II. Special topics on the euro area economy

II.1. Analysing euro-area inflation using the Phillips curve (17)

This section reviews recent inflation developments and discusses the short-term outlook for inflation using a simple open-economy New Keynesian Phillips curve (NKPC).

We first estimate the NKPC with time-varying parameters to analyse whether any longer-term changes could be detected in the relationship between inflation and its determinants. We then provide short-term inflation projections for the euro area and discuss the level of uncertainty surrounding these projections.

Our results suggest that the sensitivity of euro-area inflation to the output gap may have increased since 2007. It remains unclear, however, whether this implies a structural change in the relationship between inflation and output. Looking ahead, projections obtained using the NKPC support the view that we are going to see a prolonged period of subdued inflation in the euro area. Annual inflation is projected to slowly start accelerating only towards the end of 2014. Based on the historical variance of the parameters of the NKPC, our assessment of the uncertainty surrounding the projection suggests that the probability of euro-area inflation turning negative over the next two years is small, while the probability of inflation rising to significantly above 2% is close to negligible.

Introduction

Inflation in the euro area, as measured by the harmonised index of consumer prices (HICP inflation), has been falling markedly since autumn 2011. It declined from an average of 2.7% in 2011 to 1.4% in 2013, and to an average of 0.6% for the first five months of 2014. This low level of inflation has resulted from the interaction of a number of factors: the temporary effects of previous increases in indirect taxes and administered prices faded in 2013, and slowing inflation of commodity prices, subdued global price pressures, and a strong euro have all contributed to a decline in import prices. At the same time, the weak economic environment in the euro area, together with the ongoing macroeconomic adjustment in a number of Member States, has acted as a drag on inflation from the domestic side.

To gain a better insight into the current inflation dynamics in the euro area, this section examines recent inflation developments and considers the short-term outlook for inflation using the Phillips curve. The Phillips curve represents the relationship between real economic activity and inflation, the original version having been based on the link between unemployment and wage growth. There are a number of different specifications of the Phillips curve, each reflecting different assumptions on, for example, price rigidity and the way in which inflation expectations are created. (18) Two central elements common to most modern specifications, however, are the positive relationship between real economic activity and inflationary pressures in the short term, and the importance of inflation expectations.

The specification used here is a simple open economy New Keynesian Phillips curve (NKPC), which includes, as explanatory variables, realised inflation, directly observable inflation expectations, the output gap (as a gauge of cyclical price pressures) and exchange-rate-adjusted oil prices. We first use the model to analyse whether any longer-term changes could be detected in the relationship between inflation and its determinants. We then generate short-term inflation projections for the euro area and assess the level of uncertainty surrounding these projections.

The New Keynesian Phillips curve and inflation dynamics seen to date

The estimates of the time-varying parameters are based on an open-economy NKPC, with annual changes in HICP as the dependent variable:

---

(17) Section prepared by Christina Jordan and Lauri Vilm. 

\[ \pi_t = \epsilon_t^E \pi_{t+1} + \epsilon_t^{hil} \pi_{t+1} + \lambda_{gap} + \gamma \ln(e_{oil}) + \epsilon_t \]  (1)

The model features both a backward- and a forward-looking inflation component (i.e. it is a hybrid model).\(^{(19)}\) As price setting is assumed to be staggered, expected future price developments affect current prices. We also assume, however, that a certain proportion of firms either set their prices on the basis of a backward-looking rule, or index them to past inflation.\(^{(20)}\) In the baseline estimation, expectations \((E, \pi_{t+1})\) for inflation rates one year ahead are obtained from the European Central Bank’s (ECB’s) Survey of Professional Forecasters.\(^{(21)}\) By using measured inflation expectations such as these, we are effectively able to keep any information on the inflation outlook that may have influenced professional forecasters’ predictions, which we would not have been able to infer by modelling inflation expectations.\(^{(22)}\) Moreover, this approach allows us to avoid making specific assumptions on the way in which inflation expectations are formed.

Domestic price pressures are measured by the output gap \((\text{gap})\) which, under certain assumptions about production technology and the labour market structure, approximates real marginal costs, the most relevant measure of economic activity in NKPCs.\(^{(23)}\) In view of the difficulties with measuring cyclical price pressures and inflation expectations, we also generate estimates using alternative measures of the output gap and inflation expectations (see below).\(^{(24)}\)

As euro-area inflation is significantly affected by volatility in energy prices, we control for energy prices by adding the annual percentage change in Brent crude oil prices in euro terms \((\Delta \ln(e_{oil}))\). Changes in the euro exchange rate have a strong influence on import prices and inflation, via their impact on imported energy and oil prices. Our specification can therefore be considered an open-economy model in which external price pressures are represented by oil prices in euros. The last term is an independently and identically distributed error term.

The estimates of the time-varying parameters are shown in graph I.1.1.\(^{(25)}\) They suggest two main trends, the first being the increasing influence of changes in oil prices on inflation. Intuitively, this appears to reflect the general increase in oil prices over the last decade and the corresponding increase in expenditure on oil as a proportion of total consumption expenditure.

The second, and more important, trend to be observed from the graph is the increase in the sensitivity of inflation to the output gap since 2007. This could either indicate a ‘re-steepening’ of the (linear) Phillips curve\(^{(20)}\) in recent years (i.e. a change in the structural relationship between inflation and the output gap) or reflect the concave nature of the Phillips curve (implying that inflation responds noticeably to a widening of the negative output gap only if this gap is sufficiently large). There is only scant and controversial evidence on the functional form of the euro-area Phillips curve. Irrespective of the assumed shape of the curve, however, the notion that euro-area inflation has...
reacted more strongly to economic slack in recent years is plausible, given the size and persistence of the negative output gap. The existence, over a period of time, of a large negative output gap may have weakened the downward rigidity of nominal wages, or may have induced firms to accept lower mark-ups than they would have otherwise. Structural reforms, especially relating to labour markets, may also have increased the sensitivity of inflation to economic slack. Although our findings are in line with evidence provided by Benkovskis et al. (2011), who suggest that the relationship between inflation and activity in the euro area has indeed been changing over time, (27) with the correlation peaking during recessions, further research would be needed in order to analyse this question in depth.

**Projecting future inflation in the euro area using the NKPC**

What does the NKPC tell us about the outlook for inflation? Our inflation projections are based on the latest values of the Phillips curve parameters, the growth outlook from the 2014 Spring Forecast (28) and, in respect of the future development of oil prices and the exchange rate, on the assumptions used in the European Commission's forecasts. (29)

---


(29) While oil-price assumptions are based on the prices prevailing on futures markets, exchange-rate assumptions are made on the basis of the technical assumption of constant nominal exchange rates.
In addition to the baseline estimation introduced previously, we also estimate NKPCs using alternative measures of the output gap and inflation expectations. In the ‘output gap, production function approach’ estimation, we base our proxy for the output gap on official data on potential output, as published in the 2014 Spring Forecast, which is calculated using the production function methodology. (30) While this measure of the output gap provides an alternative way of estimating the degree of economic slack in the euro area, it does not resolve the main issue that output gaps are difficult to measure precisely, let alone in real time.

In the ‘inflation-linked swaps, 1 year ahead’ estimation, we use the output gap data from the baseline estimation (Hodrick-Prescott filtered) but use one-year spot inflation-linked swap rates as a measure of inflation expectations. (31) Market-based measures appear to be somewhat more forward-looking than inflation expectations based on the ECB’s Survey of Professional Forecasters.

The ‘inflation-linked swaps, 1 year forward, 2 years ahead’ estimation uses one-year implied forward inflation-linked swap rates two years from the date in question to address the fact that short-term inflation expectations tend to closely follow actual inflation. As implied forward inflation-linked swap rates are likely to react less to actual inflation than spot rates, this approach may at least partly mitigate the problem stemming from the endogeneity of inflation expectations.

All the estimations support the view that there will be a prolonged period of subdued inflation in the euro area (see graph II.1.2). Depending on the specification used, inflation is projected to bottom out in the second or third quarter of 2014. All the specifications show inflation starting to accelerate slowly towards the end of 2014 and reaching a level of between 1.0% and 1.2% in the first quarter of 2016.

Inflation is projected to stop declining partly as a result of the assumed slowdown in external disinflationary pressures (see graph II.1.3). The recent fall in oil prices, which has seen Brent crude oil sliding from USD 120/bbl in the first quarter of 2012 to USD 109/bbl in the first quarter of 2014, is projected to slow. Brent futures show that oil prices are expected to fall to USD 107/bbl in the fourth quarter of 2014 and to USD 102/bbl in the fourth quarter of 2015. At the same time, the effects of the marked strengthening of the euro, which appreciated by some 11% against the US dollar between July 2012 and March 2014, slowly fade, as we assume that the exchange rate will stay constant at 1.36 USD/EUR (a technical assumption). In addition, the predicted strengthening of economic growth and the associated narrowing of the output gap is expected to cause a gradual increase in domestic price pressures in the euro area in the years ahead. Both survey- and market-based measures of inflation expectations confirm the view that inflation in the euro area will remain low, only increasing very gradually in the short to medium term.

---

(30) As the official potential output data is annual, we derive a quarterly series using quadratic interpolation, ensuring that the sum of the quarterly points within a year is equal to the annual point.

(31) Inflation-linked swaps are contracts that are usually structured as zero-coupon instruments, where, at maturity, the two parties exchange payments of a fixed rate of inflation and a floating rate linked to realised inflation.
II. Special topics on the euro area economy

The NKPC projection shows an inflation profile similar to that in the 2014 Spring Forecast, albeit at a slightly lower level. The difference reflects the fact that the Spring Forecast is based on a bottom-up approach, which takes into account country-specific factors affecting inflation, e.g., changes in economic policies, changes in indirect taxes and administered prices, and base effects (i.e., the effect of the inflation seen in the corresponding period of the previous year). It is therefore based on a more comprehensive and disaggregated view of future price developments, whereas the NKPC projection provides information on factors relating to the euro area as a whole that could affect the inflation outlook, and can thus serve as a useful ‘cross-check’.

Uncertainty surrounding the NKPC projection

The NKPC projection could be brought into question by either the uncertainty surrounding the assumptions made or the uncertainty surrounding the model itself. To measure the level of uncertainty associated with our projection, we derive confidence intervals around the NKPC baseline projection, based on the historical volatility of both the explanatory variables and the model itself. For the purpose of constructing the related fan chart, the assumptions used are considered mean assumptions. For simplicity, inflation expectations are assumed to be formed on the basis of past trends in inflation. In addition, the NKPC is assumed to be subject to stochastic shocks whose standard deviations are derived from fixed-coefficient estimations.

The methodology used in constructing the fan chart has several caveats and it should therefore be interpreted as an indicator rather than as an exact measure of uncertainty. First, the assumptions that inflation expectations are formed on the basis of past inflation rates and that the explanatory variables follow autoregressive processes are considerable simplifications of reality. Secondly, we assume that disturbances to the NKPC, $\epsilon_t$, follow the historical variance derived from the fixed-coefficient estimations. Observed changes in the NKPC parameters may well, however, have caused a change to the uncertainty associated with the projection. Thirdly, this methodology derives uncertainty from historical volatility, but current uncertainty around the projection may in fact differ significantly from this.

Graph II.1.4 shows the fan chart with 40%, 70% and 90% confidence intervals around the NKPC inflation projection. Based on the historical volatility of the explanatory variables, inflation is expected to be between 0.2% and 2.3% at the start of 2016, with a likelihood of 70%. Although, in 2015, there is a small probability (around 10%) of negative inflation rates, this would occur only were there to be a very severe shock to the forecast assumptions. Such a shock could, for example, take the form of a decline in oil prices of around 25% together with a negative output gap 0.5 percentage points larger than expected. Alternatively, the NKPC simulations suggest that a negative output gap around 1.5 percentage points larger than expected could on its own drive inflation into negative territory. At the other end of the

Footnotes:

(32) For oil prices, exceptionally volatile periods (from Q1 1999 to Q4 2000 and from Q4 2007 to Q4 2010) are excluded from the calculation of historical variance.

(33) In constructing the fan chart, we assume that parameters will remain constant at their Q1 2014 levels over the time period in question. Assumed processes for the explanatory variables are

$$\Delta \ln(e_{oil}) = \beta^2 \Delta \ln(e_{oil_{t-1}}) + \epsilon_t^{\text{oil}}$$

and

$$E_{t} \pi_{t+1} = \beta^3 \pi_{t-1} + \epsilon_t^{\pi}$$. 

(34) There are several reasons why the current level of uncertainty around the inflation projection may differ from the historical average. First, the euro-area economy has just begun to recover and the relatively high uncertainty around current growth forecasts directly increases the uncertainty associated with our inflation projection. As noted in the 2014 Spring Forecast, downside risks to the growth outlook are still present. Secondly, economic slack in the euro area has been historically high for a prolonged period, which may have a larger-than-expected disinflationary effect.
probability band, the likelihood of inflation rising to significantly above 2% over the next two years is very small.

**Concluding remarks**

The time-varying parameter estimations of the NKPC suggest that there have been some changes in the relationship between euro-area inflation and its determinants since the late 2000s. In particular, the role of the output gap in explaining inflation in the euro area appears to have increased. This seems plausible given the size of the output gap in the euro area in the aftermath of the financial crisis and the persistence of this gap in recent years. It remains unclear, however, whether this implies a structural change in the relationship between inflation and output in the euro area. Looking forward, the NKPC confirms the picture of a prolonged period of low inflation in the years ahead and projects inflation to slowly start accelerating towards the end of 2014. The baseline projection yields average annual HICP inflation rates of 0.7% for 2014 and 1.0% for 2015, on the basis of the technical assumption of a stable exchange rate, market expectations that the fall in oil prices will slow, and the gradually strengthening economic recovery in the euro area.