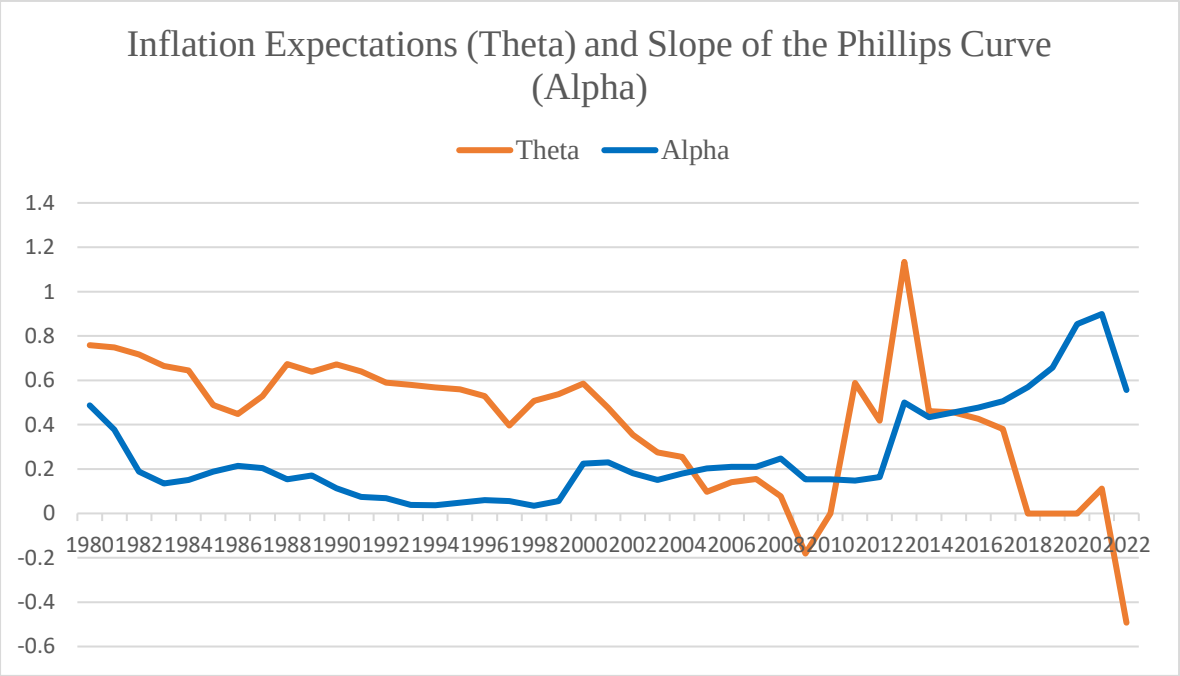


Figure 8. Inflation expectations and slope of the Phillips Curve from 1980 to 2023.

Our analysis confirms the evidences founded in the literature as we also observe a flattening of the Phillips Curve until the beginning of the twenty-first century. As we already discussed, this phenomenon has as a consequence some limitations in the conduction of the monetary policy, as there is a weaker relationship between inflation and the output gap.

Starting from the early 2000's, there is a bullish trend in the slope, with an important surge in the year 2012. This important change in the shape of the Curve is due to the fact that, after the 2007-2008 financial crisis, there's been a contraction in the production capacity of the countries in the euro zone. As shown by a Discussion Paper of the Bank of Finland [9], starting from the 2008 and during all the consequent years, there's been a negative level of output gap, meaning that countries were producing less than their

[9] Sami Oinonen and Maritta Paloviita, 2014

potential level. Riggi and Venditti (2014) propose two reasons that can explain this increase in the slope, that are either lower nominal rigidities, meaning that there is a decrease in the average duration of prices, or an increase in the short run response of inflation to real activity, as a consequence of two consecutive recessions experiences that led to the closure of many businesses.

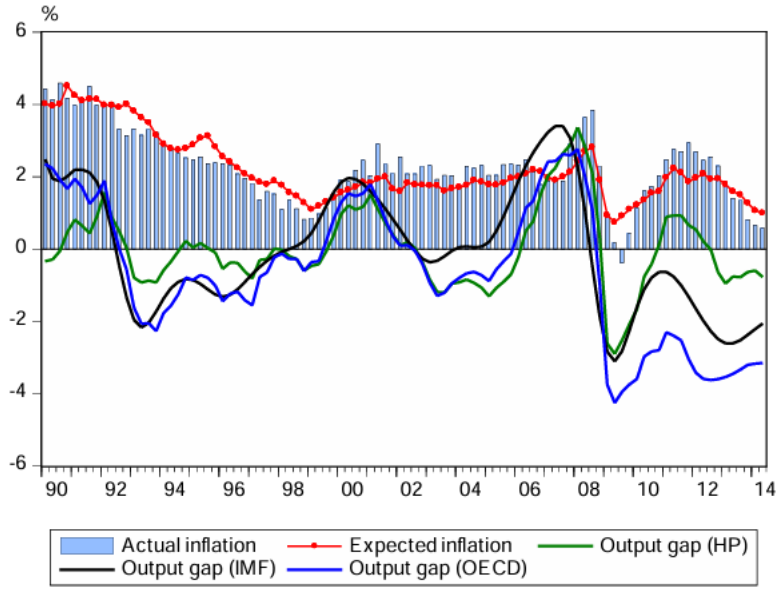


Figure 9. Euro area actual inflation, inflation expectations and output gap. Bank of Finland (2014).

Let's now look at inflation expectations, captured by the term θ. As we already discussed previously, a value of theta closer to 1 means that economic agents expected inflation levels to follow those of the previous year, that is the case of unanchored expectations, while a θ parameter closer to 0 suggests anchored expectations, hence inflation rate does not depend on the past.

The value of θ has progressively declined, reaching his minimum value in 2009. It is interesting to notice that starting from the years of the introduction of the euro currency, inflation expectations became strongly anchored. From 2001 to 2009, in fact, θ dropped as a consequence of the credibility of ECB in directing monetary policy, that became more effective in influencing people's beliefs on economic activity.

Once this period has been passed, however, it is evident a sharp steepening in the inflation expectations term and, soon after, a decline following the 2013. The surge of 2009

coincides with the global financial crisis, that led to chaos in different countries across all over the world. After the bankruptcy of Lehman Brothers occurred in September 2008, central banks moved to an expansive monetary policy, with interest rates reaching all-time low levels, with target being around 0%. This policy was undertaken with the aim to stimulate the economy, since after the crisis several financial institutions and firms had to close their activities, leading to the well-known period of "Great Recession". In this scenario of low inflation, economic agents were worried that these levels would remain for some time, and that led to a fall in trust in central banks. In particular, a 2012 Working Paper from ECB[10], are identified as main causes of the mistrust in the authorities' the sharp deterioration in economic situation, the overall fall in public trust in the European project during the crisis, and the fact that ECB was associated with troubles in the financial sector. These factors correctly fit with our finding that inflation expectations de-anchored in the post-financial crisis period.

After the instability peak, however, in 2013 ECB communicated in a clear way, through a forward guidance, his intention to keep interest rates at a low level. Moreover, the adoption of non-conventional policy tools such as Quantitative Easing helped inflation rate to assess around a stable range, even if slightly below ECB's target of 2%, and, most importantly, to improve inflation expectations in the euro zone. "In fact, in a regime where only conventional monetary policy tools are available, economic agents might question the ability of the central bank to ensure price stability and avoid a liquidity trap scenario which would be characterized by persistent deflation and deflation expectations. Under this reasoning, QE policies reassure private agents of the central bank's ability to reanchor inflation expectations[11]".

This decline of θ, following the intervention of European Central Bank, has represented a positive news for the European policymaker, who finally succeeded in conquering again the trust of householders and firms, with the consequence of an easier conduction of the monetary policy.

Finally, a really interesting result emerged from our regression is that the 'Euro effect on inflation persistence', γ, has reported a value of -0.21, and is statistically significant at

[10] Ehrmann, Soudan, and Stracca, 2012
[11] Beck, Duca, and Stracca, 2019

the usual 5% level of confidence. According to this result, we can comment that, on average, the entrance in the euro area has reduced the effect that the inflation level of the previous year had on the current inflation level, suggesting a phenomenon of anchoring driven by the euro introduction.

The variables we have taken into account until now are also analysed for the sample of countries that joined euro area immediately. Results show an even stronger effect of the γ term (-0.37), suggesting that early adopters benefited more from the euro in terms of credibility, with stronger trust in the ECB and its monetary policy from the start.

As the last check, we control for a change in the output gap following the introduction of the euro currency. We look at the variation using the following model

$$\pi_{i,t} = \theta\pi_{i,t-1} + \gamma D_{i,t}\pi_{i,t-1} + \alpha\left(Y_{i,t} - Y_{i,n}\right) + \delta\gamma D_{i,t}\left(Y_{i,t} - Y_{i,n}\right) + \varepsilon_{i,t}$$

where δ captures the variation in the output gap. Results show a positive value of δ (0.06), meaning that inflation reacts more to economic activity. However, since the coefficient is not statistically significant, we cannot draw firm conclusions from this result, as the observed effect may be due to other variations.

Coefficients	(1)	(2)
α	0.11**	0.08
	[0.04]	[0.06]
γ	-0.21**	-0.37***
	[0.09]	0.133
θ	0.70***	0.78***
	[0.065]	[0.02]
δ	0.06	
	[0.05]	
Time Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
Observations	664	467

Note:Standard errors are in square brackets. Column (1) shows results for the full sample, while Column (2) only for the early adopter countries. $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$.

Conclusions

Overall, we can conclude saying that the introduction of the euro currency has had for sure an effect on the parameters that compose the Phillps Curve. Our results show that over the period 1980-2020, inflation expectations have progressively declined, indicating a stronger anchoring of expectations, particularly in the years following the introduction of the euro. This anchoring has made monetary policy more effective by reducing the dependence of current inflation on past inflation trends, and it reflects the credibility gained by the ECB in managing inflation expectations.

Moreover, through our model, we were able to confirm a flattening of the curve until the beginning of the twenty-first century, as it has been already highlighted in the literature, due to a weaker emerged between inflation and output gap. However, following the 2007-2008 global financial crisis, we observe a reversal of this trend, with an increasing slope that shows a renewed sensitivity of inflation to real economic activity.

Finally, the estimation of our "Euro effect on inflation persistence" term shows a negative and statistically significant impact, further supporting the conclusion that the euro has played a decisive role in reducing inflation inertia within the euro zone. This result underlined the importance of a credible, coordinated monetary frameworks in achieving macroeconomic stability.

Appendix: From unemployment to output gap

The same relation between inflation and unemployment could be written as relation between inflation and output gap, that is the difference between the actual production of a country and the potential output that could be produced if one country used efficiently all his resources. To show this relation, let's first recall our equation

$$\pi_t - \theta\pi_{t-1} = -\alpha(u_t - u_n)$$

and let's define the unemployment rate as the ratio between unemployed people in a country over the total labour force

$$u \equiv \frac{U}{LF}.$$

We can consider unemployed people as the difference between the total labour force and the employed workers, so we can write the unemployment rate as

$$u = \frac{U}{LF} = \frac{LF - N}{LF} = 1 - \frac{N}{LF}$$

and

$$N = LF(1 - u).$$

Now, to come to production, we have to assume that the total output of production, Y, depends only to one input, labour, following this function of production

$$Y = AN$$

where A, that we assume being constant, is the productivity of work. If we furthermore assume $A = 1$, we can write Y as

$$Y = N.$$

So now, by rearranging terms, we can write the output gap, defined as $Y_t - Y_n$, as a function of the unemployment rate. By doing that, we obtain

$$Y_t - Y_n = LF[(1 - u_t) - (1 - u_n)] = -LF(u_t - u_n)$$

and by substituting this result in the Accelerated Phillips Curve equation, we finally get to

$$\pi_t - \theta\pi_{t-1} = \frac{\alpha}{LF}(Y_t - Y_n).$$

We can interchangeably use the unemployment gap or the output gap to check for the consistency of the Phillips Curve. In the papers elaborated from the 80's on, very often we observe an analysis focused to the relation between inflation and output gap, rather than the one between inflation and unemployment gap.

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