EUROPEAN CENTRAL BANK

EUROSYSTEM

Understanding Inflation Dynamics and Monetary Policy

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1. Introduction[1]

This paper addresses the main challenges in understanding inflation dynamics. It discusses recent developments in euro area inflation and their related implications for monetary policy.

Inflation dynamics since the Great Recession have shown signs of instability that have led to a sequence of systematic forecast errors. Following a short introduction, Section 2 of this paper dwells into the two puzzles of "missing disinflation" in 2009-11 followed by "excessive disinflation" after 2012 for the euro area case. In particular, it examines the drivers of low inflation, assessing domestic and external factors. Section 3 reviews a number of unsettled issues pertaining to the Phillips curve that prove essential for its use as a vehicle to discuss inflation dynamics: (i) the measurement of the economic slack, the curve's slope and its stability; (ii) the merits of the hybrid New Keynesian Phillips curves in understanding inflation dynamics and (iii) the stability of the coefficients of inflation inertia, economic activity, inflation expectations and external prices. The Phillips curve seems to be working well in the euro area but it faces some limitations that justify the need to use several different approaches to understand inflation dynamics. Finally, Section 4 concludes drawing the lessons for monetary policy, notably the use of models and judgement to understand, forecast and design policies to influence medium-term inflation. As the link between inflation and real activity appears to have strengthened in the euro area recently, it concludes that, as long as policies are able to significantly reduce the output gap, they should be contributing to bring the inflation rate closer to target in the euro area.

Understanding inflation dynamics has become particularly important in view of the low inflation regime now prevailing (see Figure 1.a. and Figure 1.b) and because the traditional relationship between slack in the economy and inflation seems to have weakened significantly in some countries.

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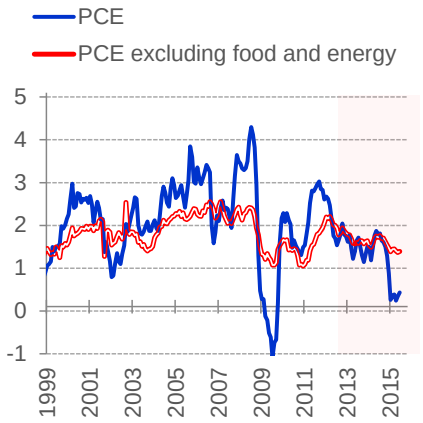
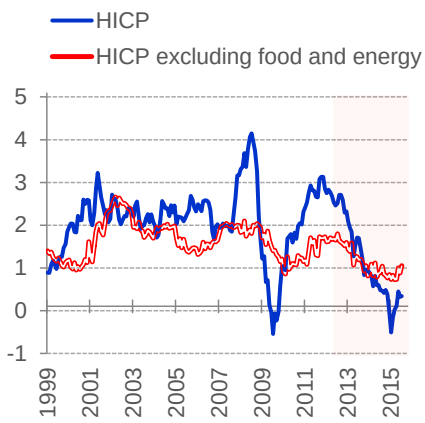
[1] I would like to thank the ECB staff members that have done the econometric work for this intervention, in particular, Matteo Ciccarelli, Chiara Osbat, Elena Bobeica, Marek Jarocinski, Carlos Montes-Galdon and Marco Groß.

Figure 1.a: US inflation
(annual percentage changes)



Source: Eurostat and Haver Analytics.

Figure 1.b: Euro area inflation
(annual percentage changes)



Source: Eurostat and Haver Analytics.

If confirmed, the flattening of the Phillips curve would be relevant for monetary policy because that relationship was the traditional linchpin of the transmission mechanism that gave central banks control of inflation. The subsequent focus on the role of expectations and their management in the toolkit of monetary policy reduced but did not eliminate the relevance of that traditional mechanism. In 2006 both the International Monetary Fund (IMF) and the Federal Reserve started to highlight a decade-long decline in the slope of the Phillips curve, i.e. the coefficient of economic slack (IMF (2006), Iakova (2007) and Roberts (2006)). This decline has been challenged by Gordon (2007 and 2013) as being too dependent on the Phillips curve specification, being particularly associated with variants of the New Keynesian Phillips curve (NKPC), but not verified by Gordon's own "triangle model". Coibion and Gorodnichenko (2015) show that evidence of slope decline is mixed for the United States. Stock and Watson (2010) say that "there are some hints that the slope parameter might be smaller at low levels of inflation but these hints are not robustly confirmed by statistical tests". Stella and Stock (2012) even find signs of a steepening of the Phillips curve for the United States.

2. Prolonged low inflation: puzzles and forecasting errors

More important, however, was the emergence, after the Great Recession, of a twin puzzle: first, missing disinflation in 2009-11, and second, excessive disinflation after 2012, particularly in Europe. During the Great Recession (the recession that followed the financial crisis), inflation in advanced countries did not fall as much as a traditional Phillips curve and past experiences would have predicted, given the severity and length of the recession (Williams (2010) and Ball and Mazumder (2011)). Just as puzzling, more recent global developments point in the opposite direction, since, in spite of the ongoing recovery, headline inflation rates in advanced (and a few emerging market) economies remain below target. Clearly, one reason for the low inflation rates is the recent large decline in oil prices. But core or underlying rates of inflation have also been below average almost everywhere. The seemingly weakened relationship between inflation and economic slack in the cases of

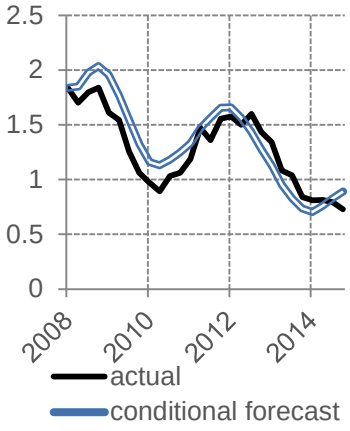
the two puzzles seemed to have disposed of the Phillips curve. We will see why that is not true after all.

Ex-post, we are not in the dark: If we exploit all available information we can recover the dynamics of inflation after the fact fairly well (see Figure 2), and rationalise inflation developments after the financial crisis. For the euro area we can identify two distinct periods of disinflation in the case of HICP excluding energy and food: the first from 2008 to 2010 and the second starting in 2012. The analysis is based on a Bayesian VAR[2] which includes HICP excluding energy and food, real activity indicators (real GDP, the unemployment rate and real investment), external variables (NEER, non-energy commodity prices, oil price in US dollars and foreign demand) and financial variables (short-term interest rates lending rates and real loans to non-financial corporations).

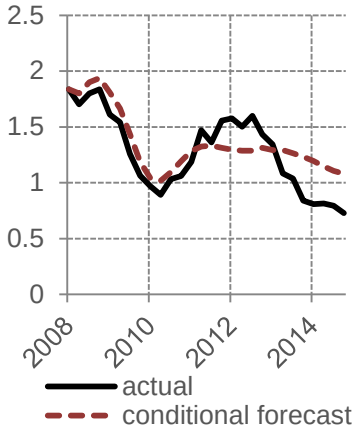
Figure 2: Ex-post analysis of HICP excluding energy and food

(annual percentage changes)

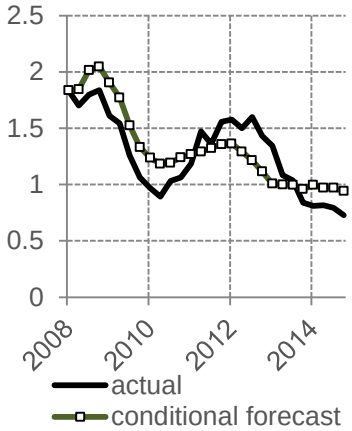
a: Conditioning on real activity variables



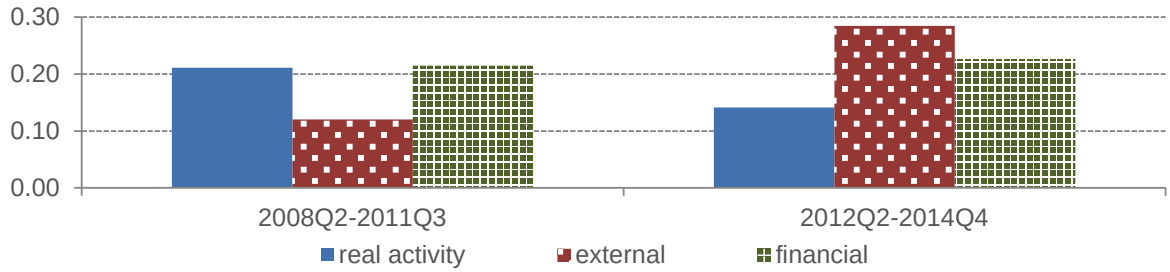
b: Conditioning on external variables



c: Conditioning on financial variables



d: RMSE of conditional forecasts of HICP inflation excluding energy & food



Note: evidence from the ESCB Task Force on Low Inflation. Results based on Bayesian VAR including: HICP excluding energy and food, real activity indicators (real GDP, the unemployment rate, real investment), external variables (NEER, non-energy commodity prices, oil price in USD, foreign demand), financial variables (short term interest rate, lending rate to NFCs, real loans to NFCs). Estimation sample: 1995-2014, conditional

[2] The methodology is similar to Jarociński and Smets (2008), House prices and the Stance of Monetary Policy, Federal Reserve Bank of St. Louis Review, July/August, 90(4), pp. 339-65.

forecasts start in 2008Q2. The RMSE is computed vis-à-vis actual inflation.

Each inflation dip had different origins: the first was mainly due to external factors (falling energy and food prices), while the second was driven more by domestic sources in an environment of weak demand (see Figure 2.d).

There is a vast body of literature on the first puzzle of the "missing disinflation", which offers a variety of explanations: the increased anchoring of expectations by a credible monetary policy (Bernanke (2010) and IMF (2013)); the continued decline of the responsiveness to economic slack (IMF (2013)); the increased downward wage rigidities in a recession that bend the wage Phillips curve (Daly and Hobijn (2014)); the higher forward-looking expectations of marginal costs in a dynamic stochastic general equilibrium (DSGE) model (Del Negro, Giannoni and Schorfheide (2015)); a fall in total factor productivity and increased costs of working capital (Christiano, Eichenbaum and Trabandt (2014)); a regime switch in the slope explained by sticky prices and sticky information (Murphy (2014)); or, finally, the role of higher mark-ups of liquidity-constrained firms (Gilchrist, Schoenle, Sim, and Zakrajsek (2015)). Others pointed to important measurement issues and suggested e.g. using short-term unemployment to measure slack (Gordon (2013), Krueger et al. (2014) and Ball and Mazumder (2014)) or household expectations from surveys to relevantly measure inflation expectations (Coibion and Gorodnichenko (2015)).

Most of these approaches, besides solving the puzzle a posteriori, also provide new methods that promise to improve future inflation forecasting, even in the context of reduced-form Phillips curves. The use of short-term unemployment[3] or household inflation expectations that are closer to those of economic agents, are two examples of promising developments. It is also helpful to introduce time-varying coefficients or regime-switching estimates, to account for many possible sources of non-linearity in the Phillips curve.

For headline inflation, external supply shocks, for example in commodity prices, have played a significant role but the two highlighted puzzles also apply to core inflation. Very importantly, the trend for a weaker relationship with economic slack applies also to core inflation. Most of the papers I have cited use the consumer price index (CPI) without energy and food or the GDP deflator as inflation variables. Only a few also use headline inflation. Core inflation reflects mostly domestic factors, as indirect effects from external developments are muted and take time to operate. That is why I consider it more useful to focus on core inflation dynamics for the purpose of discussing their consequences for monetary policy.

Despite a few dissenters, the majority view in these papers is favourable to the idea that the slope of economic slack in the Phillips curve has declined. There are several possible explanations:

1- The increased anchoring of inflation expectations makes inflation less sensitive to economic activity.

[3] See in particular Ball and Mazumder (2014), who use a parsimonious Phillips curve for core US inflation, with only long-term inflation expectations (reduced in practice to a constant) and short-term unemployment. They get a good fit for 2000-14 and even for a long period that starts as early as 1985 (the beginning of the Great Moderation).

2- Higher import volumes as a result of increased globalization have also increased the importance of international prices relative to domestic prices, forcing domestic mark-ups to be less sensitive to the state of the domestic economy.

3- Also as a result of globalization, inflation across countries displays an important common factor that explains a substantial part of the national inflation variation. Ciccarelli and Mojon (2010) and Ferroni and Mojon (2014) show that the commonality of inflation goes beyond what can be captured by commodity prices. They also report that the global inflation factor would improve forecasts of domestic inflation in different specifications, from augmenting an AR (1) model to using it in Phillips curves or BVARs. Further, they demonstrate that the importance of the common factor does not depend on spillovers among countries but is more the result of common shocks and convergence of monetary policy frameworks around the world. Confirming these results, Medel, Pedersen and Pincheira (2014), using a sample of 31 OECD countries, report that the global inflation factor improves the inflation forecast for 50% of the countries in the case of headline inflation and for 40% in that of core inflation. Nevertheless, the improvements in the forecasts mentioned in these papers are contained, producing a 5% to 6% reduction in the root mean squared errors.

4- The fourth type of explanation relates to possible non-linearities in the relationship between inflation and real activity. More precisely, the coefficient of the real activity measure in a Phillips curve may depend on the size and duration of economic slack, on the level and volatility of inflation, and on the degree of anchoring of inflation expectations. Specifically:

a. Clark, Laxton and Rose (1996) and Macklem (1997) point to the role of capacity constraints: during recessions, when firms operate below their full capacity, if demand is successfully stimulated, firms will be able to produce more without incentives to raise prices. During boom times, when firms operate closer to full capacity, additional demand translates into stronger price increases. Thus, the slope of the Phillips curve is an increasing function of excess demand.
b. Ball, Mankiw and Romer (1988) and Ball and Mankiw (1994) discuss convexity of the Phillips curve in the context of adjustment/menu costs. Ball, Mankiw and Romer (1988) show that in a new-Keynesian framework the frequency of price changes increases when the average rate of inflation increases, because firms must adjust their prices more frequently to keep up with the general rise in prices. As a consequence, the slope of the Phillips curve increases with the level of inflation.
c. Stiglitz (1986), Fisher (1989) and Akerlof, Dickens and Perry (1996) developed models with downward wage and price rigidities. These models embed the fact that workers are more reluctant to accept a decrease in their wages than an increase. At times of excess supply, the slope of the Phillips curve becomes an increasing function of the level of inflation.

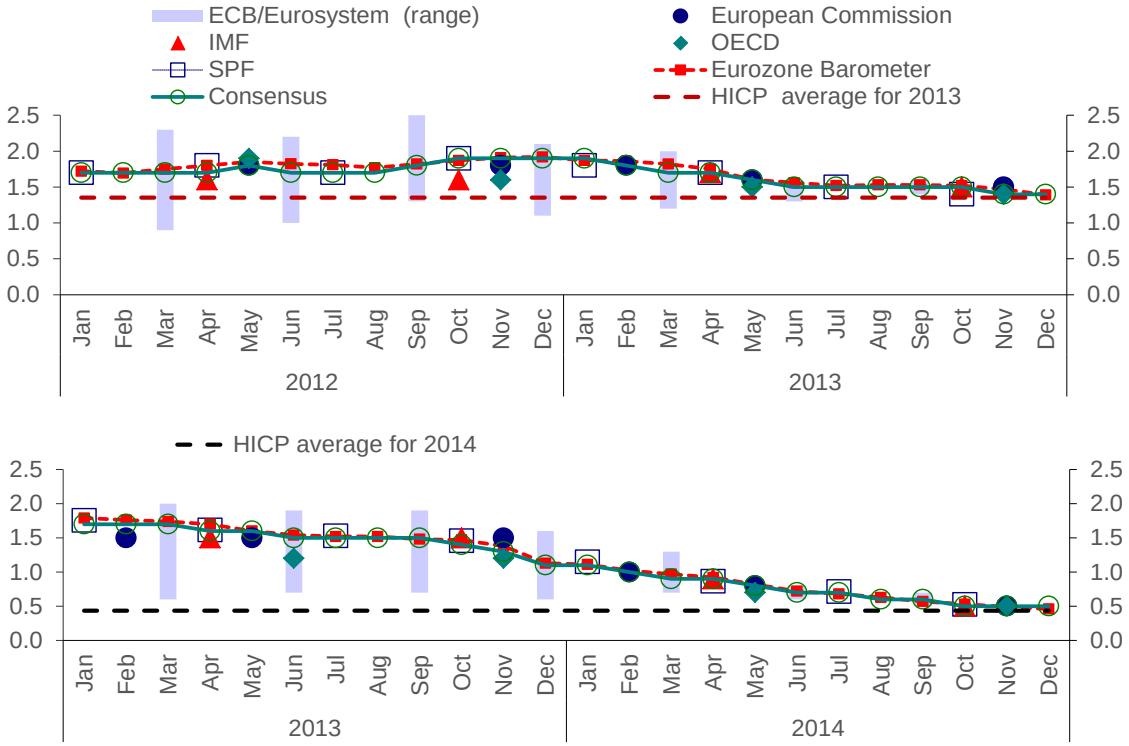
The theories that imply convexity rationalise relatively stronger expansionary monetary policy action during times of recession (as price pressures induced by expansionary policy are expected to be smaller during recessions).

The consequences for monetary policy of the weakening of the link between the level of economic activity and inflation, if this weakening indeed happened, would be significant. First, it has consequences on the sacrifice ratio: if inflation increases as a result of shocks not related to domestic slack, then the cost of bringing inflation down in terms of output loss would increase sharply. Second, if instead inflation becomes very low, monetary policy would have to stimulate economic activity more strongly and could lack effective instruments to do so. In sum, a flatter slope of the Phillips curve makes controlling inflation either more costly or more difficult. Naturally, when that flattening is associated with more strongly anchored expectations, the difficulties are mitigated.

What this underlines is the need to carefully monitor the relative importance of different drivers of domestic inflation: inertia, expectations, economic slack, supply shocks and external variables. Several methods and models are necessary for the task, as policy makers cannot rely on the perspective provided by a single tool.

Nevertheless, the fact remains that forecasters were not able to anticipate the disinflation for the euro area as a whole from 2012, or for the larger member countries. This is particularly surprising because forecasters did take into account the fall in economic activity in most euro area countries after 2011, which generated significant gaps between actual and potential output. The ECB has not been alone in over-predicting euro area inflation. The IMF, ECB Survey of Professional Forecasters (SPF), Consensus Economics, Euro Zone Barometer, OECD and European Commission have also systematically over-predicted both headline and core inflation at all horizons, especially since the second quarter of 2012 (Figure 3).

Figure 3: Evolution of projections of average euro area HICP inflation for 2013 (top) and 2014 (bottom)



Sources: IMF, ECB, Consensus Economics, OECD and European Commission.
Note: The dates on the x-axis indicate the publication dates of each projection. The time span between the cutoff date for the information used and the actual publication date varies across projections.

3. The Phillips curve as a vehicle to discuss inflation dynamics

However, as policy makers we need more than just good inflation forecasts: we also need to understand the inflation process in order to better assess the role of monetary policy. We also need to be able to explain our reasoning to the public, as the management of expectations has become such an important monetary policy instrument. This is one more reason for continuing to use the Phillips curve as a tool to discuss inflation dynamics.

The current attention to the relationship between inflation and economic slack has led to an intense debate on the stability of the Phillips curve and its power to explain the twin puzzle. Empirical research, especially in the United States, shows that the slope of the Phillips curve has varied over time, with a clear tendency to flatten over the years.

For the euro area, the evidence from several recent papers points to a steepening in recent years (see e.g. Oinonen and Paloviita (2014), Riggi and Venditti (2015) and Foroni and Porqueddu (2015)). This development is especially marked in those countries which experienced deeper and longer recessions and made greater efforts to reform their product and labour markets, with an impact on nominal rigidities (see, for Italy, Riggi and Santoro (2015) and, to a lesser extent, for Spain, Banco de España (2013 and 2015). When analysing

the excessive disinflation in the euro area since 2012, natural questions arise as to whether we are facing a new regime of low inflation (e.g. due to demographics, integration of low-cost countries in global trade, less powerful trade unions, dominance of a service economy), and whether the Phillips curve (and "which" Phillips curve) is still an appropriate framework of analysis.

A number of technical issues pertaining to the Phillips curve have not yet been settled in the literature.

a. **A key problem in this debate is that single-equation estimates of the Phillips curve might not correctly identify its slope**, as inflation and economic slack are determined simultaneously.

b. **Moreover, economic slack is a multidimensional concept that is not directly observable** and choices must be made on how to estimate or measure it.

c. **An additional problem is that inflation is also influenced by foreign shocks**, either directly via imported inflation or indirectly via global economic slack, as a consequence of international integration of production. How do we account for such external shocks?

d. **Further, the standard hybrid New Keynesian Phillips curve includes agents' inflation expectations, which are also difficult to measure.** Recent work by Coibion and Gorodnichenko (2015) uses expectations from surveys, with some practical success. It highlights that the choice of the measure of inflation expectations is crucial in understanding inflation dynamics in the United States, advocating the use of surveys of household inflation expectations rather than those of professional forecasters. Naturally, expectations from surveys or professional forecasters are not microfounded. More generally, NKPC has had many problems to predict inflation even when embedded in a DSGE model. As King and Watson (2012) highlight when using the labour income share or unit labour costs the models do not capture that the last 15 years do not show a co-movement of inflation with the significant decline of those ULCs. Gürkaynak, Kisacikoglu and Rossi (2013) also illustrate the subpar performance of DSGE models to forecast inflation. In their encompassing survey Mavroeidis, Plagborg-Møller, and J. Stock (2014), also conclude that without rejecting the NKPC, "we are unable to pin down the role of expectations in the inflation process sufficiently accurately for the results to be useful for policy analysis".

e. **Finally there is the question of stability of Phillips curve parameters, in the form of non-linearities or structural changes.** As sudden decreases in forecasting ability are frequently associated with instability, a plausible explanation for the recent inflation surprises is a change in the slope of the Phillips curve. In what follows I am going to show some robustness analysis of the Phillips curve. Let us focus on slack.

Economic slack is the great unknown: it is unobservable and is highly sensitive to the assumptions used for the decomposition of economic activity into trend and cycle. Usual measures of slack can vary substantially across methods and variable inclusion, although they tend to agree on the timing of peaks and troughs.

The fact that economic activity is multidimensional suggests that there might be advantages in using large dynamic models to estimate it. For instance, ECB staff used a

dynamic factor model that performs a trend/cycle decomposition of real activity variables and core inflation.[4] The model uses a single factor to capture common cyclical fluctuations and estimates the output gap as the deviation of output from its trend. Different modelling assumptions, such as different sets of real activity indicators and different specifications of the trend components of the variables, lead to different estimates of the output gap (see Figures A.1.a and A.1.b). These differences are economically very relevant, with some models estimating an output gap that was close to zero in 2014 on average, and others estimating remaining slack of as much as -6%.

One way to discriminate among different estimates of the output gap is to check their ability to forecast inflation. It turns out that the variants associated with a continuation of a positive growth trend, implying a wider output gap, are the ones that produce better inflation forecasts. The best variant from this perspective implies that the output gap was as large as -6% in 2014 (see Figure 4.a). Assuming the opposite, namely a break in the output trend, which we could call a secular-stagnation hypothesis, leads to a much poorer forecast ability of recent inflation. The output gap estimated by the IMF and the European Commission are halfway between the extremes arising from the dynamic factor model I have described (see Figure 4.b).

Figure 4.a: Six variants of the output gap from a Bayesian dynamic factor model
(percent)

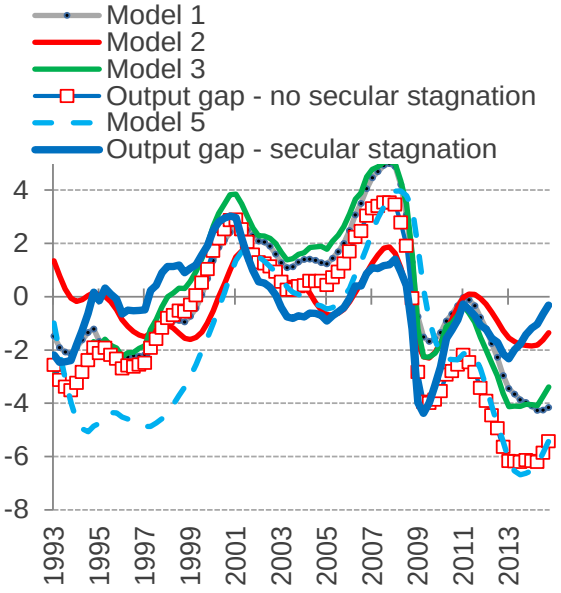
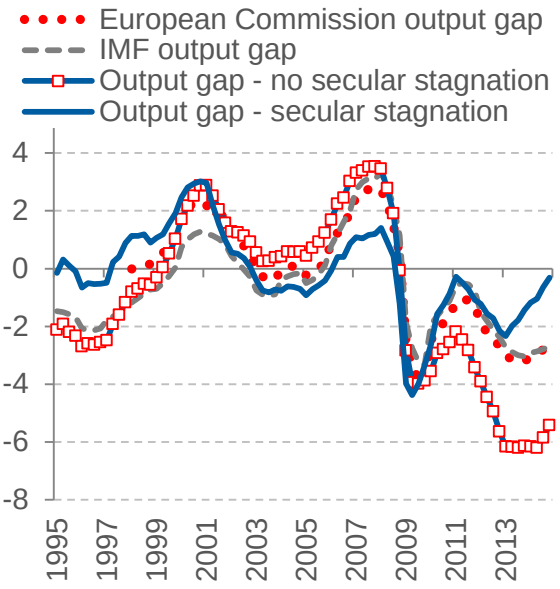


Figure 4.b: Comparison with traditional measures of the output gap
(percent)



Source: IMF WEO, AMECO, ECB staff calculation.
Notes: the six variants of the output gap from a Bayesian dynamic factor model are derived in "Inflation forecasts in Bayesian dynamic factor model of the euro area", M. Jarocinski and M. Lenza, 2015, mimeo;

- *The assumption on no secular stagnation implies continuing trend growth, large*

[4] Jarocinski M. and Lenza, M., "Inflation forecasts in a Bayesian dynamic factor model of the euro area", ECB WP forthcoming.

output gap. Good inflation forecasts.

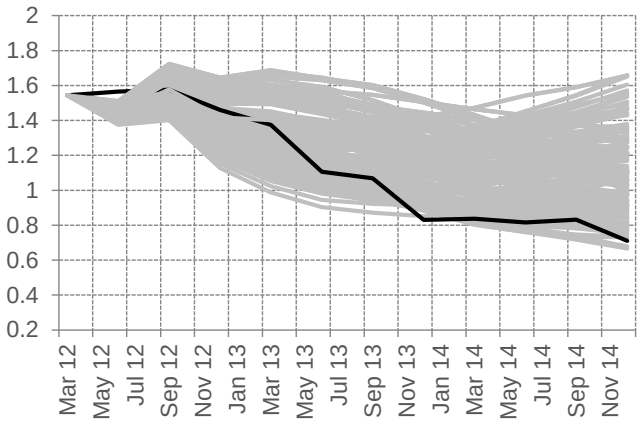
- *The assumption on secular stagnation implies slow trend growth, closing output gap. Less good at forecasting inflation.*

The IMF and European Commission output gap measures are interpolated.

Taking into account uncertainty over how to measure slack and inflation expectations, the Phillips curve is alive and well in the euro area (in some form). The dynamic factor model just discussed is not the only one that can explain the recent excessive disinflation. ECB staff have conducted a specification search with a hybrid NKPC using different measures of slack and of inflation expectations, and also including import prices as a measure of external shocks.

Figure 5: Conditional out-of-sample projection of HICP excluding energy and food 2012Q2:2014Q4

(annual percentage changes)



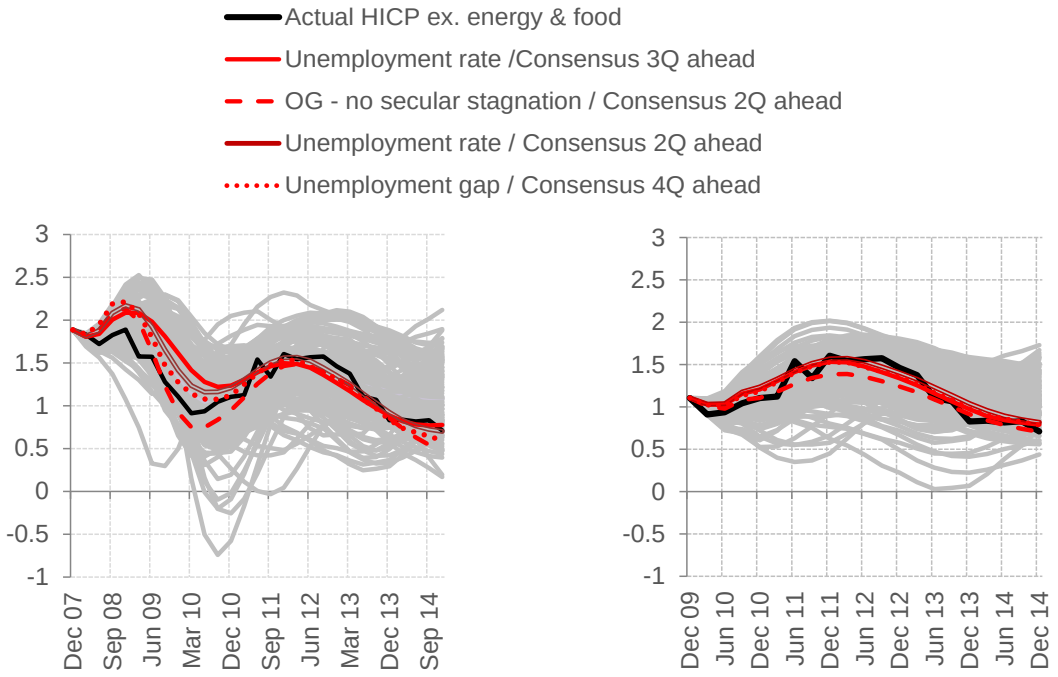
Sources: ECB staff calculations.
Note: The estimation starting date is 1995Q1 depending on data availability.

Several specifications are indeed able to track the recent disinflation. The results are shown in Figure 5, where each grey line is the conditional out-of-sample projection of inflation excluding energy and food, based on its own lag, lagged import prices, a measure of slack (lagged) and a measure of inflation expectations. The projection is based on the realized values of the explanatory variables except for lagged inflation, which is determined dynamically. While indeed many models pointed to inflation increasing faster than it did, some are able to track the disinflation quite well. These models tend to be those that use the unemployment rate (or gap) and a short to medium-term measure of inflation expectations.

The result holds also for conditional forecasts that start earlier, through the financial crisis and since the first recovery. In fact, the best specifications of the same hybrid NKPC were evaluated by looking at out-of-sample dynamic projections of inflation over the period up to end-2014 based on two different estimation samples, one ending in 2007 and the other in 2009. Figure 6 shows that the results are satisfactory for both exercises.

Figure 6: Conditional forecasting starting in 2008Q1 (left-hand) and 2010Q1 (right-hand)

(annual percentage changes)

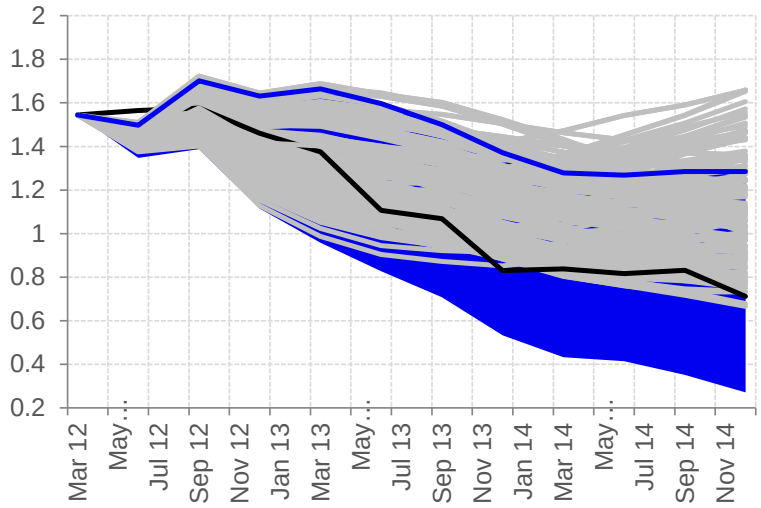


Source: ECB staff calculations.

However, as I have already hinted, the coefficients of the Phillips curve may not be stable. As I mentioned above, the slope of the Phillips curve might have increased over the period when we were over-predicting inflation. Running the same specifications just described over two samples, one stopping at 2012 Q1 (when we started to systematically over-predict inflation excluding food and energy) and the other covering the full sample ending in 2014 Q4, there is some evidence of an increase in the slope estimate (see Figure A.2). This suggests the specific possibility of non-linearities that could be due to state-dependency of the Phillips curve or to structural change of some form. Indeed, regime-switching estimates, accounting for parameter change due to state-dependency on various measures of the business cycle can help to explain the "excessive" disinflation since 2012. The results are shown in Figure 7 below.

Figure 7: conditional projection of HICP excluding energy and food from 2012Q2 to 2014Q4

(annual percentage changes)



Sources: ECB staff calculations.

How much time variation is there in the slope of the Phillips curve, and in which direction? The discussion on the steepening or flattening of the Phillips curve brings me to recent discussions that pointed to a flattening, particularly for the United States, but also for various other advanced economies. Let us take an agnostic view on the origins of the time-variation (that is, without necessarily making it conditional upon regimes identified by a specific variable) and estimate a hybrid NKPC with time-varying parameters, similar to that in Blanchard et al. (2015). Over the sample period running from 1999 Q1 to 2015 Q2, the slope of the Phillips curve for headline inflation had a general tendency to decrease until 2011, after which it rebounded (see Figure 8.a). For core inflation the upward shift started earlier (see Figure 8.b). This is true for the euro area as a whole but particularly valid for some countries that experienced longer recessions and made greater efforts to reform their product and labour markets with an impact on nominal rigidities.

Figure 8.a: Time-varying slope for headline inflation

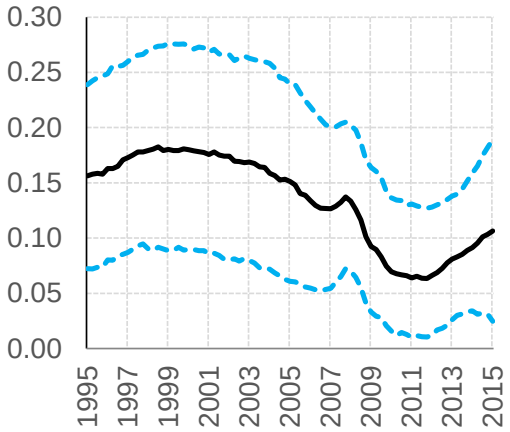
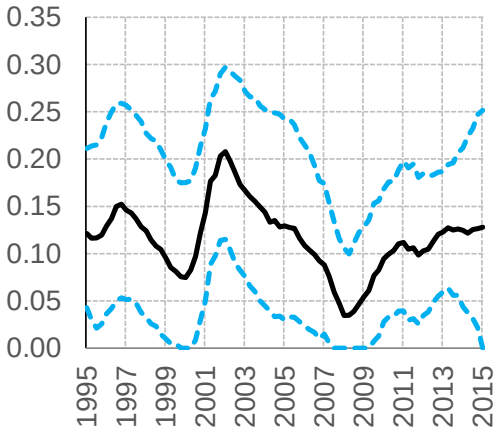


Figure 8.b: Time-varying slope for inflation excluding energy and food



Source: ECB staff calculations.
Note: Annual inflation regressed against its first lag, unemployment gap, imported inflation and survey inflation expectation.

Some variation is also visible in the estimates of the other parameters (Figure 9), with the weight on expectations increasing over most of the 2000s relative to the level of persistence, and the effect of the exchange rate, but not relative to the level of import prices in euro, which slightly increased over time.

Figure 9.a: Coefficient of slack measure

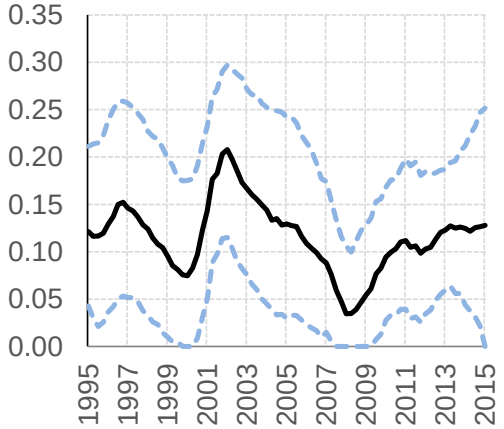


Figure 9.b: Weight on expectations

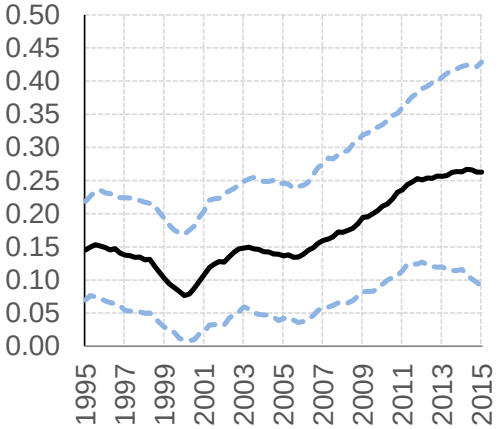


Figure 9.c: Weight on inflation persistence

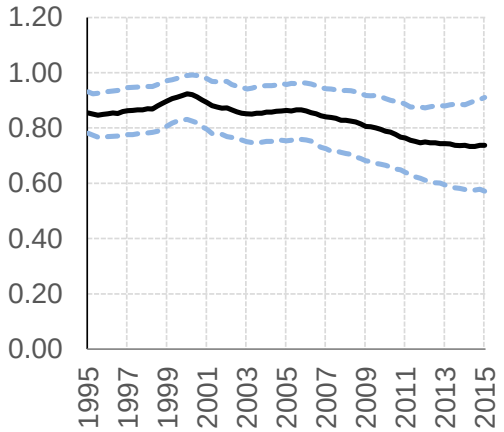
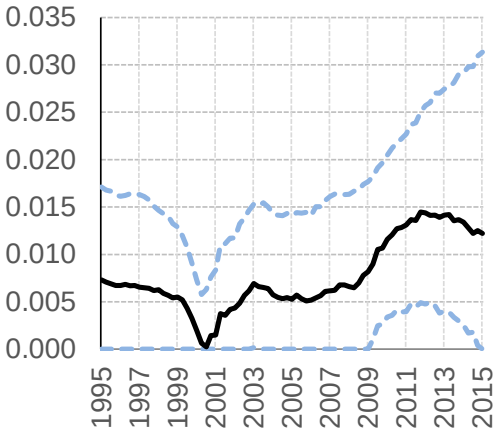


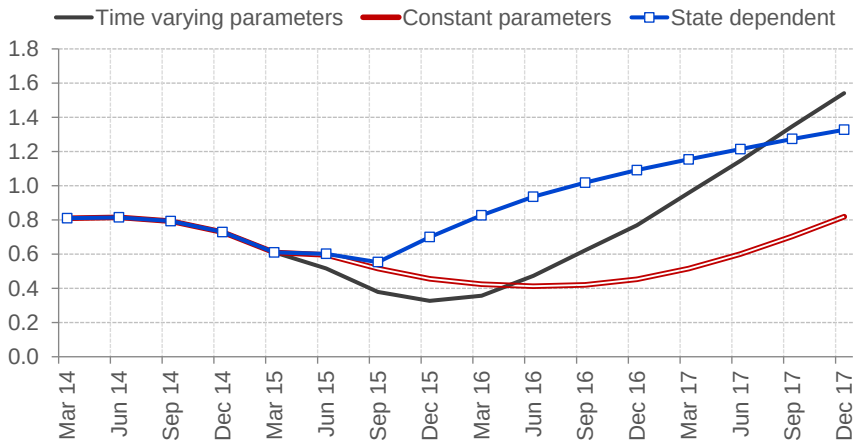
Figure 9.d: Coefficient of import prices



Source: ECB staff calculations.

The impact of the change in the central parameter estimates on conditional predictions is not negligible. Indeed, estimating this model with constant and with time-varying parameters and feeding it with technical assumptions based on the June ECB staff macroeconomic projections for import prices, exchange rates and the measure of slack (i.e. the unemployment rate, as the gap is estimated endogenously within the model), as well as for projected inflation expectations, yields a significantly steeper profile for inflation excluding food and energy over the next two-and-a-half years (Figure 10). The steepening of the Phillips curve also helps improve its ability to fit the low inflation episode, together with the use of measures that indicate wider negative slack and short- to medium-term survey inflation expectations.

Figure 10: conditional forecast of HICP excluding energy and food: constant vs time-varying parameters (state-dependent and unrestricted approach)
(annual percentage changes)



Source: ECB staff calculations.
Note: conditional on the expected path of the unemployment rate, import prices, exchange rate, and a proxy for medium term inflation expectations for 2015Q2 to 2017Q4

4. Conclusions and lessons for monetary policy

Inflation dynamics since the Great Recession have shown signs of instability that have led to a sequence of systematic forecast errors. The two puzzles of "missing disinflation" and successive "excessive disinflation" triggered a surge of new research around the Phillips curve and its possible demise, which seems to have been prematurely foretold.

There is an important common factor in inflation in the advanced economies that helps explain national inflation dynamics. The current phase of low inflation, aside from commodity price developments, is significantly influenced by negative demand shocks both at the global and national level.

In particular, the recent low inflation in the euro area was largely triggered by domestic demand weakness, which probably led to a larger degree of economic slack than was predicted by the usual methods.

The Phillips curve seems to survive the recent reassessment and is still a valid tool of analysis in the euro area, meaning that a sustained recovery in inflation is conditional upon real activity and inflation expectations.

The link between inflation and real activity appears to have strengthened in the euro area recently. Provided our policies are able to significantly reduce the output gap, we can rely on a material effect to help bring the inflation rate closer to target.

APPENDIX

Figure A.1.a:Two estimates of potential output

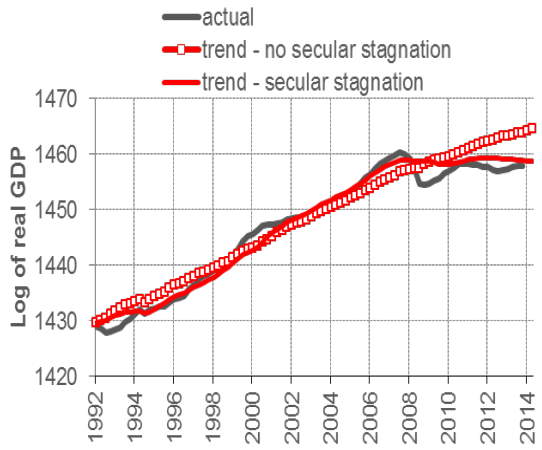
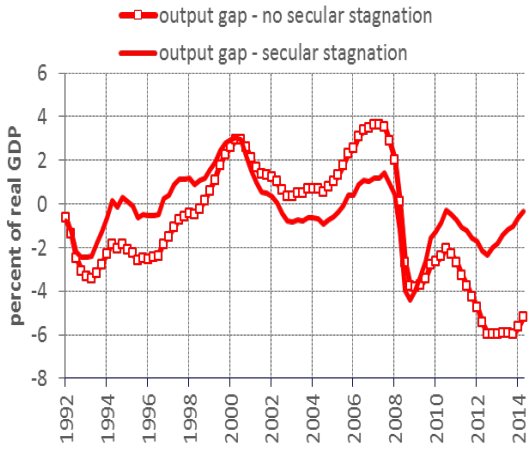


Figure A.1.b:Corresponding output-gap



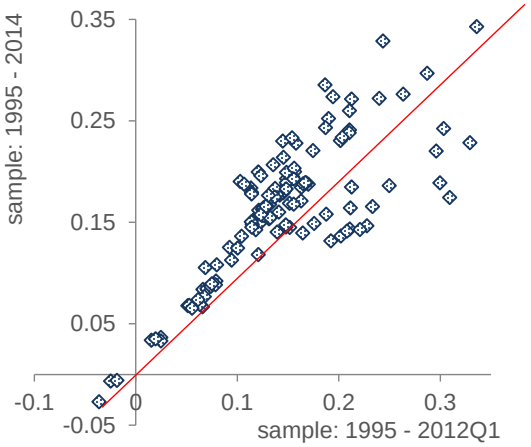
Source: M. Jarocinski and M. Lenza (ECB WP, forthcoming).

Note: Models include the same real activity indicators (real GDP and its components, unemployment rate, capacity utilization, consumer confidence) but differ in the econometric model of trends:

Model 1 (no secular stagnation) – restricts changes in trend output growth.

Model 2 (secular stagnation) – allows permanent changes in trend output growth.

Figure A.2: Euro area Philips curve estimated over two samples



Source: ECB staff calculations

Note: Annualized Q-o-Q growth rates of seasonally adjusted HICP excluding energy and food regressed against its first lag, lagged slack measure, lagged imported inflation and inflation expectations. Slack measures are standardized for comparability.

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