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Low inflation in the euro area: Causes and consequences

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Contents

Abstract

After 2012, inflation has been unexpectedly low across much of the developed world and economists speak of a “missing inflation” puzzle, namely inflation was expected to be higher on the back of an ongoing recovery. This paper investigates the causes and consequences of low inflation in the euro area after 2012 and analyses whether monetary policy has been successful in dampening the risks associated to low inflation. The paper finds that the missing inflation was primarily due to cyclical factors – domestic in the earlier part of the period and global in the latter part – and that the Phillips curve remains a useful tool in understanding inflation dynamics over the period of interest. The succession of negative shocks constrained headline inflation for a prolonged period, and there is evidence of an increase in the persistence of inflation and a fall in the trend inflation rate, which had begun to have a greater influence on longer-term inflation expectations. This may have signalled uncertainty over the effectiveness of unconventional monetary policy measures, but public belief in the ECB’s commitment to keep the annual rate of HICP inflation below but close to 2% has remained intact. The paper concludes that unconventional monetary policy measures are effective in mitigating the downside risks to price stability, curtailing risks of de-anchoring, and expanding aggregate demand.

Keywords: low inflation; Phillips curve; inflation expectations; unconventional monetary policy

JEL codes: E31; E52; E58

Executive summary

Since the Great Recession, inflation worldwide has become more difficult to understand, and economists speak of a twin puzzle. First, inflation was expected to be lower between 2009 and end-2011, given the severity and length of the recession in most advanced economies (missing disinflation). Second, more recent global developments point in the opposite direction (missing inflation): inflation was expected to be higher in most advanced economies after 2012, on the back of the ongoing recovery. Instead, inflation was persistently below target largely due to global disinflationary shocks that were mostly related to the fall in the price of oil since 2011. Since mid-2014, this fall in oil prices has become even more severe. This prolonged and surprising low inflation prompted monetary policy action through non-standard measures, without which inflation would have arguably been much lower.

This paper presents research conducted by a network of experts from the European System of Central Banks (ESCB) – i.e. the 28 national central banks of the European Union (EU) and the European Central Bank. It focuses on the second puzzle after 2012 and on the euro area, and addresses missing inflation through three interrelated questions: (i) Why has inflation been low? (ii) What have been the consequences? (iii) Has monetary policy been successful in counteracting them and through which channels?

Between 2012 and mid-2016, both headline and core inflation in the euro area and in most member states have been lower than the forecasts produced by the Eurosystem and by other institutions. Over the same period, there are indications that trend inflation declined and inflation persistence increased.

There is an increasing literature pointing to possible structural changes (e.g. demographics, technology), which could be consistent with decreasing trend inflation. However, a key finding of this paper is that the missing inflation was rather due to cyclical factors, both global and domestic. Global shocks and commodity prices were the main drivers of the disinflation in the euro area, but after 2012 domestic drivers were also very important.

For domestic sources of inflation, one of the main conclusions of this paper is that the Phillips curve remains a useful tool in understanding inflation dynamics in the most recent disinflation period. In the euro area and in some euro area countries – especially where labour market slack has been large and protracted – the sensitivity of inflation to economic slack has recently strengthened.

The main potential consequence of low inflation is that it may become self-sustaining through three main channels: de-anchoring of inflation expectations, competitiveness, and debt deflation. The paper discusses the latter two theoretically and dives empirically in the expectations channel.

Some empirical studies suggest that potential risks of a de-anchoring of inflation expectations might have emerged in 2014, following a prolonged period of low inflation due to a sequence of adverse shocks at the effective lower bound (ELB) of interest rates. This is consistent with declining indicators of trend inflation, the finding that disinflationary shocks have been both global and domestic, and the evidence of a recent increase in the intercept of the Phillips curve in the euro area.

When discussing de-anchoring of expectations, however, it is essential to disentangle decreased confidence in the *commitment* of the central bank to its stated objective from increased inflation persistence. At the ELB, increased persistence reflects both the sequence of negative shocks and the longer-than-usual time lag of monetary policy transmission. Hence, agents may take time to learn about the *effectiveness* of the policy instruments.

The results in this paper point to signs of increased inflation persistence. After the fall in oil prices in 2014, pass-through from current inflation and short-term inflation expectations to longer-term inflation expectations (a standard metric to gauge anchoring of inflation expectations) also increased. However, when looking at a variety of measures of pass-through based on the reaction of expectations to macroeconomic news, the signs of de-anchoring became weaker, the longer the horizon of expectations. These findings imply that the confidence in the central bank's commitment has remained largely intact.

Has policy been effective in counteracting the consequences of low inflation, and through which channels? In terms of available monetary policy instruments at the ELB, unconventional measures such as forward guidance and asset purchases are effective in mitigating the downside risks to price stability, curtailing risks of de-anchoring, and expanding aggregate demand.

This paper analyses the expectations or re-anchoring channel and the exchange rate channel. It finds robust evidence on the effectiveness of the Asset Purchase Programme (APP) in re-anchoring expectations. The exchange rate channel can also be powerful even if it is difficult to pin down the exact size of its impact because of large estimation and model uncertainty. It is particularly strong when the exchange rate is moved by monetary policy shocks, both conventional and unconventional. These findings imply that unconventional monetary policies have been successful in counteracting low inflation.

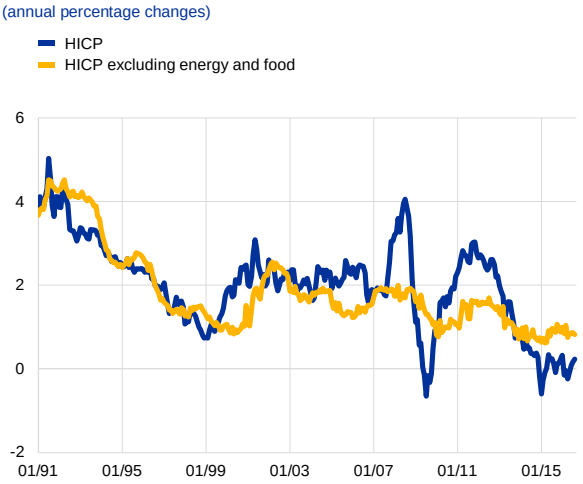
1 Introduction

This paper is about low inflation in the euro area over the period 2012-2016. It discusses some of the structural and cyclical factors behind inflation developments and proposes answers to three main questions: (i) Why has inflation been so low in the euro area? (ii) What are the economic consequences of this low inflation? (iii) What can policy do and through which channels?

Inflation has been low for a prolonged period and there has been a decline in trend inflation after 2012

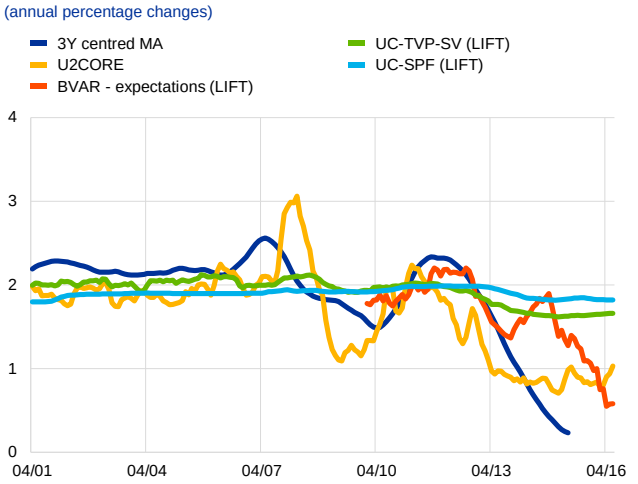
Inflation in the euro area has been persistently low after 2012 despite the progressive economic recovery (**Figure 1**) and, apart from cyclical factors, there is also discussion about a decline in trend inflation. Trend inflation is unobservable and there is no clear agreement on its definition or its measurement. Over the longer term, trend inflation should equal the quantitative '*below-but-close to*' 2% inflation objective. However, if the shocks moving inflation away from the policy target have been protracted and the economy is undergoing adjustment, there may be limits to the speed at which monetary policy can bring inflation back to target and this is picked up by measures of trend inflation.

Figure 1
Headline inflation and HICP inflation excluding energy and food



Source: Eurostat. Last observation: June 2016.

Figure 2
Measures of trend inflation in the euro area



Source: SPF, Eurostat, ESCB calculations. Last observation: June 2016.
Note: see footnote 1.

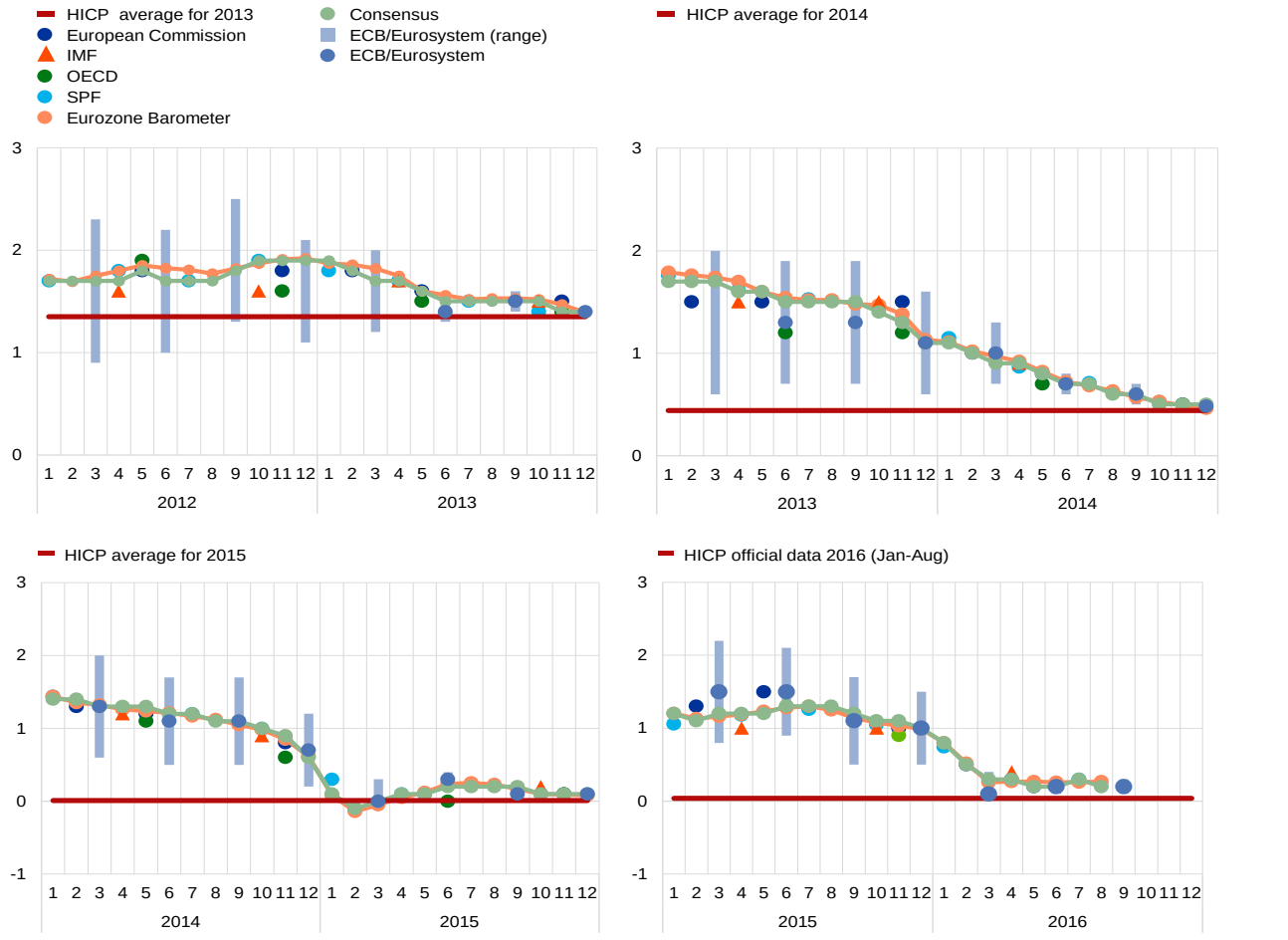
Available measures for the euro area indicate that trend inflation in 2014-16 was well below pre-crisis levels. **Figure 2** shows five such estimates, which, despite some variability, point to the same conclusion of a decrease in trend inflation.[1]

Inflation has not only been low, but also systematically over-predicted…

Not only has inflation in the euro area been persistently low: from 2012 to the summer of 2016, both headline and core inflation (measured as HICP ex energy and food) were also systematically overpredicted by the ECB and Eurosystem, as well as other institutions and professional forecasters. (The four panels of **Figure 3** show how the inflation projection for 2013, 2014, 2015 and 2016 from various institutions evolved over various projection rounds).

Figure 3

Evolution of projections for average headline inflation in 2013, 2014, 2015 and Jan.-Aug. 2016



Source: ECB, IMF, European Commission, OECD, Consensus Economics.
Note: The horizontal axis shows the publication date of the forecast.

[1] The measures are: (1) a three-year centred moving average; (2) U2CORE, based on a dynamic factor model approach; (3) the long-term mean (or steady state) of the inflation process within a BVAR with market-based inflation expectations at various horizons (estimated with a rolling window); (4)-(5) are measures based on unobserved component (UC) models, where trend inflation is the permanent component of the Beveridge-Nelson decomposition: the first measure (4) assumes time variation in the persistence and volatility of inflation (UC-TVP-SV), and the second (5) uses long-term inflation expectations to estimate the trend within the UC model (UC-SPF).

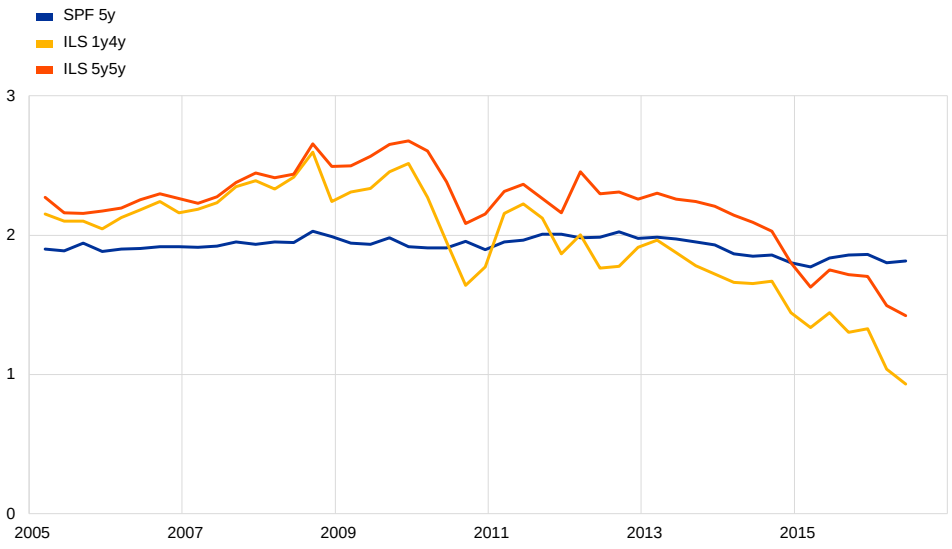
…and inflation expectations have declined

A third worrisome fact beside the prolonged period of low inflation and its systematic overprediction was the decline in inflation expectations over 2013-15. Unfortunately, reliable measures of the expectations of economic agents, such as from consumer and business surveys, are not available for the euro area: the only ones that are readily available are from surveys of professional forecasters and financial markets. Both have been falling at various horizons following the low inflation since 2012, although the survey-based ones to a much lesser extent (see **Figure 4**). The protracted downward movements in market-based inflation expectations deepened significantly in the second half of 2014. The launch of the ECB's Asset Purchase Programme (APP) early in 2015 stabilised expectations as measured by surveys, while market-based measures continued to respond strongly to commodity prices. For a discussion of the effectiveness of the APP and its channels, see e.g. Andrade et al. (2016).

Figure 4

Historical evolution of market-based and survey-based longer-term inflation expectations

(HICP; annual percentage changes)



Source: Market-implied rates are based on ILS (inflation-linked swaps) and survey-implied rates come from SPF (Survey of Professional Forecasters). Last observation: June 2016.

These developments raised several concerns. HICP inflation that deviates from target persistently is worrisome for monetary policy because it may become entrenched in expectations. This study tries to shed light on whether it was just “bad luck” (due to external supply forces such as falling commodity prices and, until 2014, the high euro exchange rate), or also longer time lags in the transmission of new policy instruments.

Was it only the fault of unexpected, largely foreign, shocks?

Not only headline, but also underlying rates of inflation have been below average almost everywhere. HICP inflation excluding energy and food has also been systematically overpredicted since early 2012. This is particularly worrying for monetary policy because, although the ECB primary objective is stated in terms of headline HICP inflation, HICP excluding energy and food inflation is a better predictor of the trend in headline inflation than the headline itself on a medium-term

horizon.[2] Moreover, the decline in core inflation (and the steady gap between core inflation in the euro area and in other advanced countries over the period 2012-2016) may indicate that the decline in inflation in the euro area is to a significant extent a domestic phenomenon.

Prolonged low inflation and "growth-inflation disconnect"

The persistent decline in inflation since 2012 with a (slowly) recovering economy has also led observers to question the traditional relationship between economic slack and inflation, not only in the euro area but also in most advanced economies. In fact, after the Great Recession, a twin puzzle emerged: during the recession that followed the financial crisis, inflation did not fall as much as a traditional Phillips curve would have predicted, given the severity and length of the recession.[3] Just as puzzling, in spite of the ongoing recovery, headline inflation rates in advanced economies have remained below target for a long time.

Domestic cyclical drivers of inflation: is the Phillips curve dead?

If we ignore long-term structural features, from a cyclical point of view the seemingly weakened relationship between inflation and economic slack in the cases of the two puzzles seemed to have disposed of the Phillips curve. Indeed, despite a few dissenters,[4] the majority view in the literature, especially for the US, is that the coefficient of economic slack (or slope) in the Phillips curve has declined since the 1990s, so inflation would not rise as much as expected even if the output gap were closing.[5] This has been explained in many ways, some more cyclical and some more structural, as discussed below.

Structurally, globalisation may have reduced the responsiveness of inflation to domestic cyclical conditions

From an external/global perspective, higher import volumes due to increased globalisation have 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. Also, as a result of globalisation, inflation across countries displays an important common factor over and above the impact of international commodity prices, which is the result of common shocks propagated over more complex global value chains and the convergence of monetary policy frameworks around the world. This is shown for OECD countries (including the euro area) by Ciccarelli and Mojon (2010) and Ferroni and Mojon (2016), who also report that taking the global inflation factor into consideration would improve forecasts of domestic inflation. Confirming these results, Medel et al (2016), using a sample of 31 OECD countries, report that properly accounting for the global inflation factor improves the inflation forecast for 50% of the countries for headline inflation and for 40% for core inflation. Nevertheless, the improvements in the forecasts mentioned in these papers are moderate, producing a 5% to 6% reduction in the root mean squared errors.[6]

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2 See Box 7 "The relationship between HICP inflation and HICP inflation excluding energy and food" of the ECB Economic Bulletin Issue 2, 2016.

3 See Williams (2014) and Ball and Mazumder (2011).

4 See, for instance, Stella and Stock (2012).

5 See e.g. Kuttner and Robinson (2010) for a review of the literature on the flattening of the Phillips curve, and Choi and Kim (2016) for a theoretical explanation based on alternative price-setting behaviours.

6 By contrast, Lodge and Mikolajun (2016) find a smaller role for global slack in domestic inflation.

The analysis presented in Section 2.3 below shows that the path of inflation in the euro area since 2012 was not out of the range of outcomes that standard Phillips curves would have predicted, although in some periods it was closer to the lower end of that range. This indicates that domestic economic conditions were an important driver of the low inflation, along with external disinflationary shocks and, possibly, some interaction with the secular structural forces discussed below.

The slope of the Phillips curve may be state-dependent

In terms of domestic factors, one explanation for the weak recent inflation outcomes relates to possible non-linearities in the relationship between inflation and real activity. The coefficient of the real activity measure in a Phillips curve may depend on the size[7] and duration of economic slack, the level and volatility of inflation, and the degree of anchoring of inflation expectations. Box 2 discusses various sources of nonlinearity in the Phillips curve; a convex curve (due, for example, to capacity constraints) would not explain the low level of inflation during the prolonged recession experienced. However, the shape of the nonlinearity can be even more complex, depending not only on states characterised by recession and expansion, but also on the depth and length of recessions: in deep and prolonged recessions inflation may react more to slack, as firms are more willing to cut prices in order to maintain their market share. An increase in the response of inflation to slack has indeed been documented in some countries in the euro area, such as Spain (see Álvarez et al. (2015)). This increase in the sensitivity of inflation to economic slack is consistent with a reduction in nominal rigidities, which may in turn be due to the depth of the recession itself, as well as the implementation of structural reforms in the labour and product markets.[8] Both factors would naturally increase the degree of competition.

Are there risks of de-anchoring of inflation expectations?

The systematic overprediction of inflation and decline in inflation expectations raised concerns about the risks of a de-anchoring of inflation expectations. Were these concerns warranted? More specifically, did the degree of anchoring change over recent years?

Commitment vs ability to maintain price stability: target credibility vs increased inflation persistence

The question is also important as it addresses issues of central bank credibility and policy effectiveness. If monetary policy is credible, economic agents believe in the central bank's **commitment** and **ability** to maintain price stability. In such an environment, inflation expectations are well anchored and remain close to the officially announced inflation target without exhibiting any persistent upward or downward movements. The focus is generally on longer-term rather than shorter-term inflation expectations, because inflation can be heavily affected by shocks that cannot be counteracted by monetary policy within a short time horizon. Persistent deviations of longer-term inflation expectations from the target, therefore, suggest an increased risk of inflation expectations becoming de-anchored.

Importantly, however, one must distinguish between a shift in the long-term mean (or steady state) of the inflation process and an increase in the persistence of the

7 Using Spanish data, Álvarez et al (2015) find evidence on asymmetry in the Phillips curve, with inflation reacting more to cyclical conditions in recessions.

8 For the case of Italy, for instance, a country for which detailed data are available, Fabiani and Porqueddu (2017) find an increase in the frequency of price adjustment in the aftermath of the crisis.

inflation dynamics around the long-term mean, which leads to longer-lasting effects from temporary inflation shocks. Both indicate a risk of de-anchoring, as both represent a loss of central bank credibility, but in different dimensions and with different implications.

Conceptually, shifts in the mean inflation rate expected in the long run indicate impaired trust in the central bank's commitment to achieve and maintain price stability. In fact, they imply a de-anchoring of public perceptions of the central bank's inflation target from the officially announced target. By contrast, increased inflation persistence may imply an erosion of the effectiveness of the central bank's policy in stabilising inflation. Policy effectiveness can be hindered by strong rigidities in product and labour markets as well as by strains in the monetary policy transmission process, for instance related to financial market fragmentation. The lower bound also limits the scope of conventional monetary policy, necessitating recourse to non-standard measures.

Impaired belief in the commitment of the central bank is more worrisome than a temporarily weakened ability of the central bank to achieve the target, as it reflects fears of a worsening of the economy's long-term equilibrium. In fact, in a low-inflation environment, any loss of the credibility of the target might reveal expectations of 'secular stagnation' and associated low inflation (or even deflation). By contrast, reduced policy effectiveness, although a problem per se, would only imply a slower recovery towards the pre-crisis long-term equilibrium, featuring positive but sustainable growth and inflation near the central bank's official target.

In sum, when an increased risk of longer-term inflation expectations becoming de-anchored is observed, it is essential for monetary policy makers to disentangle, at least conceptually, the risk of loss of credibility of the target from an increased inflation persistence indicating concerns about policy effectiveness. It is very difficult to ascertain empirically what combination of the two drove the fall in inflation expectations that was observed over the period 2013-2015. However, one of the conclusions of this report is that the signs of a risk of de-anchoring can mostly be attributed to increased inflation persistence following a series of disinflationary shocks that hit while interest rate policy was limited by the effective lower bound.

Are we missing some new structural features?

The persistence of inflation forecast errors has led many to wonder whether current frameworks for interpreting and forecasting inflation may be missing new structural features coming e.g. from demographic trends or new behaviours associated with technological innovation such as the spread of online sales, both business-to-business and at consumer level.

The impact of demographic change and e-commerce has recently received increasing attention.[9] This paper focuses only on the aspects of low inflation that are more closely linked to monetary policy, but a brief overview of the impact on inflation of these two structural processes is in order.

[9] See for example in the public debate, an article in the Wall Street Journal of 13 December 2015, “The Mystery of Missing Inflation Weighs on Fed Rate Move”.

Some studies argue that there is a disinflationary effect of population ageing

Regarding demographic change, there is some literature on an overall disinflationary pressure from population ageing, possibly due to a preference among older, dissaving cohorts for high real interest rates (Bullard et al. (2012)). Demography can affect inflation through various channels, which can work in different directions as discussed in detail in Box 1. Most empirical results have focused on Japan, as its transition from ageing to aged society is one of the fastest (Yoon et al. (2014), Anderson et al. (2014), Bullard et al. (2012), Katagiri (2012)). All these studies find that population ageing is disinflationary. Bobeica et al. (2017) find that the growth rate of the working-age population as a share of the total population is cointegrated with CPI inflation in the EA, USA and Germany and that the shrinking share of the working age population coincided with falling inflation. However, a recent BIS working paper by Juselius and Takats (2015) contradicts this view: looking at low-frequency correlations, they find that a larger share of young or old cohorts is associated with higher inflation, while a larger share of working-age cohorts is correlated with lower inflation. This highlights how difficult it is to quantify the impact of this structural factor on inflation. The mixed empirical evidence must also be seen against the theoretical considerations on the impact of demographic changes, which affect in the first place the natural rate of interest and potential growth. They would only impact actual inflation when monetary policy does not take into account these changes properly, or when it is constrained by the effective lower bound.

The spread of e-commerce tends to contain price pressure by reducing costs and increasing price transparency

The spread of e-commerce can put downward pressure on prices through two channels: first, compared to standard distribution channels, it opens scope for cost savings at producer and retail level, which both traditional and online retailers may pass on to their customers. This effect alone would not change profit margins in the retail sector, but e-commerce may suppress price pressures through increased price transparency, constraining both traditional and online suppliers. This second effect may erode profit margins, notably in some traditionally face-to-face businesses. Both effects can kick in even when the share of e-commerce sales in the total business is still low. Data on e-commerce are generally scarce, although since 2002 Eurostat has conducted two annual surveys for enterprises and households containing various questions related to the digital economy. Electronic sales by enterprises in 2014 were on average 14% of total turnover of companies in the euro area (unweighted average). While internet sales may not seem very substantial, the share of people using the internet for either information about the features and prices of goods and services or actually purchasing them has more than doubled over the last ten years. In 2014 on average in the euro area, 65% of people looked for purchase information online compared to only 30% a decade before. In terms of buying online, the figure was around 45% in 2014 compared to around 15% ten years before. Despite the very dynamic increase in e-commerce economic activity, recent studies suggest that the effects explain only a very small part of the recent significant decline in inflation (see Box 3).

Structural models are not equipped to account for structural change in the inflation process

It is important to remark that standard (new Keynesian) models of the type used in this paper are not equipped to account for structural change in the long-term inflation process. Those models cannot account for structural changes determined e.g. by demographic changes or technological innovations of the type mentioned above, hence they may attribute structural shocks to a shift in the target. In a model à la

Cogley and Sbordone (2008), for instance, demographic or technological shocks may be (mis)interpreted as a shift in the target, affecting inflation persistence.

When considering all these potential structural forces, it should be kept in mind that they only have an impact on the natural rate of interest, but as long as monetary policy is effective, they do not affect the inflation rate in the long run.

The rest of the paper is structured as follows. Section 2 discusses in detail the factors behind the low inflation and presents robust evidence on the decline in trend inflation, the validity of the Phillips curve and the anchoring of inflation expectations. Section 3 illustrates the consequences of low inflation through the lens of structural models and the channels of self-perpetuating dynamics of low inflation at the ELB. Section 4 discusses the effectiveness of policy measures. Section 5 concludes.

2 Empirical search for cyclical and trend determinants of low inflation: the validity of the Phillips curve and the risks of de-anchoring

Three main empirical exercises were conducted to search for possible factors behind low inflation and try to disentangle the risk of loss of credibility of the target from increased inflation persistence (or to ascertain what combination of the two can account for the observed fall in inflation expectations).

The first set of exercises looks directly at time-series evidence on trend inflation and persistence. One possible cause of a decline in trend inflation (and the most relevant one for monetary policy) is a de-anchoring of expectations, but deeper analysis is needed to disentangle loss of target credibility from increased persistence of inflation following exogenous shocks.

The second set of exercises looks at the relative contribution of external, domestic (mostly real) and financial factors to inflation in subperiods when it was systematically below its mean. The impact of domestic factors is addressed by looking at the shape of the Phillips curve.

Finally, a set of empirical studies looks directly at various measures of inflation expectations and analyses de-anchoring risks mainly by looking at the response in long-term inflation expectations to macroeconomic news and short-term inflation (expectations) dynamics.

To preview the results, the time-series analysis shows a decline in trend inflation and an increase in inflation persistence. There is also a (relative) predominance of domestic drivers of low inflation from 2012 to end-2014, indicating that a self-perpetuating mechanism may have had a role in addition to (and possibly amplifying) the impact of external shocks. When the shape of the Phillips curve is analysed in conjunction with the unhinging of the expectations part of a New Keynesian Phillips Curve (NKPC), the results point to a decrease in the intercept. Finally, the most direct approaches looking at the pass-through of short-term to long-term expectations agree that expectations were anchored for most of the period under review and that signs of de-anchoring appeared in mid-2014 but either reverted or stabilised thereafter. The increase in the bands around most of these estimates in 2015-2016 indicates that uncertainty about the transmission of monetary policy increased. Dovern and Kenny (2017), who focus on the entire probability distribution surrounding long-term inflation expectations, also make this point. They identify a trend toward a more uncertain and negatively skewed distribution with higher tail risk, suggesting that agents may still be learning about the effectiveness of the new monetary policy instruments.

The next sections go through each of these exercises in turn.

2.1 Decline in trend inflation and increase in inflation persistence

Over the period 2012-2015, measures of trend inflation have declined and inflation persistence increased, giving rise to concerns about the anchoring of inflation expectations.

To identify and assess the relative importance of inflation persistence and the long-term mean of expected inflation (which may point to perceived target changes) in explaining the decline in survey and – especially – market measures of inflation expectations, one should account for the different effects of inflation expectations on the term structure. Shifts in the mean affect expectations by similar amounts over all horizons, while changes in persistence affect short horizons more, leading to changes in the slope of the term structure of inflation expectations.

Generally, the literature provides two approaches for this kind of analysis: the first is based on time series models of actual and expected inflation readings. The autoregressive structure of such models captures the persistence of inflation dynamics, while their implied long-term mean provides a measure of trend inflation that can be interpreted in terms of the public's perceived inflation target.

The second approach is a factor decomposition of inflation curves derived from market-based data on inflation compensation. More specifically, using the linearization of the Nelson-Siegel (1987) yield curve model proposed by Diebold and Li (2006), inflation expectations in inflation-linked swap (ILS) rates can be treated as a term structure defined by three unobserved time-varying factors: level, slope and curvature. In particular, the *level* of the term structure curve represents the asymptotic long-run value expected for the inflation compensation, proxying for the perceived inflation target.[10]

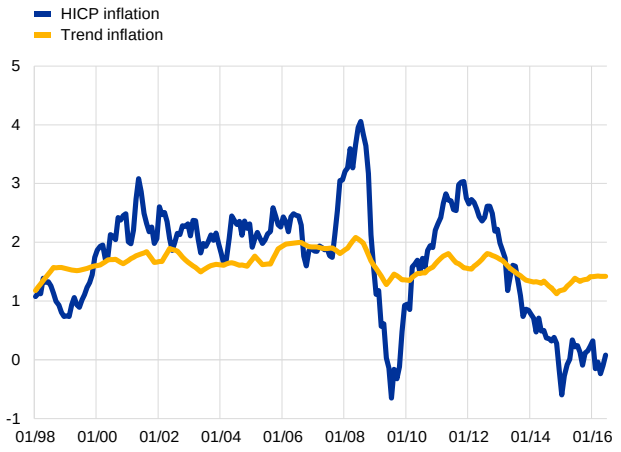
The *slope* is the difference between the level and the shortest maturity, which is the starting point of the curve. Therefore, the level plus the slope determine the short-term expected value for ILS rates. The *curvature* determines the speed of convergence between short and long-term inflation expectations; negative values indicate a delay in convergence with the long run (i.e. increasing persistence) while positive ones accelerate convergence (i.e. declining persistence).

Under the first approach, two time series models have been used to extract trend inflation from actual and expected inflation readings; the results are presented in **Figure 5** and **Figure 6**.

[10] The raw market-based data from inflation–linked swaps actually measures inflation compensation, i.e. agents' expectations plus risk premia, including inflation and liquidity premia.

Figure 5
Trend inflation estimated using survey data

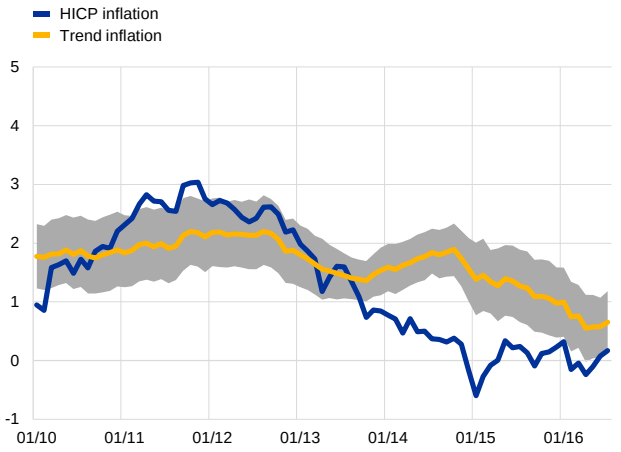
(time-varying-parameter estimates – point, monthly data, %)



Source: ESCB staff estimation. Last observation: June 2016.
Note: Shifting-endpoint model of Kozicki and Tinsley (2001) estimated with survey measures of inflation expectations from Consensus Economics.

Figure 6
Trend inflation estimated using financial market (ILS) data

(60-month rolling window estimates – median, 16/84 percentiles, %)

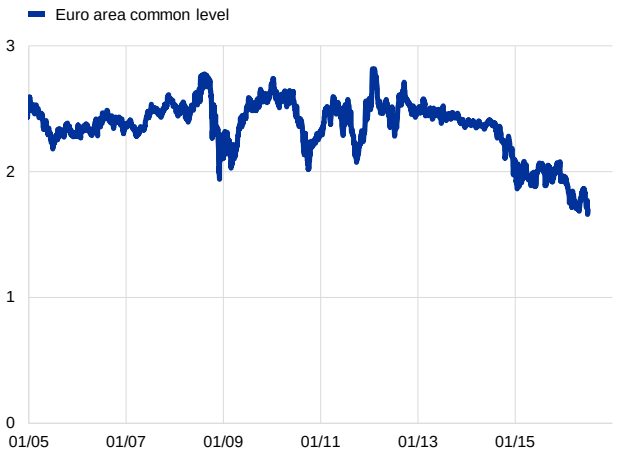


Source: ESCB staff estimation. Last observation: June 2016.
Note: The trend is the time-varying mean inflation rate obtained in a VAR model of current inflation rates and ILS compensation data. Inflation expectations are formed in a model-consistent way, applying cross-equation restrictions as in Cogley (2005). Estimated coefficients are dated at the end of each rolling sample.

According to both models, the protracted decline in headline inflation observed since 2012 indicated downward pressures on trend inflation, though with some delay. Trend inflation started to fall at the end of 2012, dropping below 1.5% in 2014-15 and showing signs of a rebound between the end of 2015 and the beginning of 2016.

Figure 7
The level factor in a term structure model for inflation expectations using swap rates

(%)



Source: Gimeno and Ortega (2016).
Note: Based on daily quotes of zero coupon euro area inflation swaps and daily bid-ask spreads for a wide range of maturities (1 to 30 years).

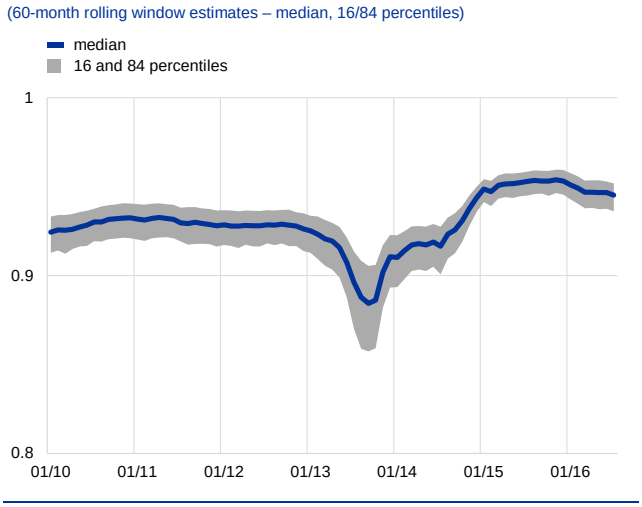
Under the term structure approach, a term structure model was estimated for inflation expectations using euro-area and country swap rates. The estimated euro-area level factor is shown in **Figure 7**. In line with the results above, this estimate fell sharply in 2014, pointing to increased risks of a de-anchoring of inflation expectations. The decline stopped over the period from announcement to implementation of the APP, but resumed at the turn of 2016. At the end of the sample, the indicator is moving sideways, but at a lower level than before the oil price shock (1.7% vs broadly around 2.4% until 2014).

Two of the above three analyses of the long-term inflation mean also provide evidence on the pattern of persistence of the inflation process. The results are summarised in **Figure 8** and **Figure 9**. More specifically, **Figure 8** depicts the time variation in inflation persistence resulting from a VAR-based assessment of actual and expected inflation dynamics. **Figure 9** represents the curvature estimates in the term-structure analysis of market-based inflation expectations.

Although they have different timing (possibly related to their different coverages), both measures point to an increased persistence of inflation towards the end of the sample.

Figure 8

Inflation persistence estimated using financial market (ILS) data



Source: ESCB staff estimation. Last observation: June 2016.
Note: Inflation persistence is the time-varying sum of the autoregressive coefficients of the inflation process obtained in a VAR model of current inflation rates and ILS compensation data. Inflation expectations are formed in a model-consistent way, applying cross-equation restrictions as in Cogley (2005). Estimated coefficients are dated at the end of each rolling sample.

Figure 9

The curvature factor in a term structure model for inflation expectations using swap rates

Source: Gimeno and Ortega (2016). Last observation: June 2016.
Note: Based on daily quotes of zero coupon euro area inflation swaps and daily bid-ask spreads for a wide range of maturities (1 to 30 years).

2.2 Large contribution from domestic factors to low inflation in the euro area after 2012

Addressing the low inflation puzzles by quantifying the contribution of foreign and domestic factors

This section quantifies the relative contributions from domestic and foreign factors since the start of the crisis in the euro area by looking at three phases: 2008-2012, 2012-2014 (when most institutions overpredicted inflation in the euro area systematically) and 2015-2016. The analysis uses Bayesian VARs in two ways: a reduced-form approach (conditional forecasts) and a structural approach (historical decomposition based on identified shocks).[11] In the conditional forecast, three sets of drivers are analysed: domestic variables related to real activity and wages, domestic financial variables and foreign variables.[12]

The first disinflation period was dominated by external factors, but in 2012-2014 domestic drivers dominate

Both approaches suggest that the first disinflation period, which started in 2009, was mainly driven by external factors, while the second period, from 2012 to 2014, was largely driven by domestic factors. Subsequently, the fall in oil prices to very low

[11] Estimations for the reduced form exercise were performed using the Bayesian Estimation Analysis and Regression (BEAR) Toolbox, described in Dieppe et al. (2016).

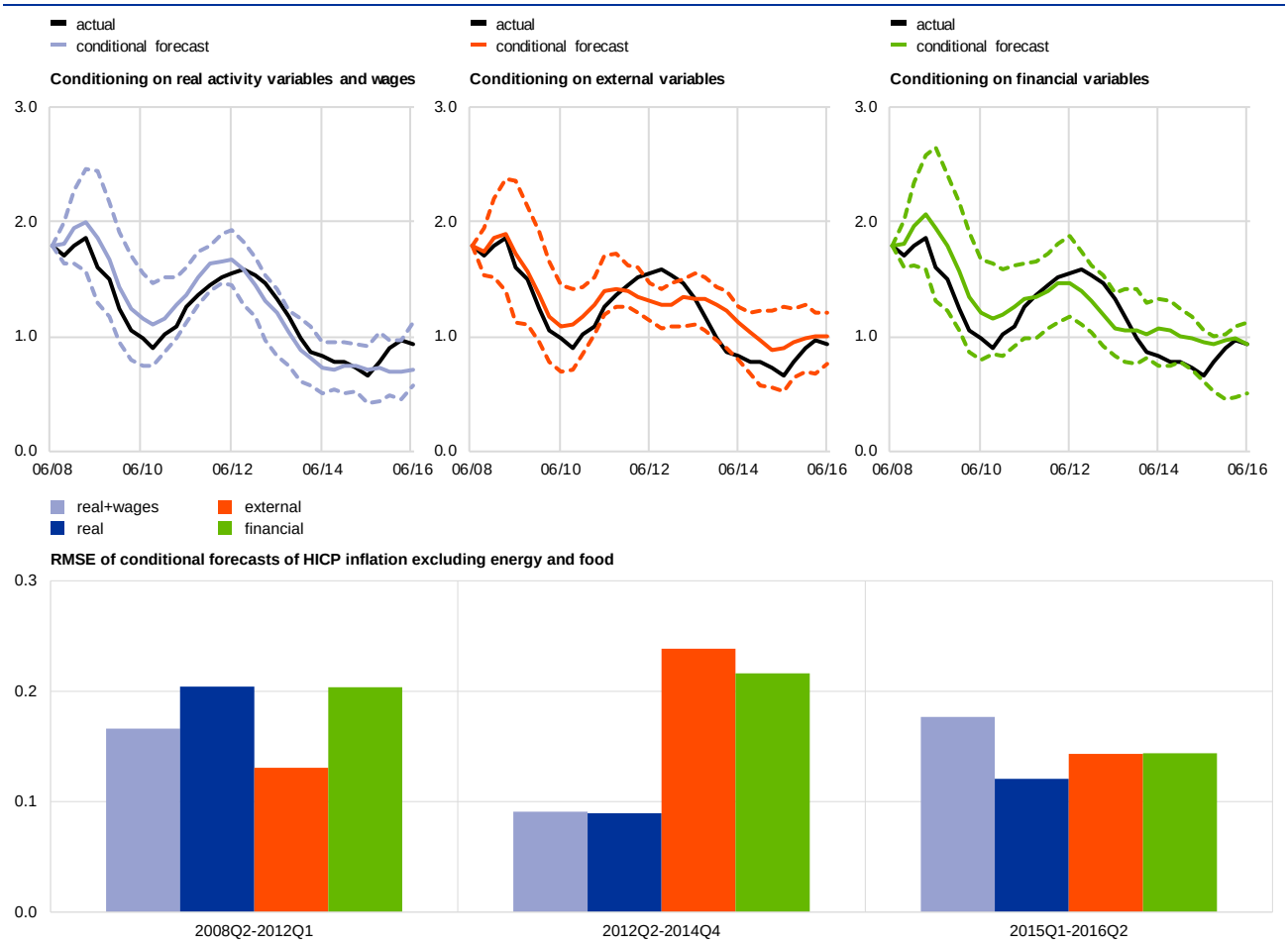
[12] Results are also robust to the inclusion of additional financial variables that better account for the crucial changes in monetary policy and financial conditions during the recent period, such as long-term interest rates, proxies for the lending conditions for households (interest rate and loans), and a stock price index.

levels in 2014 and 2015 had a very strong downward impact on headline inflation but less so for HICP excluding energy and food, where domestic drivers continued to be extremely important.

2.2.1 Conditional forecasting

The conditional forecasting exercise is based on a large vector autoregression model estimated through Bayesian methods. Apart from HICP excluding energy and food, it includes the following blocks of variables: (i) a domestic block: real GDP, unemployment rate, investment rate and compensation per employee; (ii) an external block: nominal effective exchange rates, the oil price, the nominal effective exchange rate and foreign demand; (iii) a financial block: EONIA, the lending rate to non-financial corporations (NFCs) and real loans to NFCs.

Figure 10
Conditional forecasts of HICP excluding energy and food



Source: ESCB Staff estimations.

Three sub-samples are singled out: 2008Q2 – 2012Q1 (the starting date of the euro area crisis according to CEPR); 2012Q2 – 2014Q4 (“the 2012 disinflation”), which corresponds to a sequence of inflation overpredictions by the ECB, other institutions

and professional forecasters; and 2015Q1-2016Q2, following the oil price collapse. **Figure 10** illustrates the results for the three subsamples. The top panels plot the actual path of inflation (the solid black line) and the median conditional forecast based on each group of variables. The VARs are specified in terms of the level of the price index, but for reporting the levels are transformed into year-on-year changes.

The exercise is an in-sample one, i.e. it uses coefficients estimated over the full sample and the forecast starts from 2008Q2. This approach does not address the question of overprediction as it is not a real-time forecast exercise, but it is useful to see whether one is at least able to explain inflation developments ex-post, assuming we know the relationships that hold between variables for the entire sample.

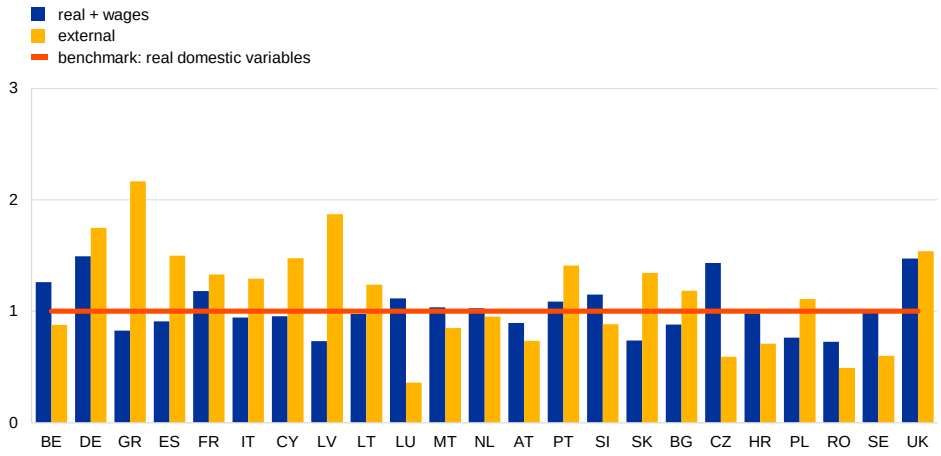
The main conclusion is that for the 2009-10 disinflation the forecast conditioning on foreign variables presented in the second plot is the closest to actual inflation, while in the 2012-14 disinflation the forecast conditioning on real activity (as measured by real GDP, real investment and the unemployment rate) is the closest to actual inflation. In 2015 and 2016, the main result is that all three sets of variables contribute to explaining inflation in almost equal proportion. In particular, the explanatory power of financial variables increases in relative terms, as would be expected in a period of expansionary monetary policy. At the end of the sample actual inflation excluding energy and food lies close to the conditional forecast based on foreign and financial variables, but above that implied by the path of domestic real variables and wage growth. The same information is summarised by the root mean square error (RMSE) shown in the lower panel of the figure for each of the three subsamples. In the final sub-period, the RMSE obtained when conditioning on foreign and financial variables diminishes, and the conditionals based on all sets of variables become more similar. Adding wages to the set of domestic variables reduces the explanatory power for core inflation in this period.

These findings characterise the euro area as a whole, but also most of the individual euro area countries as well as some non-euro area EU member states. Zooming in on the period 2012-2014, when low and overpredicted inflation became a concern but before the big oil price shocks, **Figure 11** shows the results of the conditional forecast exercise for EU countries. For the large majority of countries, domestic real variables have a larger predictive power over that period, as shown by the fact that the root mean squared error is generally lower when conditioning on these variables than on foreign ones.

Figure 11

RMSE of conditional forecast of HICP excluding energy and food

(2012Q2 to 2014Q4)



Source: ESCB Staff estimations.
Note: The RMSE is presented as a ratio to the RMSE associated with the real variables.

2.2.2 Structural shock decomposition

Structural shock identification is necessary to inform adequate policy responses

Understanding the shocks that drive inflation is important to calibrate the appropriate policy response. In principle, policy makers should pay more attention to domestic demand shocks than foreign supply ones, such as those related to oil price movements, unless these feed into agents' expectations.

The previous section discussed correlations between inflation and sets of variables, but did not offer any causal explanations. To be able to make causal inference, this section identifies structural shocks and quantifies their relative contributions to the dynamics of inflation since 2012. This section looks at headline HICP inflation. Since structural identification becomes more complicated as the number of variables increases, the Bayesian VAR used is smaller than the one in the previous section. The model contains seven variables, and seven shocks are identified and labelled using a combination of zero and sign restrictions.[13]

The seven shocks are labelled: "oil supply", "global demand", "domestic demand", "domestic supply", "short-term interest rate", "spread" and "other". The first two are global, while the other four are domestic. The seventh shock is not clearly interpretable and plays very little role in the dynamics of any of the variables except the exchange rate. For this reason, it could be interpreted as a genuine exchange rate shock, i.e. a movement in the exchange rate that does not depend on monetary policy or domestic supply shocks, etc.

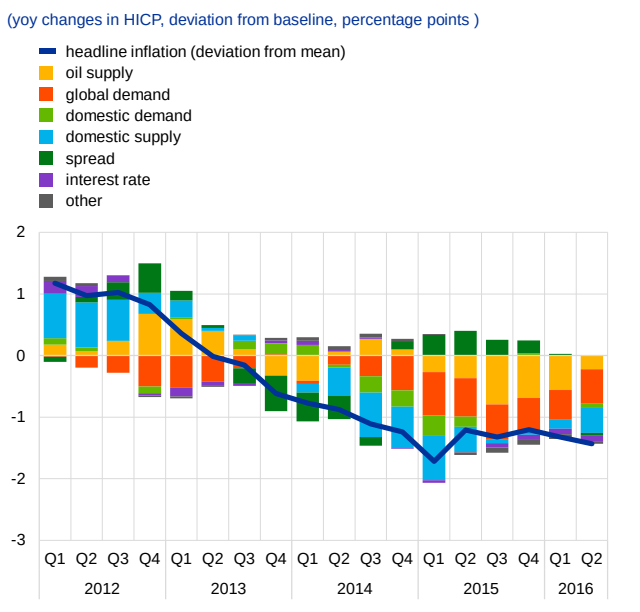
13 For details, see Bobeica and Jarocinski (2017). For this exercise, a spread between long and short-term interest rates has been added to the previous set of variables to identify a nonconventional monetary shock à la Baumeister and Benati (2013).

The identification strategy builds on the different effects domestic and foreign shocks have on the relative growth rate of the euro area relative to the rest of the world to disentangle domestic from foreign demand and supply shocks. It also uses an identification scheme proposed by Baumeister and Benati (2013) for disentangling the effects of unconventional monetary policy in the United States, which singles out the transmission channel related to the compression of the spread between long-term interest rates and the policy rate. For the euro area the spread shock has a less clear-cut mapping to monetary policy, as the spread also responded strongly to market reactions to events unfolding during the sovereign debt crisis. This should be kept in mind when looking at the contributions from the spread shock. In this framework, the exchange rate is an endogenous variable and its response to, for example, monetary policy acts as a channel of transmission. This is discussed in detail in Section 4.3.2.

As with the results from the previous exercise, domestic shocks became more and more important in the disinflation of 2012-2014.[14]

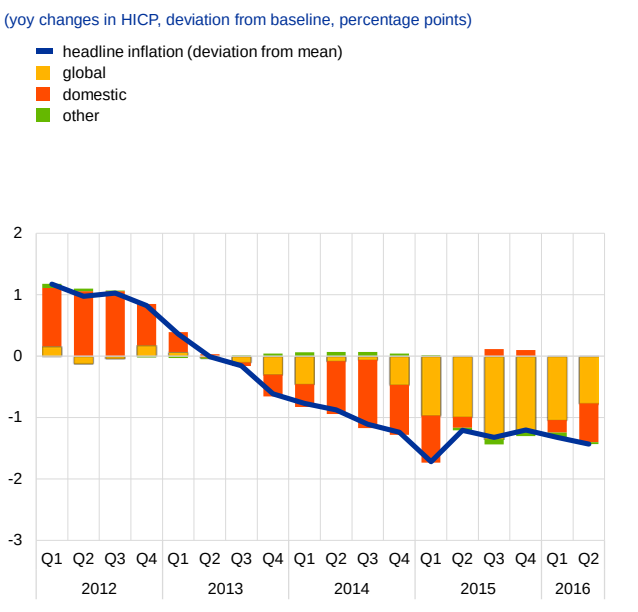
Figure 12 and **Figure 13** show the historical decomposition of inflation (year-on-year change in headline HICP). The decomposition starts in 2012Q1; the blue line is the difference between the median unconditional forecast generated by the VAR and the actual series, and the bars show the effect of each shock.

Figure 12
Historical decomposition of headline HICP



Source: Bobeica and Jarocinski (2017).

Figure 13
Historical decomposition of headline HICP – bundled domestic and global shocks



Source: Bobeica and Jarocinski (2017).

[14] For a similar result, see also Conti et al. (2017).

The structural identification also identifies foreign (demand) drivers in the first episode, but a larger role for domestic demand and supply in the second

Although not shown in the figure, in early 2009 global demand shocks accounted for about 60% of the deviation of inflation from its unconditional path, while domestic demand and spread shocks account for roughly 40% of it. The remaining shocks mattered little in that episode.

Since the end of 2012, the picture has been different: first supply shocks and then demand shocks started to turn negative. The contribution of the spread shock switched from restrictive to accommodative in 2014.

These results are not far from those obtained using a DSGE model for the euro area (the New Area-Wide Model or NAWM), which finds that since the peak at end-2011 the decline in inflation can be explained by the change in the contribution of mark-up shocks (2.1pp), especially in the goods market, and factors unexplained by the model (0.6pp). Across countries, mark-up shocks (both domestic and foreign) dominated in Spain, while in Germany foreign shocks were also important. This analysis is described in detail in Box 9.

Having ascertained that domestic conditions have had a large role in determining the low inflation since 2012, the next section takes a closer look at the Phillips curve for both prices and wages to see how this workhorse for interpreting inflation dynamics over the business cycle fares in terms of explanatory power.

2.3 Domestic drivers of inflation: are hybrid New Keynesian Phillips Curves (NKPC) useful in understanding inflation dynamics ex post? Do we see evidence of a changed responsiveness in inflation to economic activity?

The hybrid NKPC: the relationship between inflation and economic slack and the role of expectations

The relation between economic slack and inflation as described by the Phillips Curve is of fundamental interest to central bankers, because an increase in inflation as economic slack becomes tighter is a precondition for monetary authorities to control inflation by the transmission of monetary policy actions through the real economy. This implies a positively sloped Phillips curve in the inflation/output gap space or a negatively sloped one in the inflation/unemployment space. The benchmark specification for the euro area is the following:

$$\pi_t = \mu + \rho\pi_{t-1} + \theta\pi_t^e + \beta x_{t-1} + \gamma\pi_{t-2}^{imp} + \varepsilon_t$$

where π_t is the annualised quarter-on-quarter growth rate of the seasonally adjusted HICP excluding energy and food, x_t is a slack measure, π_t^e are survey-based inflation expectations and π_t^{imp} is the annual growth rate of import prices in euro from outside the euro area.[15] Both in the price and in the wage Phillips curve, inflation depends positively on expected inflation: an expected increase in prices will push labour unions to set higher wages today, and the resulting cost changes will be reflected in prices.

[15] This specification does not allow for changes in indirect taxation and regulated prices, which can strongly influence the results in countries such as Spain (see e.g. Álvarez and Urtasun (2013)).

Changes in expectations of future inflation shift the Phillips curve

A revision in inflation expectations (in turn possibly linked to changed monetary policy credibility) or a change in wage and inflation mark-ups shift the Phillips curve up or down in the inflation/output space, affecting the intercept in the curve.[16] Supply-side shocks that move inflation will also shift the curve. Finally, the slope of the curve can change over time. However, such changes are hard to distinguish from mismeasurement of economic slack.

The flexibility of the economy determines how responsive inflation is to slack

The responsiveness of prices to slack is related to the degree to which wages and other costs react to economic conditions, and to a number of other factors, such as the frequency with which firms adjust prices. Box 4 shows evidence based on micro data that the frequency of price changes in Italy and Spain has increased in recent years, pointing to a potential steepening of the Phillips curve.

The connection between inflation and economic slack is hard to pin down empirically due, for example, to mismeasurement of slack and expectations, or to exogenous shocks such as changes in indirect taxes.

Economic slack is unobservable and multidimensional

Economic activity, and especially its potential level, is unobservable and multidimensional, and there are advantages in using large dynamic models to estimate it. For instance, Jarocinski and Lenza (2016) use a dynamic factor model that performs a trend/cycle decomposition of real activity variables and core inflation. The model uses a single factor to capture common cyclical fluctuations and estimates the output gap as the deviation of output from its trend.

Alternative models can provide very different results on the size of the output gap…

Different 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.

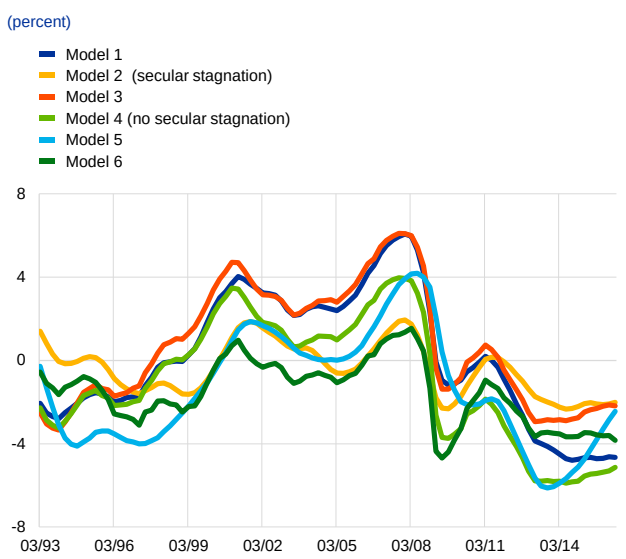
…and have different inflation forecasting ability

How do different estimates of the output gap fare in terms of their ability to forecast inflation? It turns out that the variants proposed by Jarocinski and Lenza (2016) associated with a continuation of a positive growth trend (thus implying a wider output gap) are the ones that produced better inflation forecasts over the period 2002-2015. The best variant from this perspective would imply that the output gap was as large as -6% in 2014 (see the measure called *Model 4 – no secular stagnation* in **Figure 14**). Assuming the opposite, namely a break in the output trend, which we could relate to 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 these dynamic factor models (see **Figure 15**). A caveat to these estimates is that they are obtained on the assumption that inflation reacts constantly to the output gap, and this issue – not just discerning how large the output gap is, but also separating the (mis)measurement of it from possible time variation in the Phillips curve – is central to understanding inflation dynamics and the recent overprediction of inflation.

[16] On the anchoring of inflation expectations in the period under review, see Section 2.4.2.

Figure 14

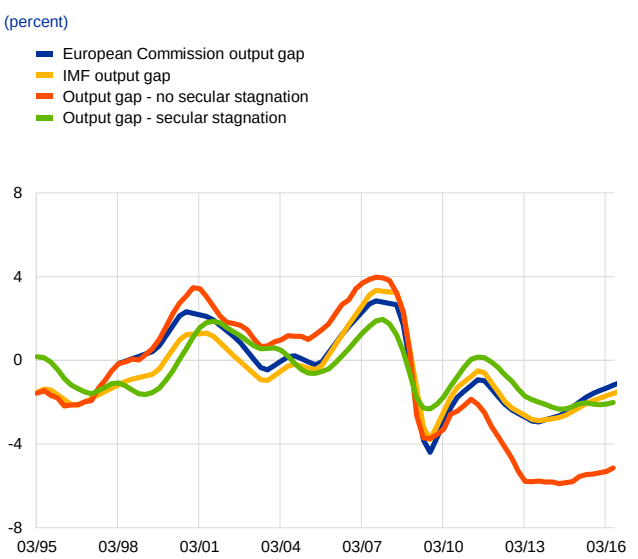
Six variants of the output gap from a Bayesian dynamic factor model



Source: Jarocinski and Lenza (2016).

Figure 15

Comparison with traditional measures of the output gap



Source: IMF WEO, AMECO, Jarocinski and Lenza (2016).
Note: The IMF and European Commission output gap measures are interpolated.

Inflation expectations can be measured from surveys or inferred from the prices of market instruments.

Inflation expectations are unobservable and can be proxied by market-based and survey-based measures (see Section 2.4.1 and Box 11 for details). For reasons of data availability, to estimate the Phillips curve specified above we use SPF, Consensus Economics and the qualitative household survey of the EU Commission. The time series of the market-based measures are too short to be included in this analysis.

Across euro-area countries, inflation expectations tend to move similarly, especially at the longer term.

In general, when considering developments in inflation expectations across euro area countries, those for short-term horizons appear broadly similar, and longer-term expectations have increasingly converged. The profile of the inflation expectations curve is similar across the large euro-area countries (i.e. upward sloping) although the slope varies owing to the different short ends.

Section 2.4.1 explains the differences in information content among these various sources and discusses their recent developments. Section 2.4.2 contains an extended analysis on whether there are signs that expectations may have become less anchored during the low inflation period.

The uncertainty about measurement of slack and inflation expectations can be tackled by estimating a large set of Phillips curve specifications obtained by combining several measures of economic activity and survey-based inflation expectations (see e.g. Banco de España (2015)). Using this form of "thick modelling"[17], one can derive a range for inflation outcomes based on the relationship between inflation and economic slack that would be consistent with past regularities. We consider the following measures of slack: (1) output gap model-based estimates;

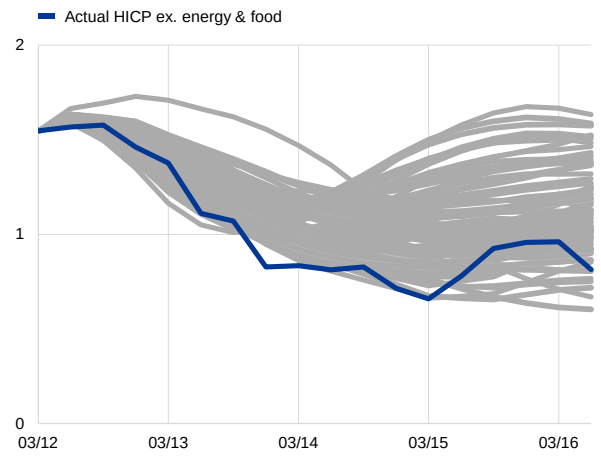
[17] See Granger and Jeon (2004).

(2) GDP growth; (3) unemployment rate; (4) unemployment gap; (5) short term unemployment rate; (6) unemployment recession gap; (7) output gap – IMF WEO estimates; (8) output gap – EC estimates; (9) output gap – secular stagnation; (10) output gap – no secular stagnation. (The latter two are based on Jarocinski and Lenza (2016)).

Figure 16

Conditional Phillips curve forecast for the post-crisis period

(HICP ex energy and food; annual percentage changes)



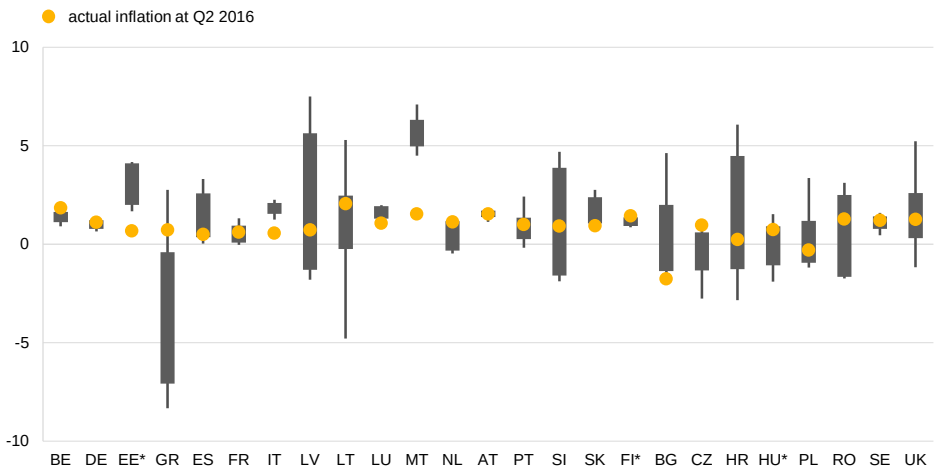
Source: ECB staff estimations.
Note: The starting point of the forecast is Q2 2012. Each line is the conditional forecast of inflation excluding energy and food on its lag, lagged import prices, a measure of slack (lagged) and a measure of inflation expectations.

Figure 16 shows out-of-sample Phillips curve projections of core inflation for the recent period of disinflation in the euro area using only specifications where the slack measure is statistically significant. The range of estimates is relatively large, pointing to high model uncertainty. In addition, core inflation lies at the lower range of the Phillips curve conditional forecasts. Possible explanations for this include underestimation of slack or a higher reaction by inflation to it, as well as other factors not captured in the Phillips curve, which might have triggered a decline in trend inflation. This over-prediction tendency is not shared by all countries. For example, in Germany inflation was generally higher than implied by Phillips curve models; the opposite holds true for Italy. Looking at the end-point of the sample, both patterns (over- and under-prediction) also hold in other countries (see **Figure 17**). For example, the pattern in Spain and Bulgaria is more similar to that of Italy in this respect, while in the Netherlands and Belgium the Phillips curve would have under-predicted inflation, like in Germany.

Figure 17

The range of Phillips curve conditional forecasts and actual inflation in 2016 Q2

(HICP ex energy and food;§ annual percentage changes; actual inflation and box plot of 10th and 90th percentiles of conditional forecasts)

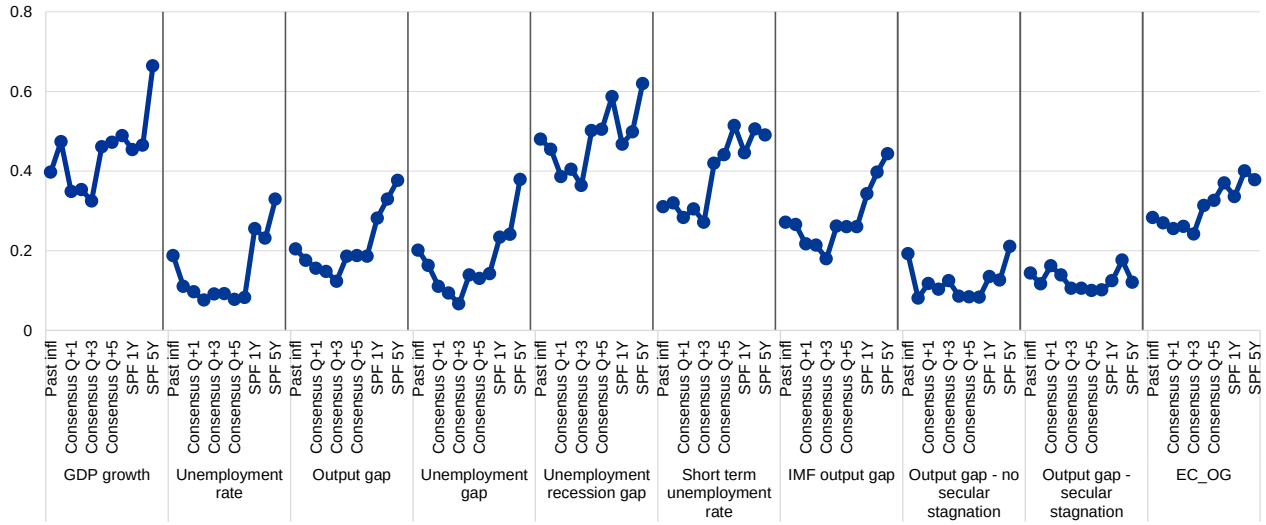


Source: ESCB staff estimations. Last observation: 2016Q2, except *2014Q4, MT 2015Q4 and NL 2016Q1.
Note: §HICP ex-energy and food and excluding VAT impact in the case of Romania.

In the euro area, some specifications explain inflation developments well. This is shown in **Figure 18**, which displays the root mean squared error (RMSE) for the full set of specifications.

Figure 18

RMSE of the Phillips curve forecasts vs realised HICP ex energy and food inflation for the period 2012Q2-2016Q2



Source: ECB staff estimations.

No specific slack measures outperform others across countries, but some do in the euro area

Across countries no particular measure of slack outperforms the others, but for the euro area specifications that use the unemployment rate, the unemployment gap (i.e. the difference between the unemployment rate and the NAIRU), the output gap and the two measures from Jarocinski and Lenza (2016) tend to perform well. In terms of expectations measures, using consensus expectations with a time horizon around one year ahead tends to yield a better in-sample fit.

Heterogeneity across countries in the slope of the Phillips curve for prices…

The main, somewhat comforting, result is that in the majority of countries one can find a statistically significant relationship between inflation and activity (see **Figure 19**), and at least some Phillips curve specifications are able to explain inflation in the most recent period of disinflation not only for the euro area, but also at the individual country level. When it comes to the magnitude of the slope of the Phillips curve, there is high heterogeneity across countries.

…and for wages

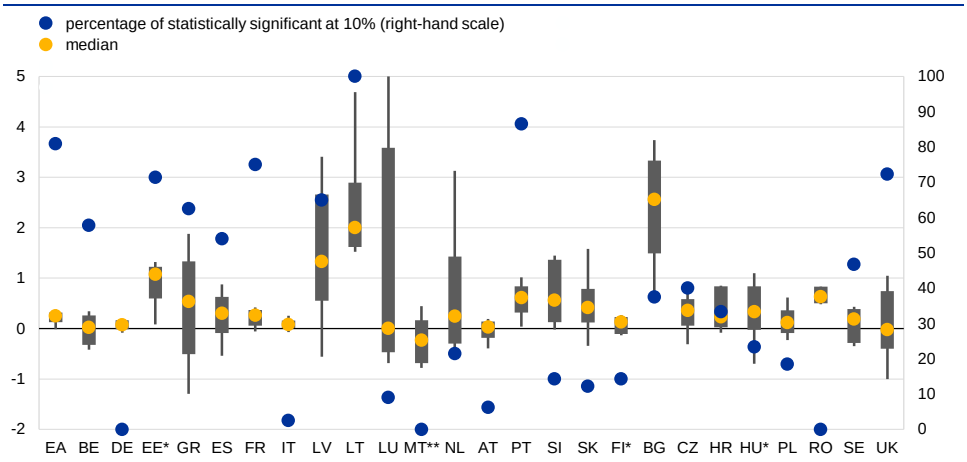
As in the case of price Phillips curves, in general, some specifications[18] do explain wage developments over the period, although in quite a few countries it is harder to model wages than prices, due, for instance, to the effect of public wage cuts in some countries during the crisis. Germany is an interesting case, as Phillips curve models based on slack measures using labour market indicators systematically over-predict wages, suggesting that wage growth could have been higher since 2012. Three main reasons have been invoked for the relatively weak wage growth despite the tightness of the labour market: the downward pressure on wages in some sectors due to

[18] Benchmark specification for wage inflation: $w_t = c + \rho w_t + \gamma \pi_t^e + \beta x_{t-1} + \delta p_t + \varepsilon_t$, where w_t is the annualised q-o-q growth rate of seasonally adjusted wages (compensation per hour), π_t^e is an expectation measure, x_t is a slack measure and $p_t$is a measure of productivity growth.

immigration, global competitive pressures in other sectors, and institutional factors, such as diminishing collective bargaining coverage.[19]

Figure 19

Phillips curve long-run slope across countries



Source: ESCB staff estimation. Last observation: 2016Q2 except *2014Q4 and **2015Q4.
Note: the slack measures have been standardised for comparability. The boxes show the 10th and the 90th percentiles. § estimated using HICP ex energy and food, excluding VAT impact in the case of Romania.

For the euro area as a whole, the overall low inflation environment was also characterised by low wage growth. In spite of improving labour markets, wage growth has systematically surprised on the downside since 2013 in the euro area as a whole. A key factor pulling wage inflation down has been the still ample amount of slack, as pointed out by the Phillips curve models, but other factors not accounted for in this simple model can also explain past wage growth weakness. These factors include labour market reforms aimed at reducing downward nominal rigidities, pent-up wage restraint and compositional effects, with the improvements in employment in the recovery occurring mainly in the low-productivity and low-wage sectors. Naturally, the prolonged low inflation could also have impacted the wage negotiation process.[20]

There is evidence of end-of-sample parameter instability in the euro-area price Phillips curve…

For the euro area there is evidence of instability in the parameters of the price Phillips curve at the end of the sample, with most of the specifications pointing towards an increase in the responsiveness of inflation to slack in the recent recession. However, the picture is very heterogeneous across the euro area and the EU in terms of increased or decreased sensitivity of inflation to economic slack, so one cannot talk about across-the-board flattening or steepening. In the euro area, for most specifications the slope is higher when one adds the years from 2012 to 2016 to the sample.

Indeed, evidence from some euro-area countries indicates that the sensitivity of inflation to economic slack has strengthened recently, especially in economies where

[19] Deutsche Bundesbank Monthly Report April 2016, article entitled “The Phillips curve as an instrument for analysing prices and forecasting inflation in Germany”.

[20] See European Central Bank Economic Bulletin Issue 3 / 2016, box entitled “Recent wage trends in the euro area”.

labour market slack has been large and protracted (e.g. Spain, Italy).[21] In some of these countries, governments have also actively reformed local labour market institutions. At the same time, in countries such as Portugal large changes in indirect taxes have also strongly affected the inflation dynamics, and the timing of tax increases unfortunately blurs the relationship between inflation and economic slack, so it is difficult to conclude whether the Phillips curve slope has changed in Portugal (or in which direction).

Can we relate the results on (potential) time variation in the coefficients of the Phillips curve to those reported in Section 2.1 showing that inflation persistence has increased and trend inflation has decreased? For this purpose, it is useful to consider long-run impacts on inflation by looking at the steady-state inflation rate within the Philips curve model estimated over different periods.

$$\pi = \frac{\boldsymbol{\mu}}{(\mathbf{1}-\boldsymbol{\rho})} + \frac{\boldsymbol{\theta}}{(\mathbf{1}-\boldsymbol{\rho})}\boldsymbol{\pi}^{\mathbf{e}} + \frac{\beta}{(1-\rho)}x + \frac{\gamma}{(1-\rho)}\pi^{imp}$$

where x and π^{imp} are the long-run values for slack (presumably zero) and import prices (of less interest). The part in bold red is the (possibly time-varying) intercept in the slack/inflation space, while $\frac{\beta}{(1-\rho)}$ is the long-run slope. What happened to these coefficients between 2012 and 2016?

Persistence of inflation increased in around 60% of the specifications between 2012 and 2016, in line with the results reported in Section 2.1 obtained using another approach. In other specifications it decreased, but to a lesser extent.[22] At the same time, the long-run mean has declined in all specifications, reflecting the fall in trend inflation documented in Section 2.1.

To gain an insight into the role of inflation expectations in the two samples, one must consider the interplay between the expectations part of the equation and the long-run mean, i.e. the bold red part of the steady-state Phillips curve equation above. This is done in **Figure 20**, which shows $\boldsymbol{\mu}/((\mathbf{1}-\boldsymbol{\rho})) + \boldsymbol{\theta}/((\mathbf{1}-\boldsymbol{\rho}))\,\boldsymbol{\pi}^{\mathbf{e}}$ calculated taking the mean of the corresponding inflation expectations measure in the two samples. This term has fallen unequivocally in all specifications, due to the fall in the mean of expectations itself (except in the case of the 5y SPF), the fall in μ and the fact that the θ coefficients have increased (not shown in the figures), albeit not enough to prevent the whole intercept from falling.

The long-run slope of the Phillips curve increased in 90% of the specifications between 2012 and 2016, as shown in **Figure 21**, in line with what Oinonen and Paloviita (2014) found.

When looking at the statistical significance of these results, only a few estimates are statistically different between samples, as can be expected given that the samples

[21] It is important to recall that there could be asymmetries in the slope of the Phillips curve during recessions and expansions or during particularly deep recessions. For a more detailed discussion, see Box 2 and the literature therein.

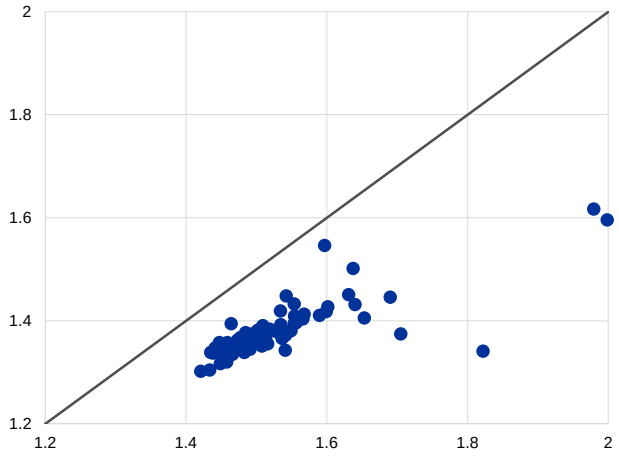
[22] The Figures from 20 to 23 only report results for specifications where the slope is statistically significant.

differ by only a few observations. However if the differences were due to pure random variation, when combining across all models one should observe random patterns of clouds around the 45-degree line, rather than the clear-cut positions above or below the line observed in **Figure 20** and **Figure 21**. This evidence points to the robustness of the results.

Figure 20
Euro area Phillips curve long-run intercept in two samples

$\mu/((1-\rho)) + \theta/((1-\rho)) \pi^e$

(x-axis: sample: 1995 - 2012Q1, y-axis: sample: 1995 - 2016Q2)

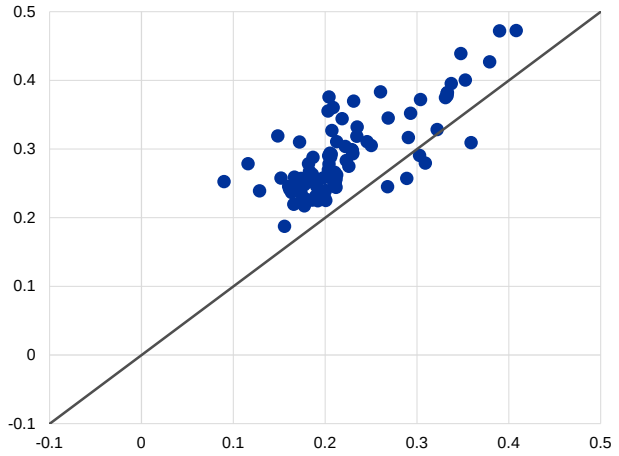


Source: ECB staff estimations.
Note: Slack measures are standardised for comparability.

Figure 21
Euro area Phillips curve long-run slope in two samples

$\beta/((1-\rho))$

(x-axis: sample: 1995 - 2012Q1, y-axis: sample: 1995 - 2016Q2)



Source: ECB staff estimations.
Note: Slack measures are standardised for comparability.

Furthermore, even when not statistically significant, the changes in the parameters are of economic significance in terms of the ability of the Phillips curve to track inflation developments during the period of "missing inflation." An in-sample Phillips curve conditional forecast – obtained by performing the same exercise underlying **Figure 16** but using coefficients estimated over the entire sample – yields Phillips-curve-implied inflation rates which are lower by an amount that is non-negligible relative to the average negative forecast error since 2012.

…with heterogeneity across countries

In terms of increased sensitivity of inflation to economic slack, the picture is very heterogeneous across the EU. The slope appears to be stable in Germany and France, while there is some evidence of a Phillips curve steepening in Italy and Spain (see also Álvarez and Urtasun (2013) and Riggi and Venditti (2015)).

Across countries, no evidence of changes in the slope of the wage Phillips curve

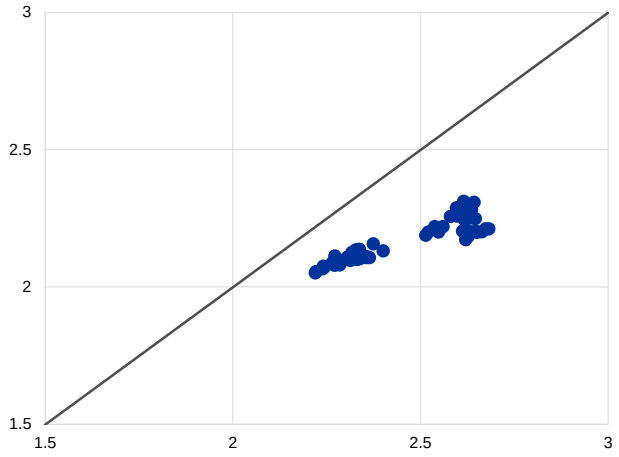
There is more homogeneity in the results on the relationship between wage growth and slack in the labour market, where there is no particular evidence of changes in the slope across countries in any direction. In the euro area, the same analysis performed for the wage Phillips curve shows a lower intercept for most specifications, as in the case of price Phillips curves, and a relatively stable relationship between wages and slack (see **Figure 22** and **Figure 23**).

Figure 22

Euro-area wage Phillips curve long-run intercept in two samples

$\mu/((1-\rho)) + \theta/((1-\rho)) \pi^e$

(x-axis: sample: 1995 - 2012Q1, y-axis: sample: 1995 - 2016Q2)



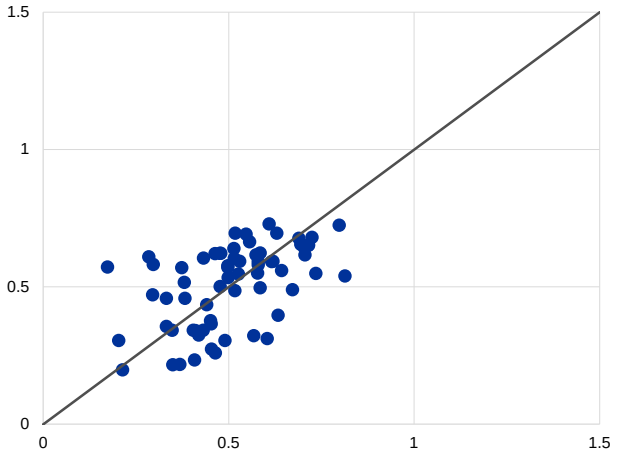
Source: ECB staff estimations.
Note: Slack measures are standardised for comparability. The following measures of slack were considered: (1) unemployment rate; (2) unemployment gap – ECB estimates; (3) short term unemployment rate; (4) unemployment recession gap; (5) output gap – secular stagnation and (6) output gap – no secular stagnation (where the latter two are based on Jarocinski and Lenza (2016)).

Figure 23

Euro-area wage Phillips curve long-run slope in two samples

$(\beta/((1-\rho)))$

(x-axis: sample: 1995 - 2012Q1, y-axis: sample: 1995 - 2016Q2)



Source: ECB staff estimations.
Note: Slack measures are standardised for comparability. The following measures of slack were considered: (1) unemployment rate; (2) unemployment gap – ECB estimates; (3) short term unemployment rate; (4) unemployment recession gap; (5) output gap – secular stagnation and (6) output gap – no secular stagnation (where the latter two are based on Jarocinski and Lenza (2016)).

The result that the reaction of wages to labour market slack appears to be unchanged, while that of prices appears to be somewhat stronger, points to changes in the behaviour of firms in terms of mark-ups. Mark-ups are strongly connected to business cycle developments, and an increased sensitivity to cyclical conditions could be an explanation for the higher responsiveness of prices (trends in profit margins in recent years are discussed in detail in Box 5). As mentioned above, the DSGE-based analysis also points to a dominant role for mark-ups in explaining low inflation in the euro area.

2.4 The role of inflation expectations

This section reviews the developments in various measures of inflation expectations and discusses their information content regarding the quantity of interest of policy-makers, i.e. the expectations of economic agents about medium to long-term inflation developments. It also analyses whether movements in these measures of inflation expectations indicate risks of de-anchoring, by means of descriptive analysis and model-based assessment.

2.4.1 Reviewing the developments of inflation expectations: survey-based vs market-based measures

Inflation expectations are usually measured through survey and market-based information, because quantitative measures of consumers' inflation perceptions and

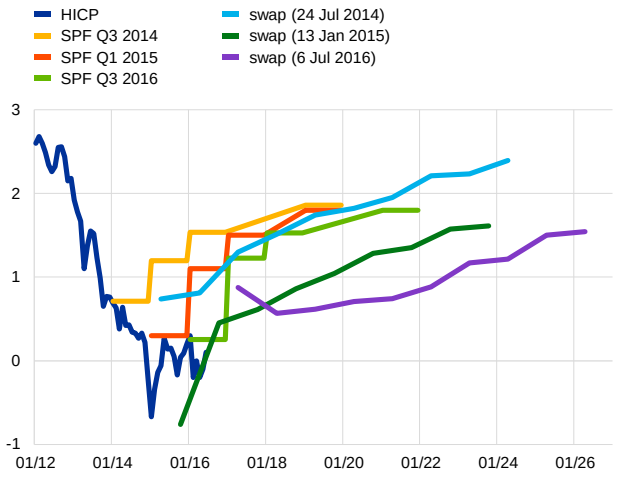
expectations are not available for euro area countries, and measures from business surveys are not as readily available as in other major economic areas.

Survey-based vs market-based measures: a trade-off between the frequency of data and the accuracy of the measure of inflation expectation

Market-based measures of inflation expectations must be backed out from derived measures of inflation compensation. The advantage of measures of inflation compensation is that they are available at higher frequency, often in real time and for a wider range of maturities (up to 30 years). This makes them more attractive for high-frequency quantitative analysis compared to survey-based data. However, market-based proxies bundle together expectations with the time-varying agents' aversion to inflation risk and other market risks, particularly liquidity conditions in various market segments (which also vary through time). Hence, a change in market-based inflation compensation measures can reflect either a change in inflation expectations or a change in inflation risk and other premia.[23] A crude measure of inflation risk premia can be obtained by taking the difference between a survey-based measure of inflation expectations and the market-based one with the same maturity. However, this approach is only possible at the date of release of survey data, so the market-based data lose their advantage of real-time availability. Furthermore, when liquidity in different segments is scarce, liquidity premia also become confused with the inflation risk premia.[24]

Figure 24

Recent movement of market-implied and survey-implied inflation expectation curves



Source: ECB staff calculation
Note: Market-implied rates are based on ILS and survey-implied rates come from SPF.

In terms of forecast accuracy, a recent study shows that both market-based and survey-based measures have a non-negligible predictive power for inflation developments, as compared to statistical benchmark models.[25] Inflation forecasts based on the SPF and inflation-linked swaps (ILS) have different properties and strengths: SPF forecasts were better predictors of inflation during the pre-crisis period (starting in 2004Q4), but ILS-based forecasts have performed better during the low inflation period. During the crisis period to end-2012, ILS-based inflation forecasts are better at the one-year horizon while SPF forecasts do best at the two-year horizon.

All these elements suggest that the monitoring of inflation expectations should be based on both types of measures, with an eye however to disentangling the information content of market-based measures from the risk and liquidity premia.

23 See Christensen et al (2010) for an in-depth discussion and a proposal on how to extract information on expectations from market-based inflation compensation measures.

24 Additionally, there is an indexation lag of three months in the inflation-linked swap rate, meaning that the reference inflation rate for a swap contract of two years duration today is the inflation rate for the 24-month period covering the last three months and the next 21.

25 See Grothe and Meyler (2015).

2.4.1.1 Recent evolution of survey-based and market-based measures of inflation expectations in the euro area

Since 2005 there has been a broad degree of co-movement between survey-based and market-based measures of inflation expectations, although the latter have tended to fluctuate more widely. From early 2013 to early 2015 both survey-based and market-based measures of inflation expectations declined, and both have since rebounded somewhat, but there have been significant differences in the magnitude of movements and the changes in the slope of the inflation expectations curve. The market-based curve has tended to move more both at the short and long end, whereas the survey-based curve has moved less, particularly at the longer end of the curve (see **Figure 24**).

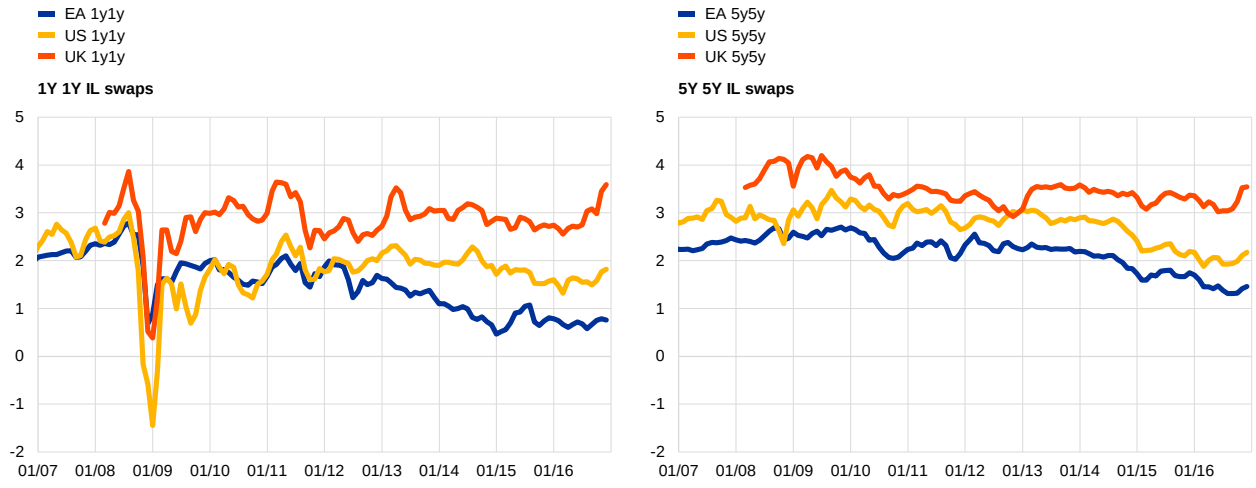
2.4.1.2 International developments concerning inflation expectations

Developments in the euro area, United States and the United Kingdom

Focusing on market-based measures (**Figure 25**), one noticeable feature when comparing market-based inflation expectations in the euro area with those of other countries (such as the USA and the UK) is that longer-term expectations declined for all economies in the second half of 2014 and have since rebounded. In the euro area they also rebounded after the announcement of APP by the ECB, but more clearly at the shorter than at the longer end.[26] Notwithstanding the heterogeneity among the three economies, the degree of commonality – especially at specific episodes, such as end-2008, mid-2010 and mid-2014 – is quite striking.

Figure 25

Comparison of market-based inflation expectations in the euro area (EA), United Kingdom (UK) and United States (US)



Source: ECB.
Note: market-based inflation expectations come from ILS.

[26] For the UK, the price measure of reference is the Retail Prices Index, which tends to be structurally higher.

Commonalities and spillovers in international longer-term inflation expectations

This commonality, and in particular the significant declines in financial market indicators of long-term inflation expectations in major economic areas since August 2014, have attracted substantial attention among policymakers and international institutions (Draghi (2015), Yellen (2015)), as well as in the specialised press and market commentary (e.g. The Economist (2014)).

Recent analysis identifying common and idiosyncratic shocks in the euro area, USA, and UK shows not only significant commonalities across countries, but also that there had been a quantitatively important spillover from euro-area long-term inflation expectations to other major markets, notably the USA, from August 2014 to end-2015.[27]

2.4.2 Model-based assessments of anchoring of inflation expectations

Recent patterns of market-based measures of inflation expectations indicate an undershooting of the ECB's '*below-but-close to*' 2% inflation target. The question remains whether this undershooting signals a persistent and significant de-anchoring of longer-term inflation expectations away from the ECB's price stability objective. This issue can be addressed with a battery of econometric analyses of de-anchoring risks.

The risk of expectations de-anchoring can be measured by the sensitivity of longer-term inflation expectations to incoming data

A usual metric of the degree of anchoring of inflation expectations is the link between short-term surprises and longer-term inflation expectations. The rationale is that if inflation expectations are well-anchored, then inflationary pressures driven by macro-economic developments, current or expected in the near future, should not *pass through* to longer-term inflation expectations. Analyses of the co-movement between market-based measures of short and long-run inflation expectations provides evidence of asymmetry between the response of market inflation compensation measures to inflationary and deflationary shocks (see Box 8 and, in more detail, Natoli and Sigalotti (2017a, 2017b)). Naturally, co-movement does not necessarily imply causality. To assess the strength of inflation pass through (i.e. how '*short-term surprise shocks*' affect long-term inflation expectations) one needs to resort to different angles of analysis and we can think of three types of approaches, which differ in their definition of short-term surprise shocks.

The first approach examines the interaction between inflation expectations and current macroeconomic developments, such as changes in actual inflation.

A second approach uses event studies that assess de-anchoring risks by the responsiveness of far-forward inflation expectations to the surprise component of macroeconomic news releases. A third approach relies on fluctuations in short-term inflation expectations as a proxy for inflation surprise shifts.

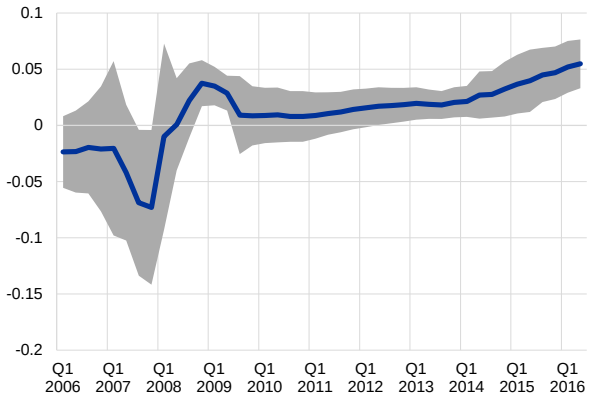
---

[27] See Ciccarelli and Garcia (2015) for details. The spillover is due more to macroeconomic than financial factors and is mainly related to the significant deterioration in the euro area inflation outlook since mid-2014, when the forward inflation curve suggested that the expected length of inflation below the ECB's 2% target rose from seven to over 12 years between mid-2014 and January 2015. The spillover is also specific to long-term inflation expectations and is higher, the longer the forecast horizon, which suggests that it captures persistent factors in the economic area where it originates.

Figure 26

Dependence of long-term SPF inflation expectations on current HICP inflation

(29-quarter rolling-window estimates mean and 5/95 percentiles; percentage points)

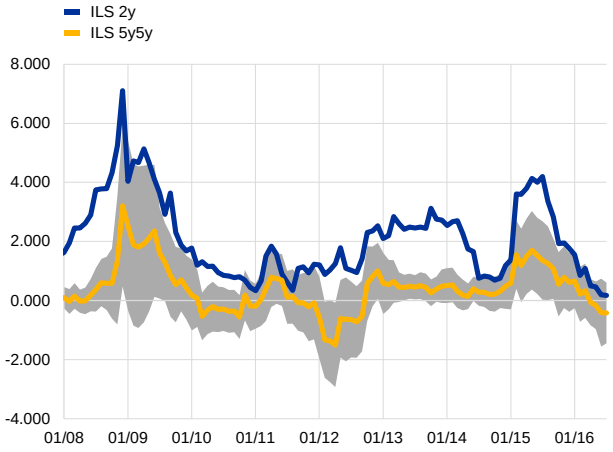


Source: Lyziak and Paloviita (2016). Last observation: 2016Q2.
Note: Newey-West standard errors. Long-term inflation expectations refer to the four to five years ahead ECB SPF forecasts. Estimated coefficients are dated at the end of each rolling sample.

Figure 27

Reaction of medium-term inflation expectations (ILS 5y5y) on macroeconomic surprises, event study

(9-month rolling window estimates mean and 5/95 percentiles)



Source: Speck (2017). Last observation June 2016.
Note: Year labels on x-axis refer to 1 Jan. Selected surprises: inflation releases in DE, ES, IT and EA and corporate sector sentiment releases in DE, FR and IT. The reaction is expressed on the y-axis in multiples of the pre-crisis reaction of the ILS 2y.

Without going into detail, each of these measures has its own advantages and disadvantages.[28] Therefore, for the sake of robustness, this section presents and discusses the main results of the three types of inflation pass-through measures.

The various pass-through analyses are based on starkly different modelling assumptions, but there are some important similarities among the various sets of results reported in **Figure 26** to **Figure 29**. First, before the crisis no significant expectations of pass-through effects were recorded. In October 2008 the collapse of Lehman Brothers, marking the beginning of the Great Recession and followed by a sharp fall in inflation, was associated with temporary upward risks to the anchoring of inflation expectations in 2009. The results remain inconclusive about the degree of anchoring during the first two years of the low-inflation period, which started around the turn of 2012: some indicate a firm anchoring, while others reveal de-anchoring risks as soon as the first signs of missing inflation materialised.

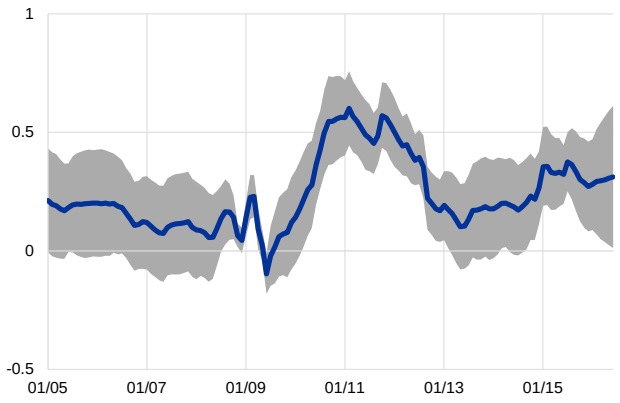
[28] For instance in analysing pass-through effects from actual HICP inflation, one possible drawback is that current inflation readings are available only at monthly frequencies. One month, however, is a long time for market participants who consolidate new information each day. As a result, short-lived or very recent changes in inflation pass-through effects might remain undetected in monthly-based assessments of time variation. In order to determine a high-frequency indicator of inflation pass-through effects one needs to resort to measures of inflation expectations obtained from prices in markets for inflation protection. However, such real-time inflation pass-through estimates are subject to perturbations related to risk premia in inflation compensation data, as discussed above. Moreover, in contrast to estimates based on current data, high-frequency assessments of pass-through coefficients require defining a proxy for short-term surprise shocks. One possibility is to apply an event study approach, which contrasts news releases with pre-announcement surveys in order to quantify new surprising information about the current state of the economy. However, news regressions might depend on the data quality and the data scope of the pre-announcement survey. If short-term market-based expectations are used, both the dependent and the explanatory variables depend on risk premia, which complicates the interpretation of the pass-through with respect to expectation de-anchoring.

After the oil price shock of mid-2014, three out of four pass-through measures identified increasing risks of a de-anchoring of longer-term inflation expectations, most likely related to the protracted past decline in inflation and the expectation of a prolonged slump in oil prices.[29] In 2015, the announcement and subsequent implementation of the APP seems to have softened these risks.

Figure 28

Pass-through from short (ILS 1y1y) to long-run inflation expectations (ILS 5y5y), univariate regression

(time-varying parameter estimates – median, 16/84 percentiles, monthly data, percentage points)

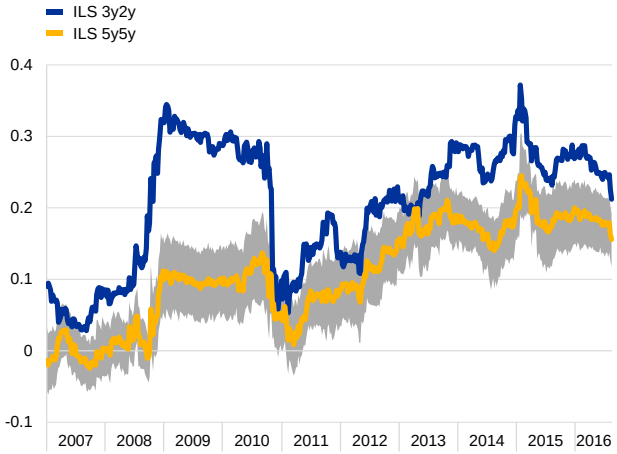


Source: ECB staff estimation. Last observation: June 2016.
Note: Time-varying estimates of the pass-through from changes in short-term inflation expectations over the previous six months onto the changes in long-term inflation expectations over the previous six months. The model is estimated with Bayesian techniques and allows for stochastic volatility.

Figure 29

Pass-through from short (ILS 1y) to medium (ILS3y2y) and long-run inflation expectations (ILS 5y5y), VAR regression

(200-week rolling window estimates – median, 5/95 percentiles, percentage points)



Source: ESCB Staff estimation. Last observation: June 2016.
Note: Time-varying estimates of the impact response of medium (blue line) and longer-term (yellow line) inflation expectations to a one pp shock in short-term inflation expectations; derived from a structural VAR model of weekly measures of inflation expectations, where the Cholesky ordering of expectation readings runs from the short to the long-run. Coefficients are dated at the end of each rolling sample.

Taken together, the above evidence suggests that risks of a de-anchoring of inflation expectations rose after the oil price shock of 2014, and different models signal different messages on more recent developments. Some pass-through models indicate that short-term inflation expectations were still affecting long-run expectations at the end of 2015. Others suggest that the pass-through signal has become insignificant, due to a noticeable increase in the uncertainty surrounding the central estimates. This increase in uncertainty was also found by Dovern and Kenny (2017), quoted above, who look directly at the uncertainty reported by SPF respondents. Finally, the event-study approach that uses very long term measures of expectations shows a decline in the response to macroeconomic news solidly into anchoring territory after the announcement and implementation of the APP.

Signs of pass-through do not necessarily imply a loss of trust in the ECB's price stability commitment

The question remains as to how to interpret the observation of increasing pass-through effects in the light of the distinction between loss of credibility of the target and increased persistence. As underscored in Section 1, evidence of a tighter link

[29] Note that in the event study analysis, the estimated sensitivity of long-term inflation expectations to macro news only turned significant as of February 2015, after the announcement of the APP. The recent observed increase in sensitivity in fact indicates upward pressures on inflation expectations.

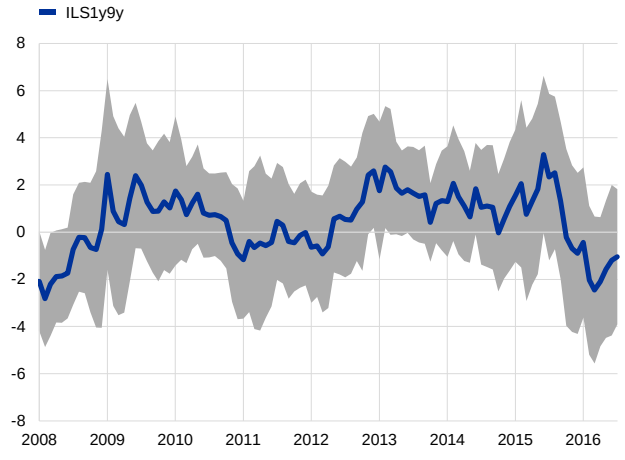
between actual and far-forward inflation rates can signal two things. In terms of credibility of the target, it may signal impaired trust in the central bank's policy commitment, but it may also signal uncertainty about the effectiveness of monetary policy, which affects the persistence of inflation. Although not explicitly designed for this purpose, inflation pass-through measures can shed some light on the relative importance of lower target credibility and the effectiveness of non-standard monetary policy instruments, which in turn affects inflation persistence in driving longer-term inflation expectations. This can be done by looking at different horizons. The insight is that changes in the inflation mean and persistence induce different effects on the term structure of inflation expectations. Shifts in the mean affect expectations by similar amounts over all horizons, while changes in the persistence affect short horizons more, leading to changes in the slope of the term structure of inflation expectations. Hence, when the pattern of persistence drives the pass-through dynamics, the term structure should steepen.

Figure 30 repeats the event-study analysis underlying the one-year forward inflation starting nine years from now. It turns out that very far-forward inflation expectations remain insensitive to macroeconomic news.

Figure 30

Reaction of long-term inflation expectations (ILS 1y9y) on macroeconomic surprises, event study

(Nine-month rolling window estimates – 5/95 percentiles)



Source: Speck (2017).
Note: Last observation June 2016. Year labels on x-axis refer to 1 Jan. Selected surprises: inflation releases in DE, ES, IT and EA and corporate sector sentiment releases in DE, FR and IT. The reaction is expressed on the y-axis in multiples of the pre-crisis reaction of the ILS 2y.

Going back to the distinction between target and instrument credibility, this observation suggests that the Eurosystem's inflation target over the period 2014-2015 could be regarded as credibly anchored in the long run. De-anchoring risks, then, were more related to increasing uncertainty regarding the ECB's *instrument effectiveness*, or the policy effectiveness in preserving price stability.

This conclusion is also supported by estimates of the inflation pass-through coefficient that control for the impact of the inflation target. In particular, applied to SPF data, such estimates provide no evidence of a reduction of the role of the inflation target for longer-term (i.e. four to five years ahead) inflation expectations from professional forecasters.[30]

Grishchenko et al. (2016), using a synthetic indicator derived from various survey measures, also find evidence of a steepening of the inflation expectations curve in the euro area, as well as a less dispersed distribution centered around 2% at the longer end of the survey horizon.[31]

[30] Lyziak and Paloviita (2016).

[31] See Grishchenko et al. (2016), Figures 5 and 6.

3 Channels of self-perpetuating dynamics of low inflation at the ELB

Persistently low levels of inflation affect the macroeconomy through several channels

This section discusses the macroeconomic consequences of low inflation when the effective lower bound on nominal interest rates has been reached and the space for fiscal policy is constrained. It focuses on three channels: (i) de-anchoring of inflation expectations, (ii) competitiveness and the exchange rate, (iii) debt-deflation and financial stability. Such considerations were particularly relevant during 2013-2014, but are of less relevance now following the launch of the ECB's Asset Purchase Programme (APP) early in 2015.

3.1 De-anchoring of inflation expectations

As a premise, standard DSGE models with rational expectations have difficulties analysing the genesis and impact of de-anchoring: long-term inflation expectations are pinned down by the monetary policy strategy of the central bank and long-term outcomes for any macroeconomic variable are assumed to be stationary processes, hence the concept of long-term expectations “de-anchoring” is not well defined in this class of models.

Insights into the policy implications of endogenous changes in long-run beliefs have been derived from two strands of literature: the first assumes that agents do not have perfect knowledge of the long-run structure of the economy, paving the way for destabilising movements in long-run beliefs; the other deals with multiple equilibria: self-fulfilling de-anchored expectations might trap the economy in a low-inflation equilibrium. The rest of this subsection looks at the genesis of de-anchoring through the lens of a model with learning and heterogeneous agents.

3.1.1 Insights from a model with learning and heterogeneous agents

Imperfect information and self-fulfilling mechanisms

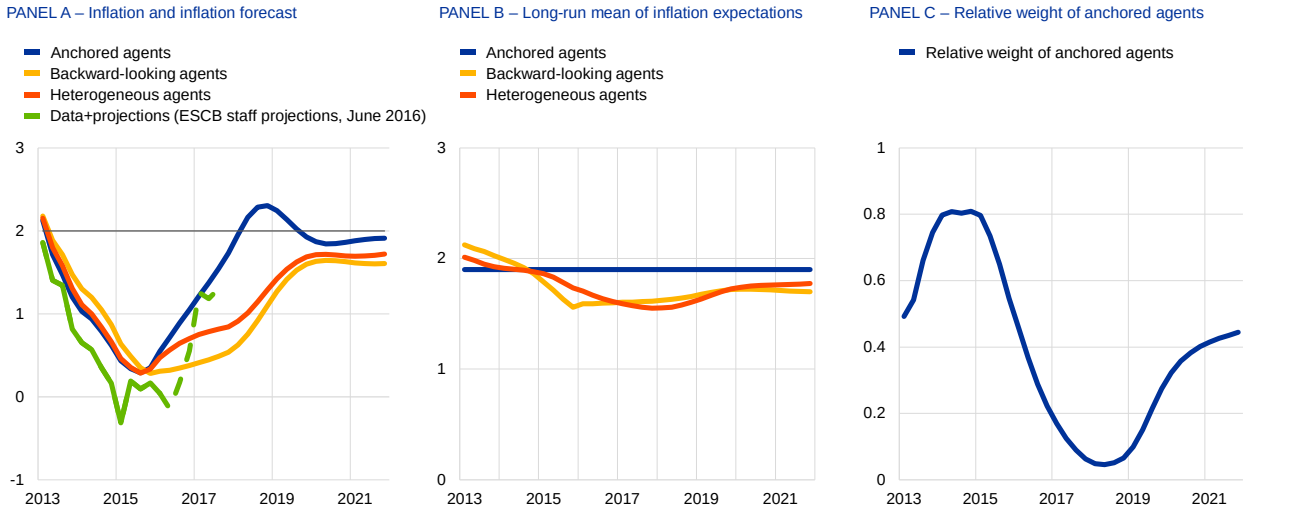
Busetti et al. (2017), extending Busetti et al. (2014), relax the hypothesis of rational expectations and allow for heterogeneous beliefs. In every period agents predict inflation and output by choosing between competing forecasting models: one is “anchored”, i.e. agents know (and believe in) the target values of the relevant macro variables, and the other one is “de-anchored”, i.e. agents form expectations using naïve adaptive rules: the better a given model has recently performed, the larger the share of agents who adopt it.

Figure 31 plots the realised values of inflation with the forecasts made in each quarter by anchored and de-anchored forecasting models (Panel A), together with the long run aggregate expectations (Panel B), and the inflation persistence as proxied by the share of anchored agents in the economy (Panel C).

The main result is that a sequence of negative shocks brings actual inflation off target, and a prolonged period of low inflation affects expectations in the two ways discussed above: it reduces the perceived inflation target and increases inflation persistence, because the relative weight of anchored agents decreases.

Figure 31

Anchored vs de-anchored models



Source: Busetti et al (2017).

3.1.2 Impact of de-anchoring of inflation expectations in standard DSGE models with Calvo pricing and indexation

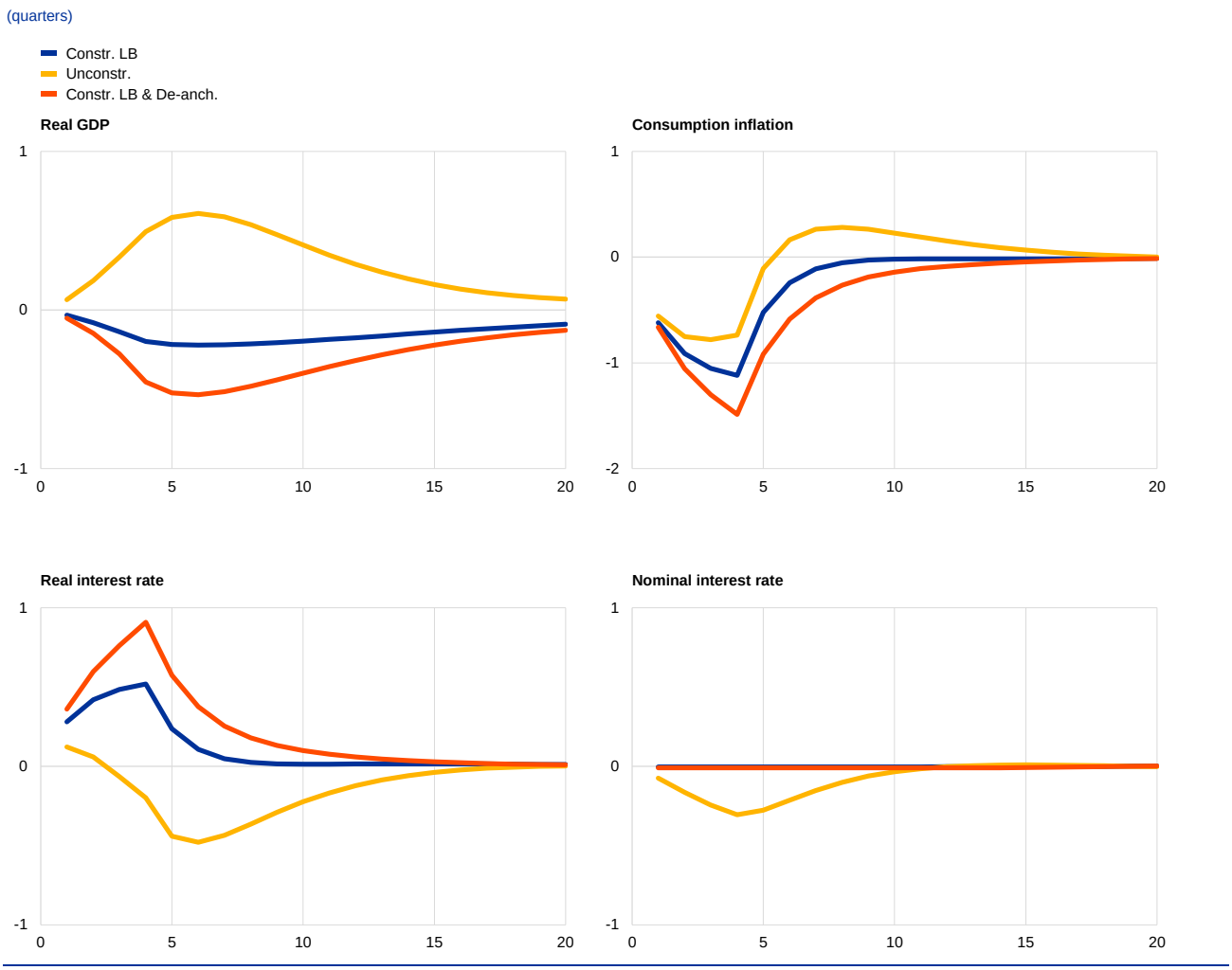
De-anchoring may also be modelled in simpler rational expectations models, where its impact is gauged by changing the parameters that affect the formation of expectations. For example, increased inflation persistence can be modelled assuming a change in the degree of price indexation.

In standard DSGE models, and in particular in the New Area-Wide Model (NAWM), only a portion of firms or households re-optimise their prices in every period and agents who are not normally able to optimise their prices are allowed to update them using previous period inflation and/or the inflation target of the monetary authority. Hence, we can consider several de-anchoring scenarios that broadly correspond to the increased inflation persistence and loss of credibility of the target delineated above: agents may give more weight to past inflation versus the inflation target or they may believe that the monetary authority has decreased its target (or is not able to achieve it).[32]

[32] Reasons behind this could be that after a period of persistent below-target inflation agents may infer that using past inflation in their expectations is more informative, as in Busetti et al. (2017).

Figure 32

Impact of a domestic negative price mark-up shock at the ELB with de-anchoring



Source: ECB, NAWM.

De-anchoring perpetuates low inflation and has a more negative impact on GDP

Figure 32 presents the results of a scenario analysis performed with the NAWM where the simulation exercise combines a negative mark-up shock with nominal interest rates being constrained by the effective lower bound and a 20% increase in the indexation to previous period inflation parameters.[33] In this case, the lower inflation is accentuated, since past inflation is given more weight in future expectations, driving inflation even lower and increasing real interest rates still more, leading to an even more negative impact on GDP. This shows how de-anchoring reinforces low inflation where expectations are rational.

[33] The NAWM features Calvo pricing for workers, intermediate goods companies, exporters and imports, with Calvo parameters around 0.8-0.5 and indexation to past inflation parameters around 0.5.

3.2 Other channels

DSGE models used by ESCB staff document that price mark-up shocks are among the most important sources of low inflation over 2013-2014. Thus, the results discussed in what follows are based on simulations that consider the effects of a negative cost-push shock.[34]

The expansionary effects of a cost-push shock on activity are mitigated at the ELB

This shock enters as a negative additive term in the linearised New Keynesian Phillips curve. Normally, in the absence of the effective lower bound (ELB), a cost-push shock moves inflation and output in opposite directions. All results highlight that at the ELB the effects on inflation are generally stronger (it decreases by more); and the effects on activity are mitigated (it increases by less or declines).[35]

3.2.1 Competitiveness and the exchange rate

When interest rates are unconstrained, a downward domestic price mark-up shock is analogous to a drop in the marginal cost of domestic production, leading to a lower price level and boosting activity. Additionally, the central bank reacts to the lower inflation by reducing interest rates. Even though real interest rates go up initially due to the persistence of interest rates under the Taylor rule and its response to the output gap, they remain lower for a significant amount of time. This is internalised by the forward-looking agents, giving an additional boost to consumption, investment and therefore imports.

At the ELB higher real interest rates dampen the effect of low inflation on GDP

The lower domestic price level and a negative interest rate differential with foreign interest rates entail a real depreciation that improves competitiveness, supporting exports and fostering domestic substitution of imports. After the shock, higher activity starts pushing up real wages and inflation, which leads the economy back towards its steady state.

Overall effect at the ELB depends on competitiveness gain and real interest rate differential

The scenario when the shock hits while interest rates are at their ELB adds another ingredient to the simulations that offsets the beneficial effects of the initial results. With the ELB, nominal interest rates cannot decrease, resulting in higher real interest rates for a significant amount of time. Again, this result is internalised by agents and has a negative impact on consumption and investment even in the short term. After the period of shocks, inflation picks up again, but with no help from monetary policy, real interest rates remain higher for some time, making the return to the steady state

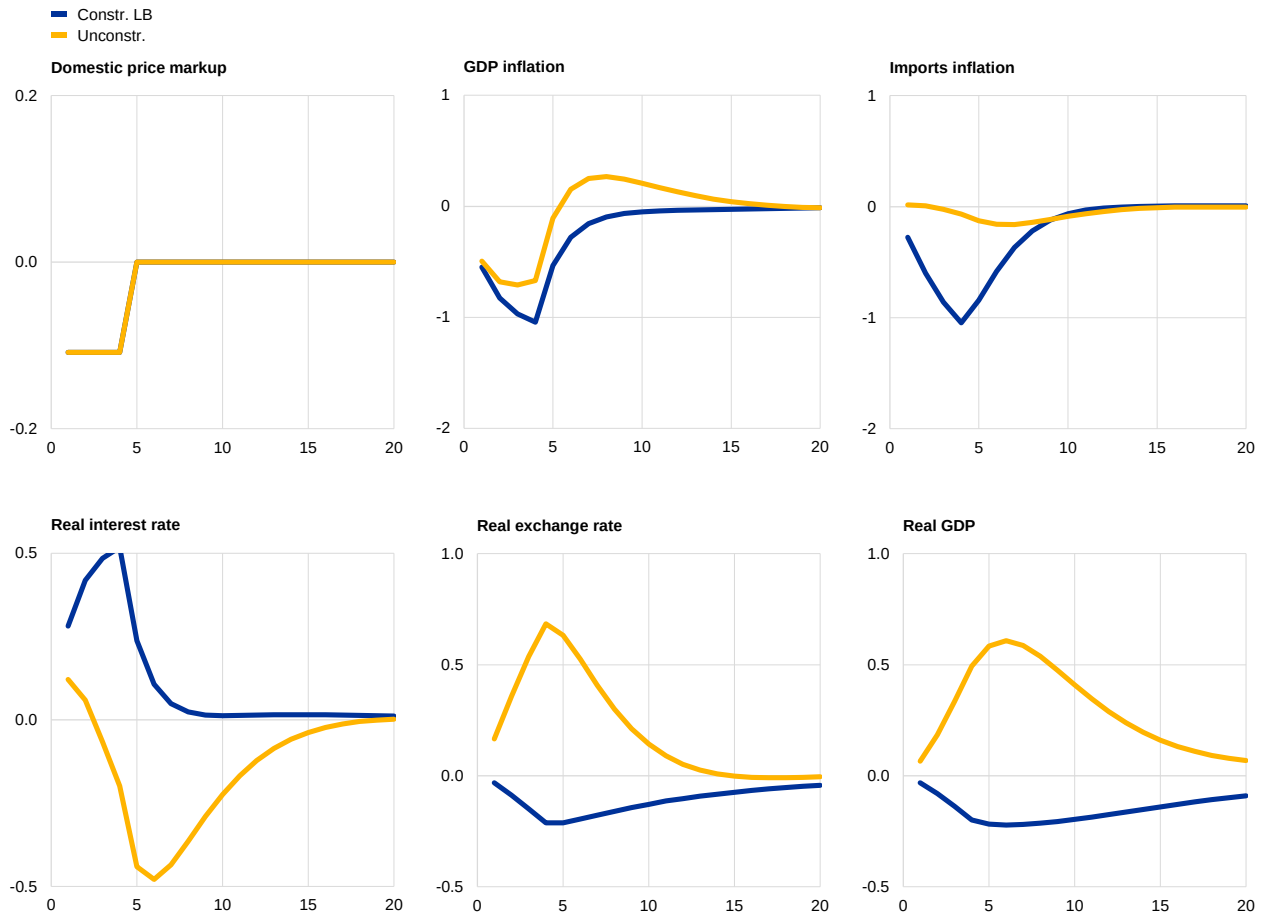
[34] The simulations consider a negative cost-push shock that hits the economy for four periods and vanishes afterwards. These findings are based on simulations in a variety of models used for policy analysis in the ESCB such as the NAWM, RAMSES II, the DSGE model for Denmark, the Bundesbank DSGE model of Hoffmann et al. (2014), the model of Neri and Notarpietro (2014) and the 3D Model as in Mendicino et al. (2015). The literature has discussed other channels that are not considered here. See e.g. Benigno and Ricci (2011) or Schmitt-Grohé and Uribe (2013) for the downward nominal rigidity channel.

[35] The analysis presented in this section abstracts from the implementation of unconventional measures, such as asset purchases and forward guidance. If such measures were in place, the central bank could affect current private sector expectations through a commitment to maintaining an accommodative stance for a period of time longer than would be warranted by a standard monetary policy framework. As a result, real interest rates could be affected and negative effects on GDP might be mitigated (see Section 4.1 on forward guidance).

very slow. However, higher real interest rates imply a positive differential with foreign interest rates, which in this model leads to persistent real appreciation of the exchange rate as a result of the Uncovered Interest Parity (UIP) condition in the model. In spite of the lower price level, higher real interest rates depress the domestic economy, while exports are affected by the appreciation of the real exchange rate. In the NAWM, the appreciation hits exports and has an overall negative impact on the economy (See **Figure 33**).

Figure 33

Impact of a negative price mark-up shock at the ELB: exchange rate channel in the NAWM



Source: ECB staff calculation.
Note: IRFs to a four-period mark-up shock for domestic goods sold domestically. Responses are reported as percentage deviations from the non-stochastic balanced-growth path, interest rate and inflation responses reported in annualised percentage points deviations.

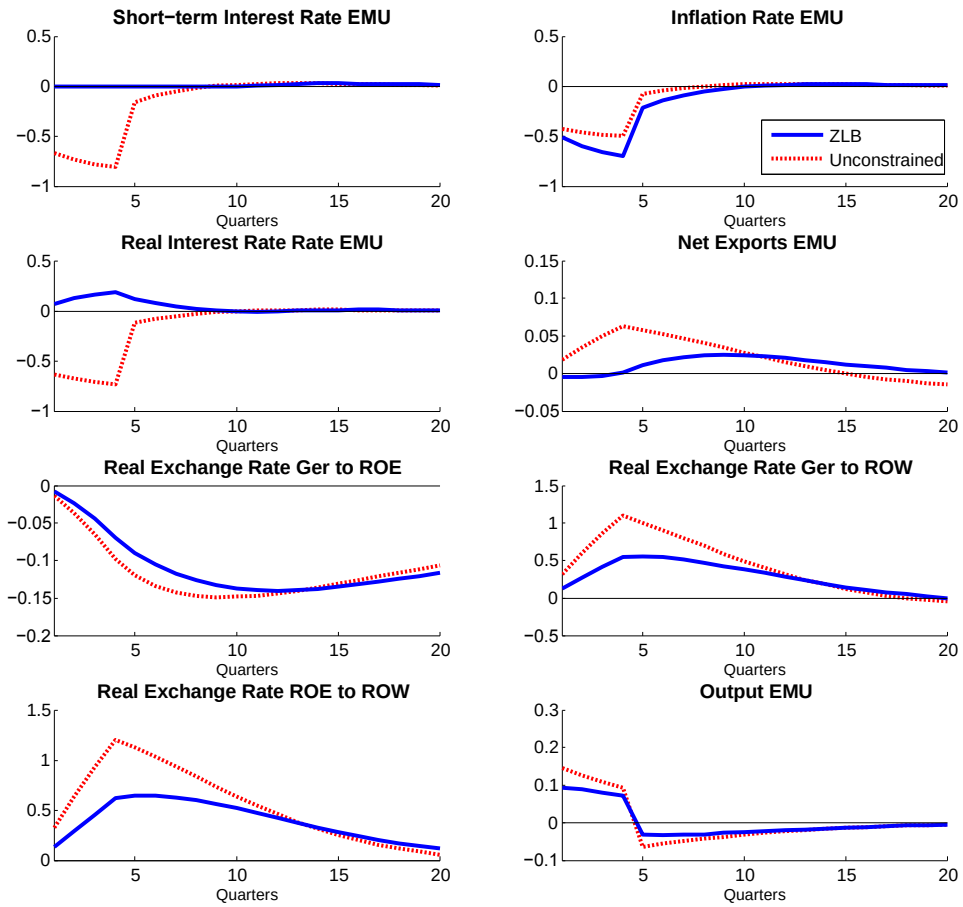
Global or regional mark-up shocks have broadly similar effects, but when agents expect the ELB to bind for long, output and inflation increase strongly

The severity of these effects depends on the size of the shock and the economic model. While the findings in the NAWM on inflation and real interest rates are shared by the models of Adolfson et al. (2013) and Hoffmann et al. (2014), these two models provide different results with respect to the real exchange rate, net exports and hence output. In these models, the competitiveness gain effect outweighs the real interest rate differential effect, and therefore they find a temporary real depreciation against the rest of the world even at the ELB. Accordingly, output increases either in general (as in Adolfson et al. (2013)) or at least temporarily (as in Hoffmann et al. (2014), see **Figure 34**). The difference between the results of the NAWM and those

of Adolfson et al. (2013) and Hoffmann et al. (2014) is related to different approaches to incorporating the UIP and the endogenous persistence intrinsic to the design and estimation of the model.[36]

Figure 34

Effect of an area-wide mark-up shock in a multi-country model where the competitiveness gain effect outweighs the real interest differential effect



Source: Hoffmann et al. (2014).

This can be interpreted as forward guidance working through the expectations channel

In addition to the setting with negative price mark-up shocks in the euro area, Hoffmann et al. (2014) also allow the analysis of shocks only in the euro area excluding Germany and in all three regions: Germany (Ger), the rest of the euro area (ROE), and the rest of the world (ROW). While absolute responses vary in size according to the country affected by the shock, the qualitative results for output and inflation remain unchanged. The situation where agents anticipate that the policy rate will remain low at the ELB for a prolonged period is also analysed. In the case where the policy rate is at the ELB for 15 quarters, i.e. longer than under the unconstrained monetary policy, agents take this information as an opportunity to temporarily increase consumption and investment, so both output and inflation increase. This

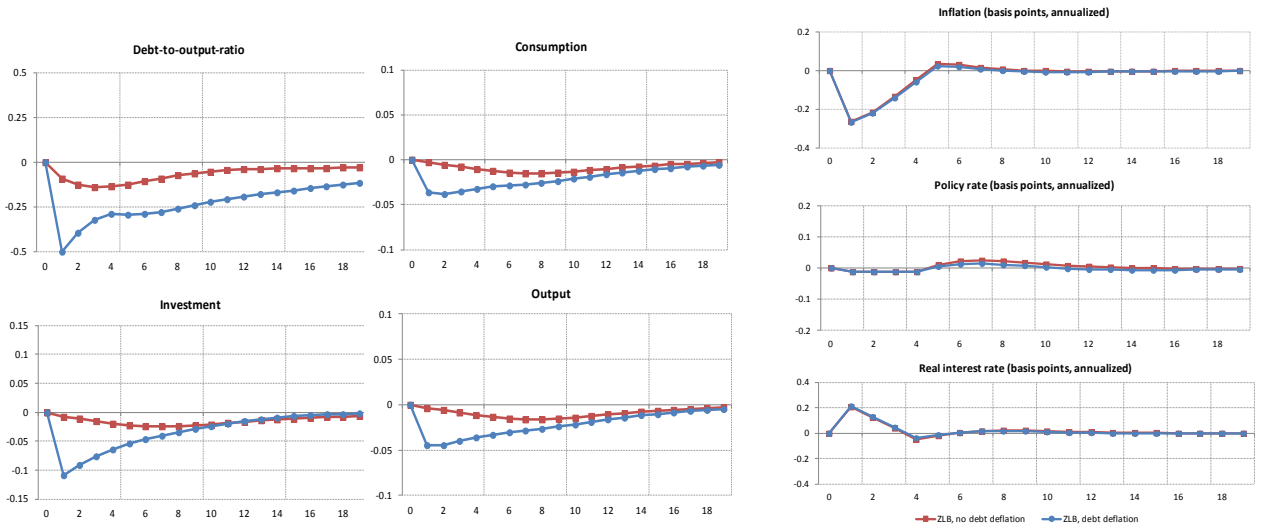
[36] The RAMSES model allows for deviations from the UIP condition. When the exchange rate is made less sensitive in the short run to contemporaneous interest rate differentials, as in RAMSES, the real exchange rate depreciates even in simulations produced with the NAWM.

scenario may be interpreted as forward guidance working through the expectations channel, and the outcome is similar to that described in Section 4.1 and Box 10.

3.2.2 Debt deflation and financial stability

Debt deflation can also cause low inflation to self-reinforce through effects on the macroeconomy. In a dynamic optimising framework, consumption and investment choices depend on the expected path of future real interest rates. Under normal circumstances, the monetary authority adjusts the nominal interest rate in response to a decline in inflation and lower inflation raises real disposable income, leading to an increase in aggregate demand. The following describes typical channels arising from low inflation at the ELB. In this context, it is important to distinguish the source of low inflation: if it is mainly due to low commodity prices, it may actually facilitate deleveraging by increasing household disposable income and reducing costs of domestic production. If however the main source is domestic, then the channels described in what follows are fully at play.

Figure 35
Debt deflation channel at the ELB



Source: Neri and Notarpietro (2014).

At the ELB the debt deflation channel amplifies the contractionary effects of low domestic inflation

Low and falling domestic inflation rates at the ELB imply an increase in the real interest rate. Intertemporal substitution leads to a reduction in aggregate demand. When debt is issued in nominal terms, a fall in the domestic inflation rate entails an increase in the real interest rate and the real value of existing debt, which starts a deleveraging process. With collateralised debt, the reduction in private sector borrowing leads to a decline in asset prices, thus reducing the net worth of the private sector and aggregate demand. This generates further downward pressure on

prices, raising the real value of debt, and leading to a self-reinforcing mechanism (see **Figure 35**).[37]

Low domestic inflation increases the real value of debt, worsening borrowers' balance sheets and making them more likely to default. As a result, at the ELB a prolonged period of low domestic inflation leads to a deep and persistent decline in economic activity. This affects borrowers and leads to a greater incidence of default for both households and firms, and in turn affects the financial sector through a deterioration in banks' balance sheets. A higher rate of borrower defaults reduces bank profitability and bank capital, and thus the supply of loans (the bank capital channel). At the same time, bank defaults increase, leading to an increase in the cost of deposit funding, which further increases the lending rates that banks have to charge (the bank funding channel).

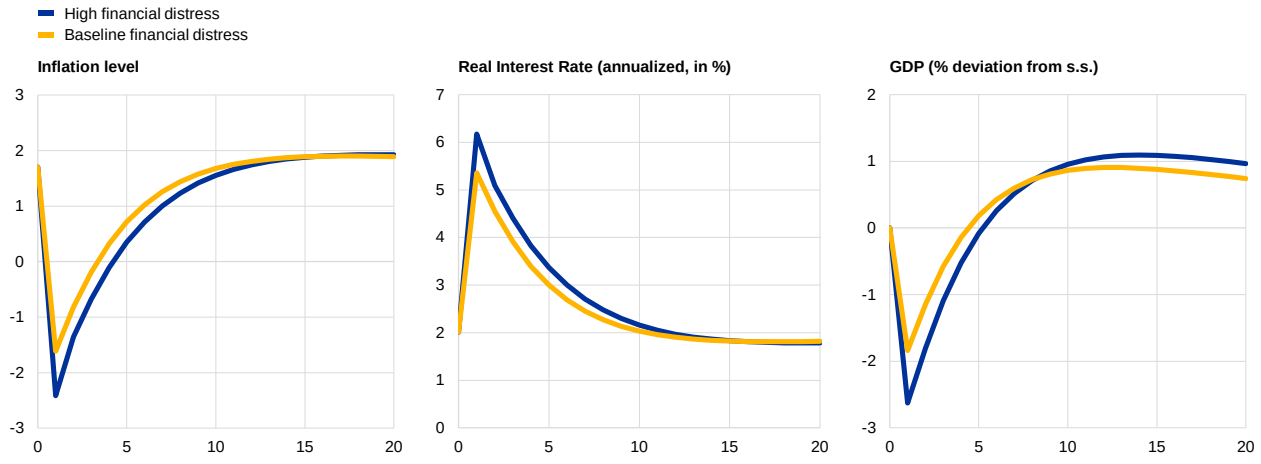
At the ELB higher financial distress amplifies the contractionary effects of low inflation

Both channels further contribute to the reduction in asset prices, leading to higher default rates among borrowers. Higher financial distress in the banking sector amplifies the negative effect of low inflation on economic activity and financial stability (**Figure 36**).[38]

All the results in this section are based on models that do not make the distinction between imported, "supply-side" inflation and domestically originating inflation. Since the low inflation in the euro area was in great part also due to external shocks, their empirical relevance might have been contained.

Figure 36

At the ELB higher financial distress amplifies the contractionary effects of low inflation



Source: Based on a New Keynesian version of the 3D Model (Clerc et al. (2015) and Mendicino et al. (2015)).

37 Neri and Notarpietro (2014), using a New Keynesian model with collateral constraints on households and firms as in Gerali et al. (2010), document that the interplay of the ELB with the debt-deflation channel amplifies the contractionary effects on economic activity.

38 Simulations carried on with a New Keynesian version of the 3D Model by Clerc et al. (2015) and Mendicino et al. (2015) document the role of financial distress in the banking sector on the effect real and financial shocks have on the macroeconomy.

4 Possible policy responses: theoretical mechanisms and empirical effectiveness

Having looked at the effects of low inflation on the macroeconomy, the final question is: what are the effects of possible policy responses when the effective lower bound on nominal interest rates has been reached and the space for fiscal policy is constrained? This section focuses on unconventional monetary policy measures, also reviewing empirical evidence of their effectiveness. Then it looks at structural reforms, which have been partly implemented but remain on the agenda of many euro-area countries.

4.1 Forward guidance

Since June 2013, the ECB has been providing forward guidance on the future path of monetary policy interest rates, conditional on the outlook for price stability. In essence, forward guidance works through an expectations channel: expected future short-term interest rates are a key element in the determination of long-term interest rates, which in turn are essential drivers of saving, consumption and investment decisions. As such, forward guidance can serve two main purposes.[39] First, it can provide greater monetary policy accommodation when the policy rate reaches the ELB, by providing assurance that the central bank will keep the policy rate at low levels for some time, and for a longer period than the public initially expected. Second, it may prevent market volatility from interfering with and hampering the transmission of monetary policy decisions. Hence, once the policy rate has reached the ELB, the introduction of forward guidance and the commitment to keep the short-term interest rate at the lower bound for a prolonged period is a deliberate monetary policy strategy.

An assessment of the macroeconomic implications of announcing a path for policy rates can be obtained using structural DSGE models, which assign a crucial role to agents' expectations about future developments of the main macroeconomic variables. Coenen and Warne (2014), using the NAWM developed at the ECB, show that with nominal interest rates at the ELB forward guidance can mitigate the downside risks to price stability. An assessment of the effects of announcing a commitment to hold nominal interest rates at the ELB for a prolonged period can also be obtained using the model developed in Arce et al (2016). Simulation results show that a short-term increase in GDP can result from this policy through a reduction in both current and expected real interest rates in the monetary union.[40] Similar results

[39] See ECB (2014a).

[40] See Box 10. For a survey of the channels see also the article "The transmission of the ECB's recent non-standard monetary policy measures", Economic Bulletin, Issue 7/2015.

can be obtained using the model of Hoffmann et al. (2014) to simulate a forward guidance scenario working through the expectations channel. In particular, in the case of the policy rate at the ELB for 15 quarters, i.e. longer than under the unconstrained monetary policy, agents take this information as an opportunity to increase consumption and investment temporarily, so both output and inflation increase (results are similar to those reported in Box 10).

4.2 Unconventional monetary policy measures

In recent years central banks in the advanced economies have enacted various rounds of quantitative easing (QE) policies aimed at supporting economic activity – and, as a consequence, inflation dynamics – when short-term monetary policy rates have reached the effective lower bound (ELB). In general, QE policies consist of asset purchases by the central bank and are expected to affect economic activity and inflation through a variety of channels.[41]

The prolonged period of low inflation, observed in the euro area since 2014, has prompted a number of unconventional monetary policy measures by the ECB. In particular, the effects of the recent introduction of the APP on euro-area economic activity and inflation can be analysed through the lens of structural DSGE models, which help clarify the different transmission channels of the policy measures implemented. Two recent contributions by the Banca d'Italia (Burlon et al. (2015), Cova et al (2015)) study the macroeconomic effects of the APP using two different models. The first accounts for the ELB, the presence of tight financial conditions in the private sector and segmentation in financial markets, while the second also includes international spillovers. In both cases, the central bank's purchase of long-term bonds reduces their yield, inducing the private sector to increase consumption and investment. The expansionary effects generate an increase in inflation, which leads to a further reduction in real interest rates and erodes the real value of private debt. The international trade spillovers are positive. Simulation results show that the APP should provide support to euro-area GDP growth over a three-year horizon, while the inflation rate should increase significantly in the same period.

[41] A number of recent papers have tried to evaluate the macroeconomic effects of the various unconventional monetary policy measures the major central banks have put in place in response to the financial crisis. Concerning the USA, in an early study Chung et al. (2011) show that the Large Scale Asset Purchase (LSAP) programmes provided a boost to the level of real GDP of about 3%, while inflation was 1% higher compared with what it would otherwise have been, according to the Fed's FRB/US model. In a more recent study, Engen et al. (2015) find smaller peak effects, e.g. inflation is increased only by 0.5 percentage points. More generally, rescaling the amount of asset purchases of the LSAPs to USD 1 trillion for ease of comparison across existing studies, the peak impact on the level of output would be between 0.25% and 1.75%, while the corresponding effect on inflation would be in between 0.25 and 1 percentage points. For the UK, Joyce et al. (2011), using a variety of approaches, estimate that the peak impact on the level of GDP was between 1.5% and 2%, while the maximum effect on consumer price inflation was between 0.75 and 1.5 percentage points. Rescaling the asset purchases to an amount of GBP 200 billion, other existing studies estimate a peak impact of between 1% and 3% on GDP and between 0.5 and 2.5 percentage points on inflation.

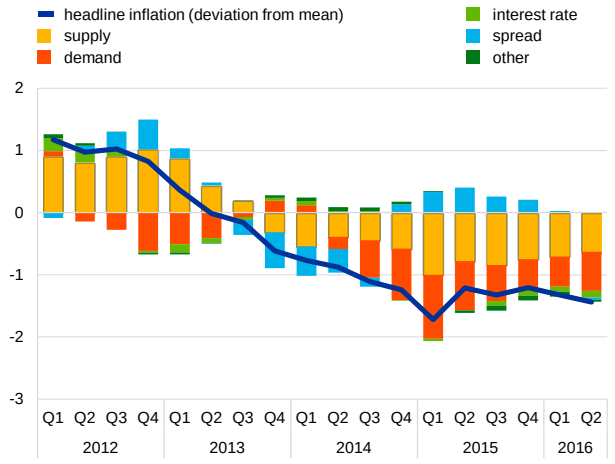
4.3 How effective can (unconventional) monetary policy be and through which channels?

Given the above theoretical mechanisms for unconventional policies, how effective has monetary policy been in raising inflation in practice?

Figure 37

Historical decomposition – headline

(HICP annual percentage changes, deviation from baseline, percentage points)

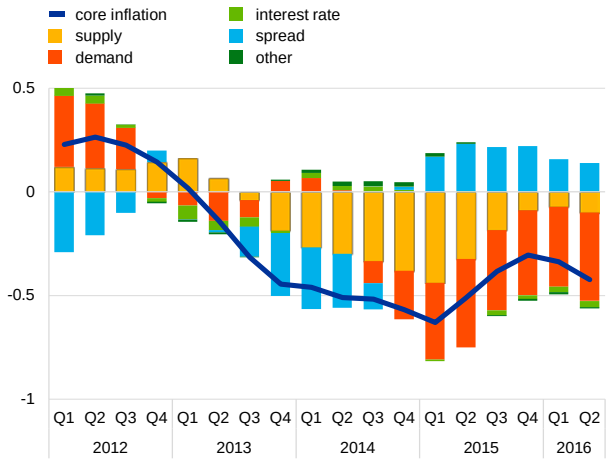


Source: ECB staff estimations.

Figure 38

Historical decomposition – core

(HICP annual percentage changes, deviation from baseline, percentage points)



Source: ECB staff estimations.

Empirical evidence based on the structural BVAR described in Section 2.2.2 suggests that it has. **Figure 37** and **Figure 38** show the historical decomposition for euro-area headline and core inflation over the missing inflation period, with domestic and foreign demand and supply shocks bundled together for simplicity. The results point to an overall reflationary contribution of spread shocks after 2015.[42] This is clearly reassuring but it does not say anything about the channels at work.

Andrade et al (2016) analyses the effects of the APP and finds evidence that its announcement in January 2015 significantly and persistently reduced sovereign yields on long-term bonds and raised the share prices of banks that held more sovereign bonds in their portfolios. It also presents a stylised macroeconomic model accounting for more channels that suggests that the macroeconomic impact of the programme can be expected to be sizable.[43]

[42] The spread shock was identified by restrictions on the spread between long and short term rate à la Baumeister and Benati (2013), where with short-term rates at zero, a decrease in the long-term rate (and hence in the spread) is expansionary. The spread shock is associated here with monetary policy but of course, it may always be related to other factors. As discussed above (and in particular in the euro area), the spread is also affected quite strongly at times by repercussions from the sovereign debt crisis rather than genuine monetary policy. Another possible way to capture the effectiveness of unconventional monetary policy that does not rely on the spread would be to use shadow interest rates or direct measures of balance sheet expansion; however, shadow interest rates are not appropriate in structural models because agents would not be able to borrow/lend at shadow rates. Using balance sheet data for the euro area is also more problematic than for the United States, due to autonomous factors and the relatively short time series.

[43] For a description of credit and quantitative easing measures taken by the ECB and their transmission channels, see also ECB (2015).

In what follows, two channels are discussed: the expectation or re-anchoring channel, and the exchange rate pass-through channel.

4.3.1 The re-anchoring channel

The risk of weakened anchoring of inflation expectations can pose a challenge for monetary policy, in particular in the light of the sluggish economic recovery in recent years. Some models point to risks of the de-anchoring of long-term inflation expectations in the euro area, and although there is some evidence that the launch of the APP has softened these risks, the question arises as to how effective central bank actions are in curtailing de-anchoring risks.

Lessons from the US Federal Reserve's experience

Some lessons can be drawn from the US Federal Reserve's experience.[44] A significant pass-through from short to long-term inflation expectations indicates an increasing risk of de-anchoring after 2009 in the USA (**Figure 39**). The expansion of the Fed's balance sheet (especially during QE2 and QE3) contributed decisively to preventing and gradually reversing these risks of de-anchoring, and counteracted high tail risks of deflation (or very low inflation). Specifically, the risk of de-anchoring decreased in periods in which the Fed was actively expanding its balance sheet through asset purchases, and increased again in periods when the balance sheet was kept constant or contracting.[45]

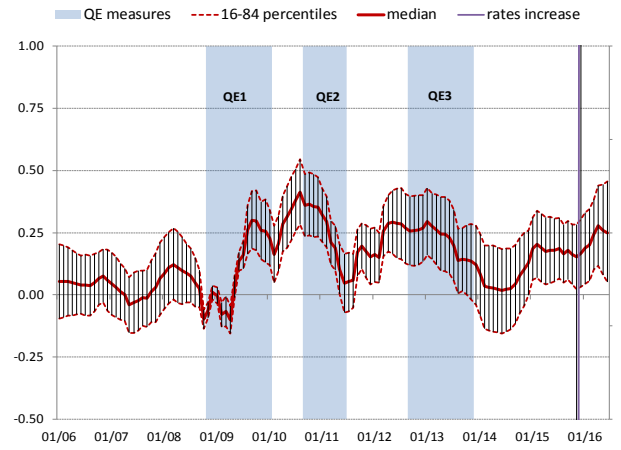
[44] Results in this section are based on Ciccarelli et al (2017).

[45] See Figure 4 in Ciccarelli et al (2017), which shows this using the probability of low inflation as implied by the Survey of Professional Forecasters.

Figure 39

Pass-through from short (ILS 1y1y) to long-run inflation expectations (ILS 5y5y), univariate regression

(time-varying parameter estimates – median, 16/84 percentiles, monthly data, percentage points)

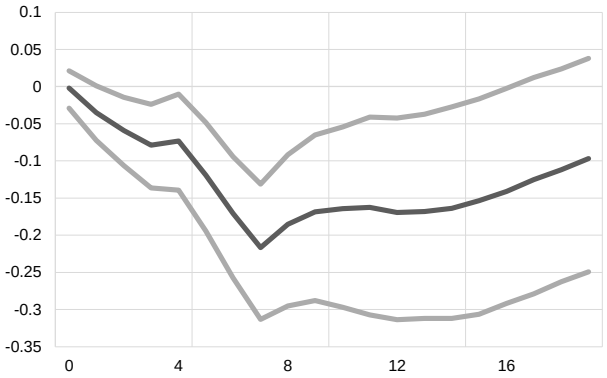


Source: Ciccarelli et al (2017).
Note: Time-varying estimates of the pass-through from the changes in short-term inflation expectations over the previous six months to changes in long-term inflation expectations over the previous six months. The model is estimated with Bayesian techniques and allows for stochastic volatility. Grey areas correspond to QE periods.

Figure 40

Impulse response function of the de-anchoring measure to a shock in an anticipated path of the Federal Reserve's balance sheet

(Impulse response function – median, 16/84 percentiles, percentage points)



Source: Ciccarelli et al (2017).
Note: SVAR model with policy news.

Accounting for the predictable path of the balance sheet following the Fed's asset purchase announcements is essential for assessing the effects of unconventional monetary policy. Both the announced (anticipated) path of the balance sheet and the unexpected component of balance sheet expansion have in fact decreased the risk of de-anchoring. For instance, **Figure 40** shows the effect on the de-anchoring measure of an announcement that the Federal Reserve's balance sheet was going to expand by 75 billion dollars each month for twelve months (mimicking the second QE program). This expansionary policy also had a strong negative effect on the de-anchoring coefficient, suggesting that LSAP programmes and announcements affected the economy through the expectations-anchoring channel.

Has euro-area monetary policy also been effective in counteracting these risks? Are asset purchases capable of triggering an expansion of the balance sheet that would cement the ECB's control over euro-area inflation expectations? Evidence that a balance sheet expansion contributes to curtailing risks of de-anchoring can be seen in **Figure 41** by comparing the estimates of (the distribution of) the pass-through coefficient of short to long-term inflation expectations over periods when the balance sheet was expanding (yellow line) to those when the balance sheet was contracting (blue line). Over the sample 2009-2016, ECB balance sheet expansions have been associated with low pass-through coefficients. In contrast, when the ECB balance sheet was contracting the density estimate of the pass-through was on average statistically higher at usual significance levels.

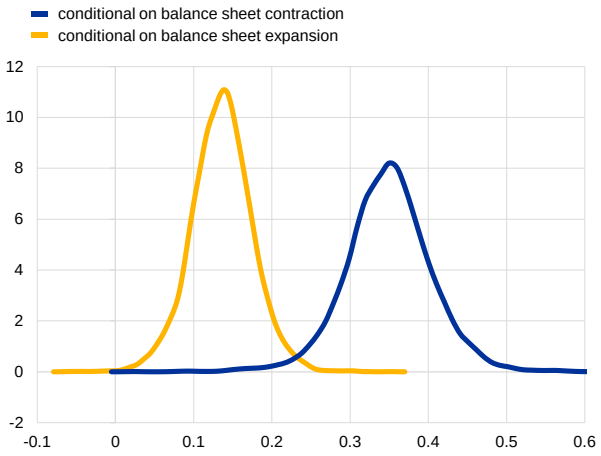
4.3.2 The exchange rate channel[46]

One of the channels of non-conventional monetary policy is the exchange rate. Evidence on the effect of forward guidance and, especially, asset purchases on exchange rates points to a large and quick reaction by the euro to monetary policy shocks,[47] but the transmission of the exchange rate channel is less well understood.

Figure 41
The effect of balance sheet expansions on the degree of de-anchoring

Conditional sampling estimates of the pass-through from short to long-term inflation

Posterior density distributions of the pass-through coefficient



Source: ECB Staff estimation. Last observation: 30 June 2016.
Note: daily estimates of the pass-through from the changes in short-term inflation expectations over the previous six months onto the changes in long-term inflation expectations over the previous six months. The model is estimated with Bayesian techniques and allows for stochastic volatility.

A vast literature reports a decline in exchange rate pass-through (ERPT), both at the import price level and down the pricing chain.[48] At the import price stage, pass-through may have declined for a number of reasons: (1) an increased role for hedging, either "naturally" by increasing global value chain integration or through cheaper financial instruments (Di Mauro et al. (2008)); (2) a sectoral shift in the composition of imports from sectors with high ERPT, such as energy, to sectors with lower ERPT, such as manufacturing and food (Campa et al. (2005), Di Mauro et al. (2008), Osbat and Wagner, (2006)); (3) the emergence of low-cost competitors in international trade; (4) increasing invoicing in euro (ECB (2014)); (5) an environment of low and less volatile inflation (Taylor (2000)). At the level of HICP, ERPT is further dampened by the increasing share of distribution costs in the final cost of retail sales and the mechanism highlighted by Taylor (2000), where a low inflation environment prevents importers from passing exchange rate changes through to consumers.

Empirically, approaches that are based on the identification of an exchange rate shock using a Choleski decomposition as described e.g. in Hahn (2003) point in many cases to a secular decline in ERPT at all levels of the pricing chain. At the same time, these estimates are surrounded by very large uncertainty. For example, Comunale and Kunovac (2017), who follow this approach, find that a nominal effective exchange rate shock has a limited impact on HICP inflation in the majority

46 This section is based on Comunale and Kunovac (2017). A recent study by Bulgarian National Bank (2015) finds that the response of prices to exchange rate movements is similar in size to the results in Comunale and Kunovac (2017). This reflects the fact that Bulgaria is a net importer in its trade with non-EU countries.

47 For recent evidence, see e.g. Ferrari et al. (2016), who find that "the external channel of monetary transmission has been alive and well, even though many central banks have hit the effective lower bound in recent years".

48 See ECB (2016c), Economic Bulletin article on "Exchange rate pass-through into euro area inflation".

of EU countries and the euro area as a whole.[49] The magnitude of the ERPT is negligible and statistically insignificant in most cases at impact, with some differences further on in time. This approach is also problematic because the definition of exchange rate pass-through depends on the ordering of the variables and other shocks are not clearly identified.

Exchange rate pass-through depends on the composition of shocks

A more economically meaningful approach, analogous to what is standard in looking at the impact of oil prices on inflation, is to ask what is moving exchange rates and consumer prices in the first place. Is it a domestic supply shock? Global demand? Monetary policy, domestic or foreign? Depending on the shock, the response in consumer prices and exchange rates will be different. This approach was pioneered by Shambaugh (2008) and was also recently made forcefully in Forbes (2015) and Forbes et al. (2015).

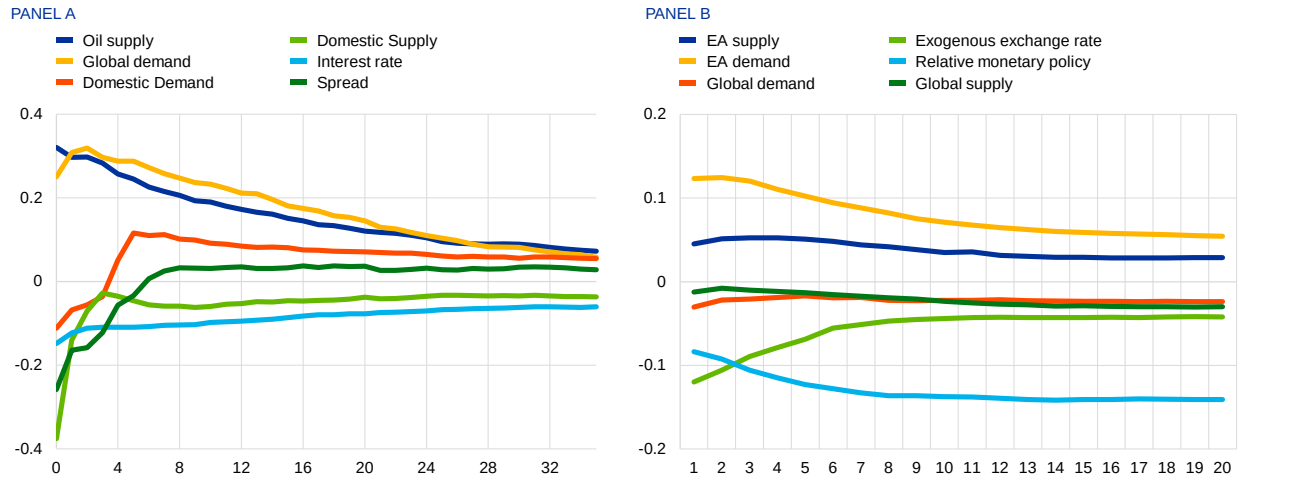
Two approaches are used here, both based on a combination of zero and sign restrictions in structural BVARs. The first is based on the BVAR used for the structural identification of shocks in Sections 2.2.2 and 4.3. The second VAR is specified using import and export prices too in order to pin down more closely an exogenous exchange rate shock. The other main difference is that it identifies a *relative* monetary policy shock.[50] For each shock, the pass-through ratio is computed as the ratio of the impulse response functions of the HICP and exchange rate.

[49] Some exceptions refer to non-euro area countries, such as Bulgaria. This result may be driven by the relatively high inflation in the starting quarters of the sample. Moreover, Bulgaria may be more susceptible to inflationary spillovers from trade partners: indeed, Iossifov and Podpiera (2014) find that countries with more rigid exchange-rate regimes and higher shares of foreign value-added in domestic demand are more susceptible to inflationary spillovers from the euro area. Another case is Luxembourg, where the response is much higher in magnitude than other members, however this estimate is not statistically significant from zero. The result may be driven by the fact that Luxembourg trade in services, especially with outside the euro area, is more important than trade in goods and dominates imports. In addition, trade in fuels represents a substantial part of goods imports and exports, so EPRT in Luxembourg should be dominated by the oil price channel in the short run.

[50] More details in Comunale and Kunovac (2017).The restrictions are as in Forbes et al. (2015) with some exceptions. In the short-run, the impact of relative monetary policy on foreign export prices is left unrestricted and the exogenous shock on exchange rate has a negative effect on foreign export prices. Instead of having a zero restriction for global shocks on foreign export prices, the authors impose the condition that global demand shocks impact positively on foreign export prices and global supply shocks impact negatively. In the long run, they only impose the condition that domestic and global demand shocks do not have any effect on EA GDP.

Figure 42

ERPT following different shocks: alternative identification schemes



Source: Panel A: ECB Staff estimation; Panel B: Comunale and Kunovac (2017).

In both BVARs, similar to the approaches that use simple VARs identified recursively, the confidence bands are very large. The identification scheme is another source of uncertainty, as shown in **Figure 42**. One common result, however, is that the ERPT following a monetary policy shock is relatively large. This implies that the exchange rate channel can also be expected to be active in the transmission of monetary policy. Ignoring model uncertainty, results from the first BVAR, which further decomposes monetary policy shocks into interest rate and spread effects, suggests that unconventional policy appears to have a more muted and less persistent effect than conventional monetary policy shocks. This depends on the different shape of the impulse response function of the exchange rate to the spread. However, using a high-frequency event-study approach that looks at the impact of both conventional and unconventional monetary policies on exchange rates, Ferrari et al. (2016) find that the sensitivity of the exchange rate to monetary policy has increased over time, including in the case of the euro.

4.4 Other policies: Structural reforms and government spending at the ELB

When addressing low growth and low inflation, the policy mix is very important. Among the possible policy measures to address a low growth environment, structural reforms in product and labour markets have been repeatedly advocated, especially for the distressed countries of the euro area. While the long-run macroeconomic benefits of structural reforms are clear and well documented in the literature, their short-run macroeconomic effects are less clear during a recession associated with a financial crisis. Specifically, reforms could allow for an earlier exit from the ELB if their short-term effects on inflation and economic activity are positive, or they could increase the duration of the ELB if their effects are negative.

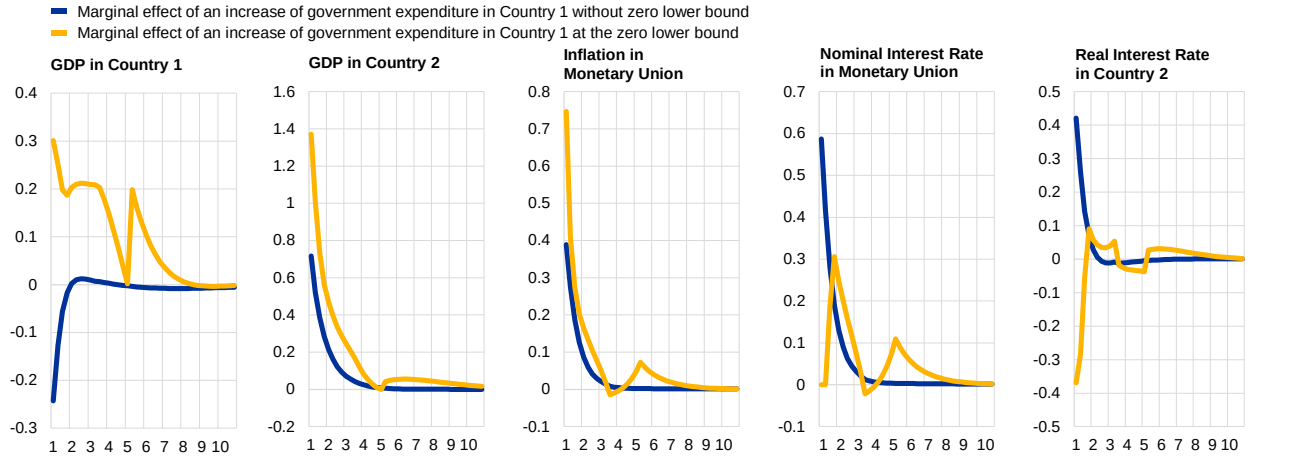
Structural reforms in the product and labour market have a positive effect on permanent income, due to the permanent expansion in aggregate supply. This increase in permanent income generates a positive wealth effect that favours an increase in aggregate demand. When the latter exceeds the increase in aggregate supply, the reforms have expansionary short-term effects. However, when the economy is at the ELB, a negative channel might also appear: since nominal interest rates cannot be reduced, any fall in inflation can translate into an increase in the real interest rate, generating contractionary effects. In particular, prices will fall if the initial surge in aggregate demand generated by the reforms is smaller than the expansion in aggregate supply.[51]

Eggertsson et al. (2014) show that, in the absence of physical capital accumulation, the fall in inflation and the lack of leeway to make further interest rate cuts render product and labour market reform contractionary in the short run, through an increase in the real interest rate. In contrast, Gerali et al. (2015) show that reforms simultaneously implemented in the whole euro area can favour an earlier exit from the ELB if they generate sufficiently large short-run inflationary effects through an increase in physical capital accumulation.

Using a more detailed and accurate model of structural reforms, Cacciatore et al. (2016) show, that in a small open economy, a reform package consisting of cutting entry barriers, reducing unemployment benefits and relaxing job protection increases output immediately and is not necessarily deflationary.

Figure 43

Marginal effects of a fiscal expansion in Country 1 (with and without ELB)



Source: Arce et al (2016).

This also holds for many individual reforms. Using a two-country model of the euro area, Arce et al. (2016) show that a reform in one country, while having short-term

[51] This negative side of structural reforms is, however, more debatable than the positive one. Since structural reforms lead to relative instead of general price changes, any short-term impact on overall inflation should not trigger a monetary policy response.

expansionary effects on the domestic economy in all cases, may generate positive or negative spillovers on the other country, depending on the presence of the ELB.[52]

Arce et al. (2016) also show that if the country that is not affected by the initial shock expands public expenditure, then the effects are actually more positive if the economy is at the ELB than in normal times. As reflected in **Figure 43**, fiscal stimulus of this type has clearly positive effects on activity in the country, that are larger when the economy is at the ELB. Moreover, spillovers to the other country, which are zero or negative in normal times (the direct effect through external demand is compensated by the increase in nominal interest rates), become positive when the economy is at the ELB.

[52] See Box 10 for details.

5 Conclusions

This paper has presented research conducted by a network of experts from the European System of Central Banks (ESCB). From 2013 to mid-2016, both headline and core inflation in the euro area (and in most member states) remained persistently below 2%. From a cyclical perspective, the lasting period of low underlying inflation seemed surprising given the recovery that started in 2013 and came along with a progressive decline in measures of trend inflation and an increase in inflation persistence. The models used by the Eurosystem and other institutions were unable to predict such low inflation outcomes.

This paper discusses the structural and cyclical factors behind the recent inflation developments and proposes some answers to three main questions: (i) Why has inflation been low in the euro area? (ii) What are the economic consequences of such low inflation? (iii) Has monetary policy been able to counteract these consequences and through which channels?

There is an increasing literature pointing to possible structural changes (e.g. demographics, technology), which are consistent with the decreasing trend inflation observed over the period of interest. This paper, however, finds that adverse cyclical factors played a more crucial role in explaining the missing inflation. What was the origin of these adverse shocks? To a significant extent, and especially from 2012 to 2014, the inflation decline can be explained by domestic factors more than external conditions (which instead were more prominent before 2012 and after 2014), and by demand more than supply forces. For domestic sources of inflation, one of the main conclusions of this paper is that the (hybrid New Keynesian) Phillips curve remains a useful tool in understanding inflation dynamics.

We also find that signs of a risk of de-anchoring appeared in 2014, following the oil price shock. This assessment is consistent with declining trend inflation, the fact that shocks were both global and domestic, and the evidence of a change in the intercept of the Phillips curve in the euro area.

The evidence of increased inflation persistence and of pass-through from current inflation and short-term inflation expectations to longer-term inflation expectations in 2014 reflects both the sequence of negative shocks and the longer-than-usual time lag of monetary policy transmission. Hence, agents may take time to learn about the *effectiveness* of the policy instruments. The subsequent stabilisation or reversion in 2015 signals the effectiveness of monetary policy to achieve its target within the monetary policy horizon.

Monetary policy can be effective through various channels. The paper analyses in particular the expectation or re-anchoring channel and the exchange rate channel, from an empirical perspective. Both channels are active in the euro area. For the re-anchoring channel, over the sample 2009-2016, ECB balance sheet expansions have been associated with a higher degree of anchoring of inflation expectations than balance sheet contractions. For the exchange rate channel, notwithstanding the

large estimation and model uncertainty, evidence shows that the pass-through depends on the kind of shocks affecting the exchange rate. This study finds that the exchange rate channel is strong when the exchange rate is being moved by monetary policy shocks. This shows that unconventional monetary policy is successful to raise inflation in the euro area.

Looking forward, the results of our study leave the door open for further investigation into several issues. In particular, they call for additional direct testing of the links between inflation expectations and the real economy, in addition to the mostly indirect approaches used for this paper. Likewise, it is worth investigating the link between wage growth, inflation and inflation expectations in more detail (for example, looking in detail at how much expectations matter, and at what horizon, for firms' price setting decisions and in the wage bargaining process).

This paper gives also no conclusive evidence on the steepening of the Phillips curve, which seems to have happened in some countries, and on what has driven it: was it the deep and prolonged slack in the economy, or was it an effect of structural reforms? Clarifying whether the Phillips curve is state-dependent, and if so in what way, remains an important research question.

Finally a detailed empirical investigation of the transmission channels of monetary policy was also beyond the scope of this study. One issue for further research that clearly arises from this work is the need to better understand the exchange rate pass-through and its determinants, focusing again on state dependence and in particular, in a way analogous to what is now standard when looking at oil price shocks, understanding the shocks that are currently driving the macroeconomy.

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Boxes

Box 1

Does demographic change affect inflation?[53]

Demographic change is a slow-moving factor with no observable immediate or short-run impact on inflation. In the first instance, it directly alters the size of the labour force, consumption and savings patterns as well as labour productivity. As such, it matters for potential growth and the natural rate of interest. Only if not counteracted by monetary policy, it may affect inflation in the long run. The impact of demographic change is ambiguous both theoretically and empirically, as the transmission channels from an ageing population to inflation are manifold and work their ways through simultaneous and offsetting effects. Furthermore, the impact of demographic change will depend on the extent of nominal and real frictions in an economy, institutional aspects and behavioural responses. This box summarises some results from the literature by focusing on the different channels through which demographic change can affect inflation.

Demographic change is likely to have a negative impact on potential growth and the natural rate of interest, as savings exceed long-term investments needed to promote future growth. According to Shirakawa (2012), population ageing lowers expectations for potential growth, implying lower permanent income for households. If the resulting decline in aggregate demand is not offset by monetary policy, it could lead to disinflationary pressures.

The impact of demographic change also depends on the process of population ageing, in particular if the ageing is due to higher life expectancy (Katagiri, 2012). If the working-age population shrinks and life expectancy increases, the number of wage earners relative to the number of people who consume is expected to decrease. The longer expected retirement period increases households' incentives to save more in order to smooth out consumption in the future. This puts downward pressure on the natural rate of interest, as the supply of funds increases. If a central bank does not take into account the change in the natural rate of interest due to demographic change, monetary policy may become too restrictive and prompt disinflationary pressures (Carvalho et al. (2016)).

According to the life cycle hypothesis, individuals plan their consumption and savings behaviour over their life cycle and smooth their consumption over their lifetime. Aggregate demand and supply shift because certain age groups and their particular economic behaviour gain in relative importance to the rest of the population. An ageing population implies that the elderly dissave and consume more, in particular non-traded goods and services, relative to people of working age. If supply does not fully meet the higher demand, the relative price of non-traded to traded goods increases, possibly also implying a real appreciation of the currency. If countries with ageing populations repatriate income from countries with younger populations to consume it at home, the real exchange rate will also tend to appreciate, exerting disinflationary pressures (Anderson et al. (2014)). Moreover, an ageing population is associated with a fall in land prices, affecting the wealth of older cohorts and hence also their consumer behaviour (Anderson et al. (2014)).

[53] Prepared by Eliza Lis (ECB).

Older generations place more emphasis on price stability and relatively low inflation, due to their creditor status. Older cohorts prefer a higher rate of return from their savings than young cohorts, who favour low real interest rates. If the older cohort has more influence on redistribution policy, it is possible that the society will place also greater importance on price stability and a low steady-state rate of inflation (Bullard et al. (2012)).

Given these various channels, an empirical literature on this issue has emerged recently. Most of the papers have focused on Japan, as its transition from ageing society to aged society is one of the fastest (Yoon et al. (2014), Anderson et al. (2014), Bullard et al. (2012), Katagiri, (2012)). All of these papers suggest that population ageing is disinflationary if not counteracted by monetary policy. Similarly, a forthcoming ECB working paper (Bobeica et al. (2017)) finds evidence of a positive long-run relationship between inflation and the growth rate of the working age population as a share of total population, which is used to proxy the demographic trend. The growth rate of the working age population has been on a downward trend and, based on the projections of the United Nations, it is likely to remain subdued in the advanced economies. Two papers by Juselius and Takats (2015, 2016) report empirical results contradicting the prevailing view in the literature mentioned above. They find that the impact of demographic change is U-shaped: A larger share of young or old cohorts is associated with higher inflation, while a larger share of working age cohorts is correlated with lower inflation. Looking ahead, this means that the growing share of old people could dominate and increase inflationary pressures.

All these considerations on the impact of demographic changes suggest that, in the first place, the natural rate of interest and potential growth are affected. They would only impact actual inflation when monetary policy does not take into account these changes properly, or when it is constrained by the effective lower bound.

Box 2
Is the Phillips curve slope flatter or steeper during recessions?[54]

The change observed in the slope of the euro-area Phillips curve may reflect structural changes in the economy, but it could also be caused by a mis-measurement of the amount of slack or state dependency in the Phillips curve. The analysis in the report addresses the mis-measurement of economic slack by taking various measures into consideration. This box deals with the other possible explanation, namely the existence of state dependencies in how inflation reacts to slack. It finds that over history, inflation tends to react more strongly to output in periods of booms; however, a deep recession such as the one recently experienced by the euro area can generate threshold effects in inflation responsiveness, with inflation reacting more to cyclical conditions.

There is no consensus in the literature on the sources of potential non-linearities or whether the Phillips curve is steeper in a boom or a recession or when the economy is close to equilibrium.

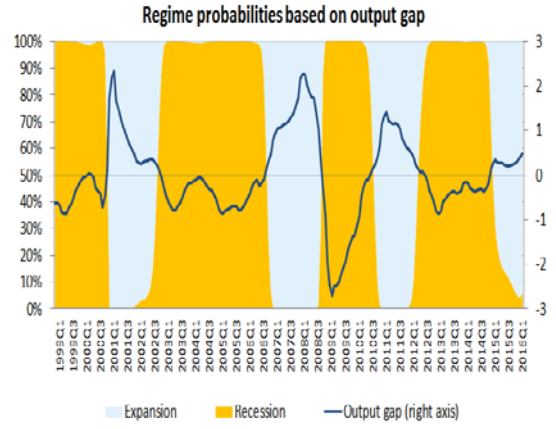
Some theories suggest that the Phillips curve might be convex, i.e. it steepens as output rises relative to trend and is flatter in a downturn. This can be explained by capacity constraints as a source of convexity in the Phillips curve, as pointed out by Clark et al. (1996) and Macklem (1997).

[54] Based on Groß and Semmler (2017), with inputs from Matthias Mohr (ECB).

During recessions, firms operate below full capacity and are able to produce more when demand starts increasing without any significant increases in marginal cost. Hence, they will not raise prices much. In contrast, when firms are operating close to or at full capacity, any further expansion of output incurs large increases in marginal cost, which translate into strong price increases. In this framework, the slope of the Phillips curve is an increasing function of the output gap itself, i.e., the shape of the Phillips curve is convex.

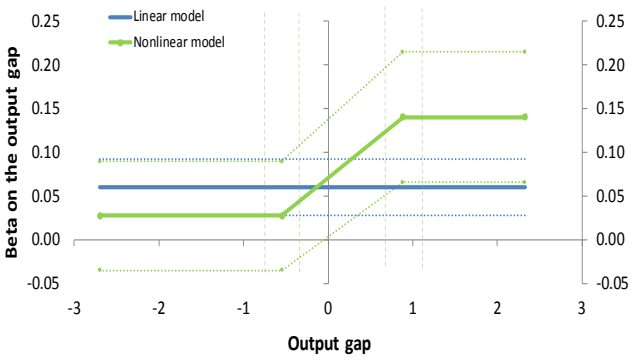
Convexity can also be explained by other mechanisms: for example downward nominal rigidities, which prevent wages and prices from adjusting to demand conditions in a downturn.[55] Another mechanism embedded in a New Keynesian framework is the higher frequency of price changes when the average rate of inflation increases, as firms have to adjust prices more frequently to keep up with the general rise in prices. As inflation tends to be higher when the economy is growing above potential, this source of convexity is linked to that generated by the cycle.[56]

Chart B2.1
Booms and recessions and regime probabilities in the euro area



Source: Groß and Semmler (2017).
Note: The regime probabilities are 'smooth' regime probabilities inferred from a Markov switching model of the output gap under the assumption that mean and error covariance matrices are regime-switching.

Chart B2.2
Constant and regime-dependent estimates of the euro-area Phillips curve slope



Source: Groß, M. and Semmler, W. (2017).
Note: the annual rate of change in the monthly HICP is regressed against its own lag, the contemporaneous output gap and a measure of inflation expectations lagged by six months. Sample: January 1999 –March 2016. The horizontal bounds surrounding the linear and nonlinear parameter lines represent the 10th/90th error bounds.

Looking at the euro area, it appears that inflation has been more responsive to slack in periods of boom. Chart B2.1 shows recessions and boom periods identified using the euro-area output gap as an identifying variable in a Markov switching model with two regimes. The estimated regime probabilities are used as weights in a weighted Phillips-curve regression to estimate two slope parameters, in recessions and booms respectively. These are compared with a linear model estimate of the slope, i.e. a constant, which suggests that an increase in the output gap by one percentage point increases the rate of annual inflation by 0.08 percentage points, irrespective of the cyclical conditions. By contrast, the regime-dependent estimates imply that a change in the output

[55] See Stiglitz (1984); Fisher (1989); Akerlof et al. (1996).

[56] Ball et al. (1988).

gap has virtually no impact in recessions but increases annual inflation by 0.13 percentage points in economic expansions (see Chart B2.2).[57]

How do these results square with the results of the analysis in Section 2.3? In the presence of convexity, as the output gap is still negative, one would expect a flat Phillips curve, e.g. because capacity constraints are not biting. What could explain the signs of steepening observed in some countries? One explanation might be that during the recent recession nominal downward rigidities have been reduced in some countries as a result of structural reforms (arguably more in labour markets than product markets). The frequency of price adjustment has also increased in the low–inflation environment (see Fabiani and Porqueddu (2017)). These factors alone would lead to a steepening, possibly even when the economy is still below capacity.

Chart B2.3

Non-linearities in the euro-area Phillips curve

Source: ECB Staff estimations.
Note: The low and high bounds are the 0.25 and 0.75 percentile, respectively. The corresponding values are-1.4% and 1.3% for the output gap and 0% and 1.1% for the inverted unemployment gap. Piecewise linear regression over 1995-2015Q3.

Some theories suggest that the Phillips curve is actually concave, i.e. it flattens as the economy recovers and is steeper in a downturn. This is consistent with firms operating under monopolistic competition, who may be more willing to reduce prices when demand is weak to avoid being undercut by rival firms (Stiglitz, 1997). In an upturn, they increase prices less, so as not to lose market share. Interestingly, micro evidence from the Eurosystem Inflation Persistence Network has found that prices in the euro area respond more strongly to a fall in demand than to a rise, which tends to support this interpretation (Fabiani et al, 2006).

More flexible approaches have shown that the nonlinearity in the Phillips curve slope may be even more complicated, namely concave when the economy is operating below trend and convex when it is operating above trend. This points to *threshold effects*, i.e. that inflation is highly sensitive to slack only when this is extreme, such as during deep recessions (Barnes and Olivei, 2003). Stock and Watson (2010) find some supporting evidence for these threshold effects, which imply that the curve is not flat during recessions. They discuss micro evidence for the US showing that, contrary to downward nominal wage rigidities, there is little evidence of price rigidity, implying that in a recession the Phillips curve should flatten for wages, but not for prices.

This more complex form of nonlinearity[58] is consistent with the evidence of higher price responsiveness to demand when slack is large (as firms try to retain market share) and lower responsiveness during the recovery, when spare capacity is large. For the euro area, Giannone et al. (2014) find some support for a stronger Phillips curve relationship when deviations of

[57] The *p*-value of a likelihood ratio test for the nonlinear against the linear model equals 1.3%, suggesting strong evidence in favour of the regime-switching relative to the linear model. For more details, and various alternative model specifications in particular with regard to numerous other output gap measures under which the finding of convexity in the Phillips curve keeps holding, see Groß and Semmler (2017).

[58] Filardo (1998) considers three regimes, as the slope can be higher in deep recessions and strong booms, but different; one possible explanations for this difference is the existence of downward rigidities.

unemployment from its natural level are large. Chart B2.3 is a stylised representation of the results based on the specification used in Section 2.3 using Consensus forecasts around 2 years ahead as inflation expectations and estimated similarly to Barnes and Olivei (2003). The slope is allowed to vary if the slack measure (output gap and unemployment gap) is outside certain thresholds. This simple exercise supports the idea that the slope is higher in deep recessions and in strong booms.[59]

Box 3

Econometric evidence for the effect of e-commerce on non-energy industrial goods inflation[60]

Following Yi and Choi (2005) the e-commerce effect on inflation is estimated using annual panel data covering EU countries (plus Norway, excluding Croatia). The data available for the internet indicator cover the years 2003 to 2015. In the following regression equation

$$Inflation_{it} = \beta_0 + \beta_1 \Delta Internet_{it} + \beta_2 Money_{it} + \beta_3 OG_{t-1} + \beta_4 \Delta OG_{t-1} + \beta_5 Energy_{it} + D_t + \epsilon_{it} + \eta_i,$$

$Inflation_{it}$ refers to the annual inflation rate for industrial goods excluding energy (NEIG) in country i at time t, the variable $\Delta Internet_{it}$ denotes the change in percentage points in individuals looking for offers of goods or services online. "$Money_{it}$", "OG_{t-1}" and "ΔOG_{t-1}" denote the contemporaneous annual M3 growth, the one-year-lagged level and the change in the output gap as estimated by the European Commission, respectively, and "$Energy_{it}$" refers to the one-year-lagged country-specific annual rate of energy inflation. Finally, D_t denotes a time dummy with the value of unity for the years 2010-12 and zero otherwise; the expressions ϵ_{it} and η_i comprise independently and identically distributed error terms over countries and time, and a fixed country effect, respectively. A negative value of the internet coefficient β_1 is expected, as the emergence of e-commerce has been widely seen as disinflationary and associated with increasing price transparency, improving productivity and falling mark-ups. The other parameters should be all positive.

The internet coefficient has a statistically significant value of -0.025. The parameters estimated for the other variables turn out to have the expected signs as well. This means that a one-percentage point increase in the share of people reported as looking online for goods or services reduces NEIG annual inflation by 0.025 percentage points. While this estimated value of the internet parameter appears to be small, large annual changes in the percentages of internet use would still yield non-trivial effects on inflation. Thus, the result suggests that past changes in the percentage of people looking online have contributed to a decrease in annual NEIG inflation by 0.1 percentage points on average per year and across countries. Clearly, the effect is larger for countries that have experienced larger increases in the share of households looking for information online.

This outcome is broadly in line with the results reported in Lorenzani and Varga (2014) who aim to estimate the difference in demand elasticity for goods and services purchased online versus those

[59] Álvarez et al (2015) find that the response of inflation to activity during the ongoing recovery seems to be less steep than in previous expansions

[60] Prepared by Ieva Rubene and Matthias Mohr.

purchased through traditional distribution channels. They calibrate a reduction in overall retail price inflation of 0.1 pp per annum on average over the period 2010-25 for the EU27.

Box 4
Micro evidence on the frequency of price changes[61]

The evidence reported in this report is in line with the conclusions of several recent papers pointing to a steepening of the Phillips curve in the euro area in recent years, meaning that inflation is more reactive to the output gap (see e.g. Álvarez and Urtasun (2013), Oinonen and Paloviita (2014) and Riggi and Venditti (2015)).

One possible explanation is lower nominal rigidities, which would imply a higher frequency of price adjustment. This could have been favoured, for instance, by structural reforms in some stressed countries. Empirical evidence on recent changes in the frequency of price adjustment in the euro area is however scarce. Berardi et al. (2015) find that during the Great Recession (data up to 2011), the patterns of price adjustment in France were only slightly modified: the frequency, average size and dispersion of price decreases increased only marginally.

For Italy, which is the only country where in-depth analysis is available, Fabiani and Porqueddu (2017) find that both the percentage of prices adjusted monthly and the average size of the adjustment have risen significantly since 1996-2001, in particular for downward changes. Their study is based on monthly observations on a sample of 960,000 elementary prices for 49 goods and services in the CPI basket between January 2006 and December 2013, collected by ISTAT.

Compared with 1996-2001, in 2006-2013 the percentage of prices adjusted monthly has increased significantly (from 9.5% to 15.5%). Both upward and downward adjustments increased in frequency (the former from 6% to 9.3%, the latter more sharply, from 3.4% to 6.2%).

The size of adjustments also increased on average; this was especially true of price reductions, which averaged 13.6% compared with 7.4% in 1996-2001. The increase in both the size and the frequency of price reductions contributed to the gradual attenuation of the asymmetry in the distribution of changes in the prices of non-food, non-energy industrial goods (NEIG) and services (the latter result driven chiefly by hotel services; see Charts B4.1 and B4.2).

Part of the change is attributable to the increasing market share of large retailers, but the deep and prolonged recession has also had an impact on the mechanism of price changes. For non-food and non-energy products, this impact has been in the form of larger and more frequent downward adjustments and smaller price rises. For services, both the frequency and the size of price increases have diminished.

Some recent evidence from the new wave of the wage dynamics network (WDN) provides additional micro-level information behind euro-area price developments in the period 2010-2013.[62]

[61] Prepared by Mario Porqueddu and Simon Savsek (ECB).

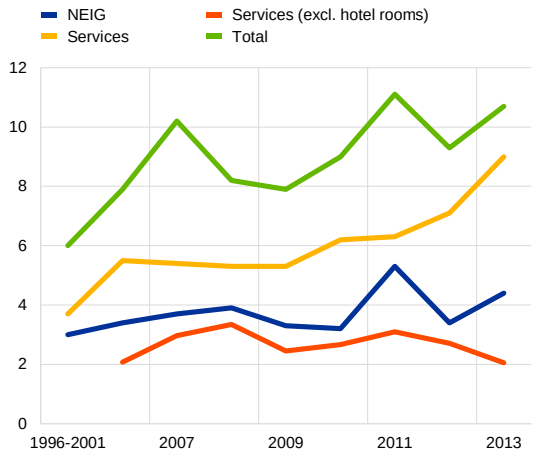
[62] See Wage Dynamics Network webpage (http://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_wdn.en.html) for country and cross-country analysis. At the same time, price developments were not a core question in the WDN3 questionnaire. Therefore, data for some of the EU countries is not available.

There are indications that the modal firm in several euro-area countries changes prices on a yearly basis, which broadly confirms the previous wave.[63]

Chart B4.1

Frequency of price increases in Italy

(percentages; intermediate censoring)

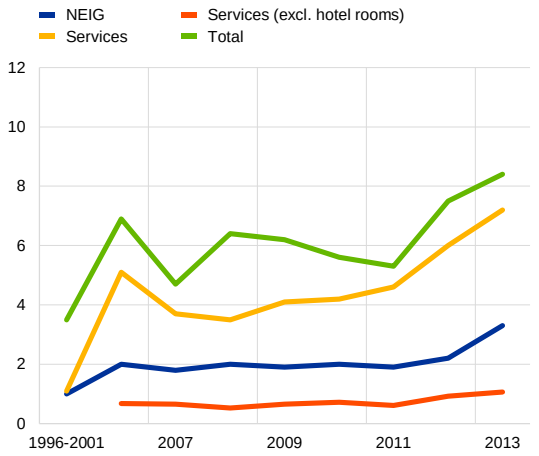


Source: Authors' elaborations on Istat data. Statistics weighted by shares of product types in CPI basket.

Chart B4.2

Frequency of price decreases in Italy

(percentages; intermediate censoring)



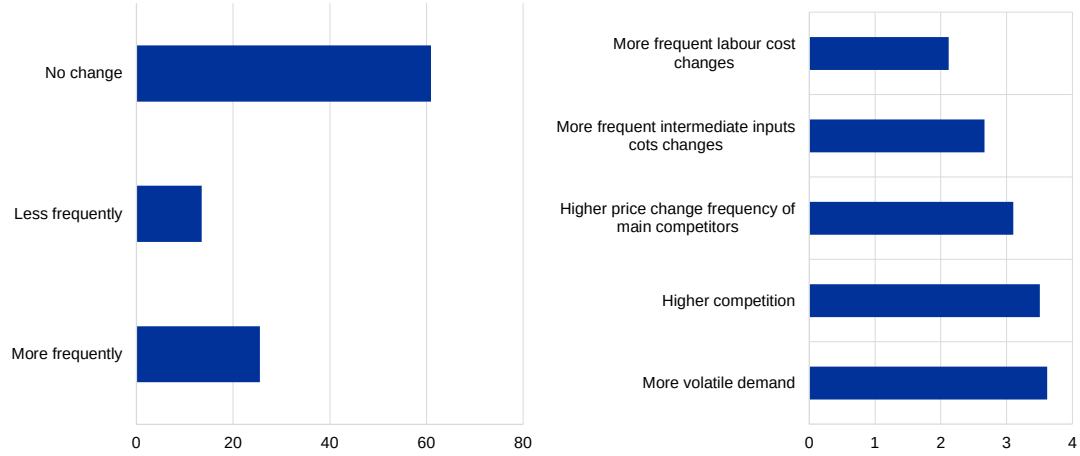
Source: Authors' elaborations on Istat data. Statistics weighted by shares of product types in CPI basket.

The frequency of price changes seems to have increased to some degree compared to the pre-crisis period, with a large number of firms reporting unchanged frequencies. Changes in frequency of price adjustments seem to be quite heterogeneous across countries, but also across sectors and sometimes even across firm sizes. In the majority of reporting countries, more than a quarter of firms report that they change prices more frequently than before, but the result varies from around 16% in Malta and 26% in Luxembourg and Spain – see an example in Figure B4.3 - to 36% in Italy. At the same time, a large number of firms report that they have not increased the frequency (the result is as high as 80% in Malta) and some firms even report a lower frequency of price changes (for example about 15% in Spain).

63 A study from the previous wave of the WDN by Druant et al. (2012) found that, on average, the frequency of price changes is higher than the frequency of wage changes. About half of the firms changed prices once a year or less frequently; a quarter did it more often, while the remaining ones did not report any particular pattern. Instead, around 85% of firms modified wages once a year or less often, only 12.1% more frequently. Another micro study by Altissimo et al. (2006), reporting the findings of the Inflation Persistence Network (IPN), identifies inertial wage behaviour as an important factor behind price stickiness in the euro area.

Figure B4.3

Changes in the frequency of price changes and the reasons behind them in Spain



Source: Izquierdo and Jimeno (2015).

For those firms that changed prices more frequently, stronger competition and more frequent price changes by competitors seem to be the main reasons. Volatile demand as an additional trigger for price changes was reported in Spain, Ireland, Italy, Estonia and Luxembourg, whereas changes in labour costs were important in Latvia. More frequent changes in other input costs were found to be significant in Malta. **The WDN3 data was also used to inform on the sectoral wage Phillips curve slopes.** ECB staff tried to explain the differences in the slope of the wage Phillips curve at country and sector levels resulting from the structural characteristics of the labour markets. To study this relationship, the authors created WDN variables such as firm size, proportion of highly skilled employees and proportion of employees affected by wage cuts. In the second stage, these variables were regressed on the Phillips curve slope coefficients obtained from macro datasets. The exercise showed that all the variables listed above significantly influenced the responsiveness of wage growth to economic slack.[64]

Box 5

The role of profit margins in shaping inflationary pressures during the double-dip recession[65]

A weakening in domestic price pressures contributed significantly to the falls in HICP inflation during the recent double-dip recession. Domestic price pressures as measured by the GDP deflator, which can be decomposed into unit labour costs, unit taxes and unit profits, moderated substantially from 2008 to 2009 and again, although to a somewhat lesser extent, in 2013 (see Chart B5.1). The receding domestic price pressures during these periods reflect corporations' declining pricing power in competitive markets characterised by excess supply in view of the sharp declines in domestic and external demand.

64 For details and other recent findings from the WDN3, see also ECB (2016b).

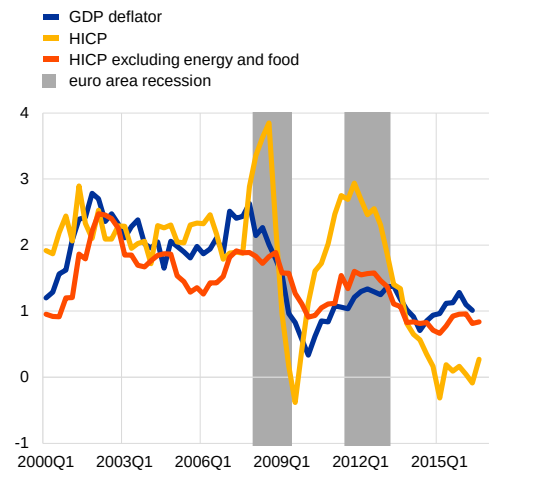
65 Prepared by Elke Hahn (ECB).

Profit margins had to buffer the increases in labour costs during the crisis. Recession periods tend to be characterised by a decline in firms' pricing power in the face of stiffer competition, i.e. more limited room for further price increases, and by increases in costs, notably labour costs.[66] With the latter, the relevant variable contributing to domestic price pressures is unit labour costs. Increases in unit labour costs are fuelled during recessions by the delayed response by wages to the downturn because wage increases are contractually fixed for a certain time span, as well as by falls in productivity reflecting a more limited or delayed response in employment than output to the fall in demand. These increases in labour costs in a recession, together with a limited ability to pass them on in selling prices, imply that profit margins are typically squeezed during downturns, i.e. they behave pro-cyclically. Chart B5.2 illustrates the strong dampening impact on profit margins (based on gross operating surplus) during the double-dip recession. The falls in profit margins over that period closely mimic the pattern of the increases in unit labour costs during the two recessions. By contrast, before and between the two recessions profit margins recovered.

Chart B5.1

GDP deflator

(annual percentage changes)

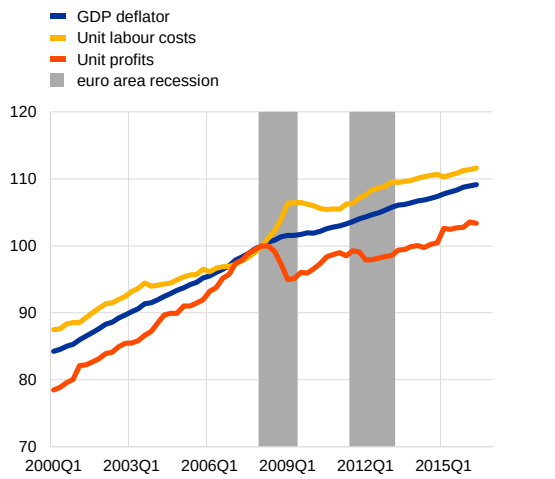


Source: Eurostat and ECB calculations.

Chart B5.2

Profits margins and unit labour costs

(index 2008Q1 = 100)



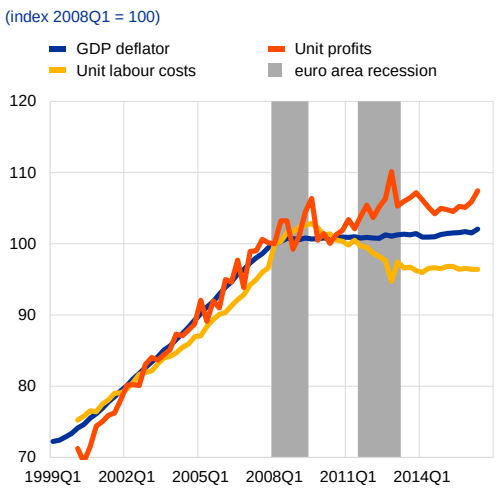
Source: Eurostat and ECB calculations.

Relative price adjustment in some euro-area countries aiming to restore price competitiveness has contributed to low domestic price pressure in the euro area but spared gross profit margins. This price adjustment implied different adjustment paths in some countries compared to that of the euro area for overall domestic cost pressure and its components. In Spain, for instance, wage restraint and productivity gains during the crisis related to strong reductions in employment led to declines in unit labour costs and had a massive downward impact on domestic cost pressures.

[66] On the other hand, in some industries, the higher firm mortality rate during recessions may lead to higher pricing power for surviving firms, if concentration increases meaningfully.

Chart B5.3

Profit margins and unit labour costs in Spain



Source: Eurostat and ECB calculations.

These reductions in labour costs compensated for a strengthening in gross profit margins, which could also reflect the impact of financial constraints or an increase in the market power of surviving firms, such that the GDP deflator remained virtually flat over the crisis period (see Chart B5.3).

Overall, a weakening in domestic cost pressures at the cost of profit margins contributed to the low inflation environment in the euro area during the double-dip recession. In a competitive economy sharp falls in demand as experienced during the crisis limit corporations' power to increase prices. The resulting lower domestic price pressures usually come at the expense of profit margins, which also have to buffer other cost increases during a recession, notably unit labour costs. However, price adjustment processes to restore price competitiveness in some euro area countries added to the low inflation environment. In the case of Spain, these adjustment processes were implemented by wage restraint and productivity gains through laying-off staff and appear to have spared gross profit margins.

Box 6

Inflation risk premia in market-based measures of inflation expectations[67]

The inflation expectations derived from traded inflation derivatives (inflation-linked swaps) and bonds contain useful real-time information on anticipated future inflation, but as they are influenced by risk and liquidity premia information content can potentially be reduced. To get a better estimate of the "true" inflation expectations contained in inflation derivatives we set up a model that tries to identify the inflation risk premia by exploiting the difference in information content between market- and survey-based inflation expectations.[68]

Since the risk-premium contained in market-based inflation expectations are unobservable we use the difference between inflation expectations derived from inflation-linked swaps and inflation

67 Prepared by N. Orloff (ECB).

68 The results and the model are also described in Box 4 of ECB Monthly Bulletin, July 2014 (https://www.ecb.europa.eu/pub/pdf/other/mb201407_focus04.en.pdf).

expectations from the ECB Survey of Professional Forecasters (SPF) as an indicator (proxy) of the inflation risk premium n years ahead:[69]

$$RP_t^n = \pi_{t,n\to n+1}^{ILS} - \pi_{t,n\to n+1}^{SPF}$$

where $\pi_{t,n\to n+1}^{ILS}$ is the implied one-year forward inflation rate n years ahead derived from inflation-linked swaps and $\pi_{t,n\to n+1}^{SPF}$ is the one-year inflation expectation n years ahead from SPF.

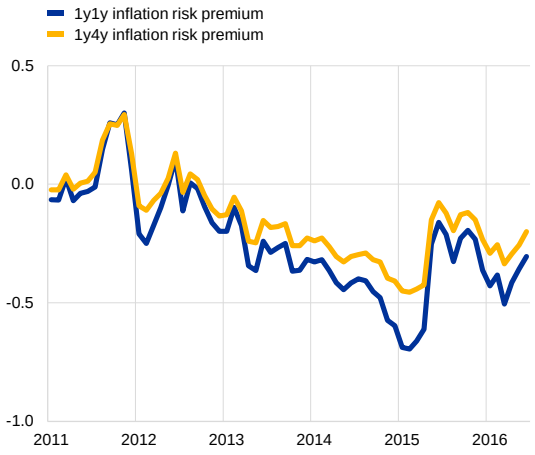
This risk premium proxy can well incorporate elements unrelated to inflation risk but to liquidity risk or heterogeneous expectation across market participants and survey participants. Therefore we regress this proxy on a selection of inflation and liquidity risk indicators available at time t:

$$RP_t^n = \beta' X_t + \varepsilon_{t+n}$$

Chart B6.1

Estimated inflation risk premium

(percentages per annum)



Source: Thomson Reuters and ECB calculations.
Note: The latest observation corresponds to June 2016.

The indicators used for inflation risk are implied bond market volatility and the realised volatility of inflation-linked swap rates. The liquidity indicator is measured as the difference between bond-based break-even inflation rates and inflation-linked swap rates at the corresponding horizon. The part of the risk premium proxy explained by the risk-related regressors is considered a measure of the inflation risk premium.

The results suggest that the inflation risk premium has been negative since 2012 (see Figure B6.1). The negative inflation risk premium indicates that market participants find inflation risk skewed towards the downside.

As with all models, the results obtained here are dependent on the specification. Other models find significantly different levels for the inflation risk premium, though often the movements of the inflation risk premium across models are in the same direction.

[69] A similar approach has also been proposed by Casiraghi and Miccoli (2015). Borrowing from the finance literature (e.g., Cochrane and Piazzesi (2005) and Piazzesi-Swanson (2008)), they study the ex-post excess return, i.e., the difference between the inflation swap rate at a given maturity and the realised inflation rate over the same horizon, and filter this return from the effect of macro variables. Under the rational expectation hypothesis, the measure obtained is an unbiased proxy for the inflation risk premia. Other empirical approaches to disentangle inflation expectations from inflation risk premia in inflation derivatives prices stem from the no-arbitrage affine term structure literature developed for nominal bonds and the idea is to jointly estimate nominal and real yield curves with a small number of common factors. This has been implemented, among others, by Ang et al. (2008) and Christensen et al. (2010) for US data; Joyce et al. (2010) for UK data; and Garcia and Werner (2010) and Hördahl and Tristani (2012) for the euro area.

Box 7

Determinants of inflation expectations – lessons from micro data[70]

Existing studies on the heterogeneity of inflation expectations across demographic groups generally find that older, economically disadvantaged and/or less educated people tend to have comparatively higher inflation expectations across different countries and different time horizons.[71] In some studies, gender plays a role as well, with women usually showing higher inflation expectations than men. Furthermore, economic literacy has been shown to significantly affect consumers' inflation expectations (e.g. Bruine de Bruin et al. (2010)).

To investigate the socioeconomic determinants of inflation expectations the Oesterreichische Nationalbank conducted a survey of 2,000 Austrian households in spring 2013. The survey contained questions about qualitative, quantitative and point estimates of inflation expectations in the short term (12 months ahead) and the long run (five to ten years ahead).The respondents were chosen to reflect the characteristics of the Austrian population above the age of 15. The survey also contains information on a range of socioeconomic characteristics of the respondents, including education, income, place of residence, type of accommodation, household size, employment status, age, and gender. To uncover the determinants of inflation expectations, an econometric analysis was conducted, drawing on quantitative inflation expectations within particular intervals. Specifically, respondents reported their short-run and long-run inflation expectations in intervals of one percentage point between –5% and +5%. Two open intervals (below –5% and above +5%) and the point interval of constant prices (0%) were also possible responses, implying a censoring issue, as the upper and lower-end intervals are open. Due to the censored nature of the data, interval regressions were used to estimate the socioeconomic determinants of inflation expectations.

The estimation results indicate – in accordance with the existing literature – that older people have significantly higher short as well as long-run inflation expectations. The higher inflation expectations of older people are sometimes explained by their greater pessimism in general or a longer horizon of experience that includes historical episodes of major inflation. Women were found to have higher inflation expectations than men. In the literature, gender differences in inflation expectations are explained by women's stronger focus on day-to-day shopping, which increases their inflation expectations as prices of food and beverage items have been rising faster than the overall HICP in recent years. Also in line with the existing literature, respondents with higher educational attainment are found to have significantly lower short and long-run inflation expectations. This is explained by a generally greater interest in economic reports and specific information on inflation and other macroeconomic variables among people with higher educational attainment.

[70] This box draws on the article by Fritzer and Rumler (2015).

[71] Pfajfar and Santoro (2008); Blanchflower and MacCoille (2009); Menz and Poppitz (2013); Bruine de Bruin et al. (2010).

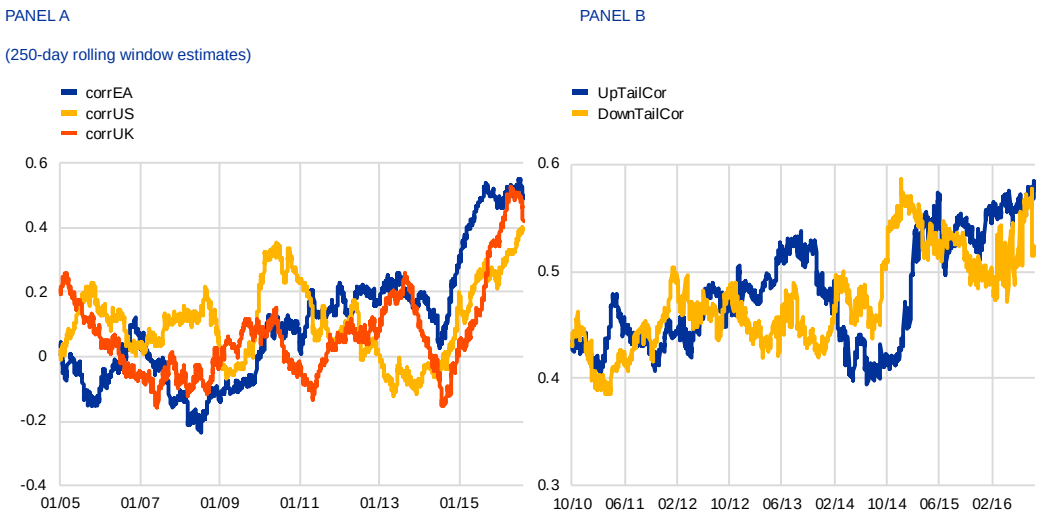
Box 8
Dependence analysis of market-based inflation expectations[72]

The question of whether inflation expectations have remained anchored can be formulated in terms of the existing relationship between short and long term-inflation expectations. In particular, when expectations are well anchored there should be no systematic relationship between variations in short and long term-inflation expectations; in statistical terms, this is a question about the degree of dependence between random variables. This box comments on some measures of anchoring based on the co-movement between daily changes in short and long-term market-based inflation expectations.

Panel A of Figure B8.1 investigates the 250-day rolling rank correlation between short (one-year forward ILS rate one year ahead) and long-term (five-year forward ILS rate in five years) inflation expectations in the euro area, the United States and the United Kingdom. The figure suggests that correlation was weak during most of the period, with the exception of the much stronger positive relationship towards the end of the sample in all three economies. For the euro area, a steady increase in the average correlation is evident from end-July 2014, rising to levels close to 55%.

Figure B8.1

Average and tail correlations between short and long-term inflation expectations



Source: Natoli and Sigalotti, (2017b).
Note: The two indicators of pass-through of short vs medium-to-long term inflation expectations in the euro area are: (i) Spearman's rank correlation coefficient, panel A; (ii) UpTailCor (blue line) and DownTailCor (yellow line), panel B. Short-term expectations are proxied by 1y1y forward inflation swaps, while the medium-to-long term ones are 5y5y forward inflation swaps. Sample: 3 Jan 2005 to 17 Aug 2016 (panel A) and 1 Oct 2010 to 17 Aug 2016 (Panel B).

Linear correlations might be not sufficient to assess the degree of anchoring in one country, because in times of falling expectations when interest rates close to the effective lower bound, the downswings in short and long-term expectations may be more informative than the upswings. Moreover, it is plausible that only sizeable and persistent shocks producing upswings or downswings in short-term expectations induce changes in long-term views. The analysis in Figure B8.1 investigates the patterns of upper and lower-tail co-movement between short and longer-term inflation expectations. The results reveal that the increase observed in the average correlation

[72] This box draws on Natoli and Sigalotti (2017b).

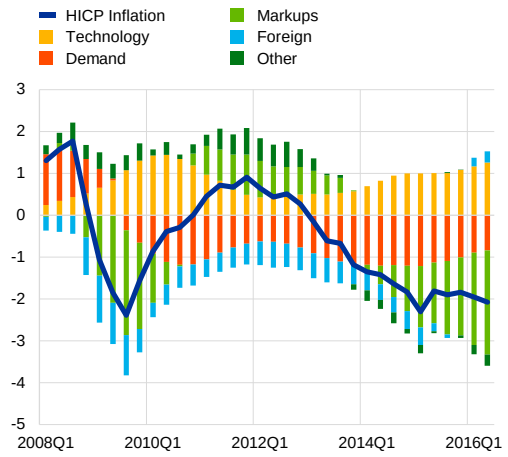
reflects, at least in part, a strengthened correlation in the tails. In particular, in 2014 correlations between left-tail variations began to rise some months before those between right-tail variations, suggesting that long-term expectations started to react to negative shocks first and then co-movements between positive changes simply followed. In the last part of the sample, both indicators remain high and volatile.

This result shows that a close analysis of both average correlation and tail co-movement is required, and underlines the need to understand what role market premia may have in this asymmetry.

Box 9
Drivers of low inflation through the lens of ESCB DSGE models[73]

A suite of DSGE models typically employed for forecasting and scenario analysis in selected ESCB members was used to assess the drivers of inflation in the euro area and individual Member States. In these models inflation is determined by a set of unobserved shocks, which for the sake of simplicity were grouped into four blocks: foreign, demand, technology and mark-up. The aim of the exercise was to decompose inflation developments into these four different components.[74]

Figure B9.1
Historical decomposition of HICP inflation (in deviation from baseline) in the euro area



Source: ECB staff computations.

The results of the decomposition for the euro area (Figure B9.1), which was derived using the NAWM (see Christoffel et al. (2008)), deliver several interesting insights. Demand shocks, and in particular high risk premia constraining consumption and investment expenditures, consistently dampened inflation by around 1pp during the period 2010Q4-2016Q2. By contrast, over the same period low productivity dynamics exerted upward pressure on inflation of about 0.9pp, which is reflected by the contribution from technology shocks. The comparatively small negative contribution from foreign shocks indicates that global slack had a rather limited impact on inflation. This might be explained by the fact that the euro area is a relatively large economy; hence inflation is predominantly driven by domestic factors. The main contributing factor to the decline of inflation by 3.2pp between the local peak reached in 2011Q4 and the trough in 2015Q1, was the mark-up shocks (2.4pp), in particular shocks in the goods market.[75]

The next step in the exercise was to check whether inflation drivers were similar in individual member states. Spain and Germany are used as they are two of the largest economies in the euro

[73] Co-ordinated by José Emilio Gumiel and Michal Rubaszek.

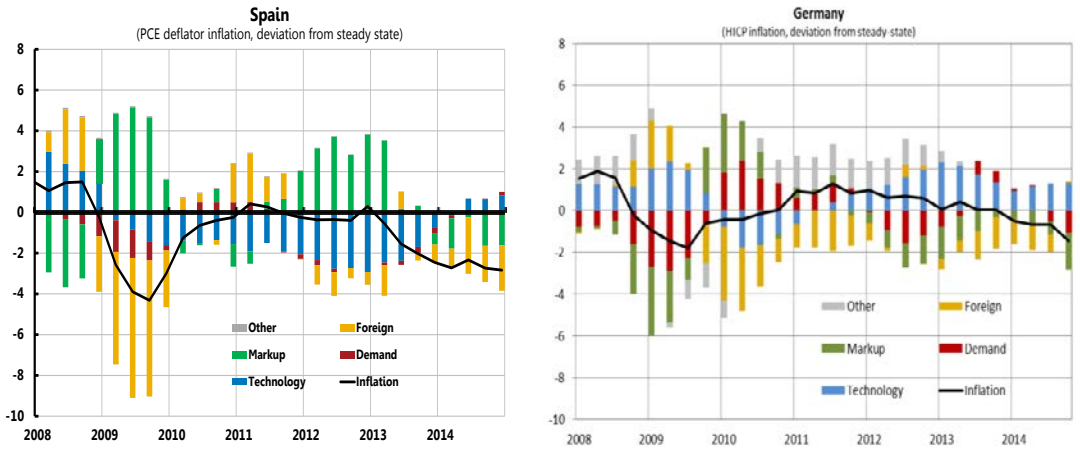
[74] It should be stressed that the results presented here are, by definition, model-dependent.

[75] It should be taken into account that these mark-up shocks may also capture some of the effects of movements in oil prices and their pass through to domestic inflation.

area to have seen substantially divergent unemployment trends during the crisis. The results for the inflation shock decomposition, which was performed using DSGE models for Spain (see Andrés et al. (2006) and (2010)) and Germany (see Hoffmann et al. (2014)), are presented in Figure B9.2.

Figure B9.2

Historical decomposition of inflation (in deviation from baseline) in selected euro-area countries

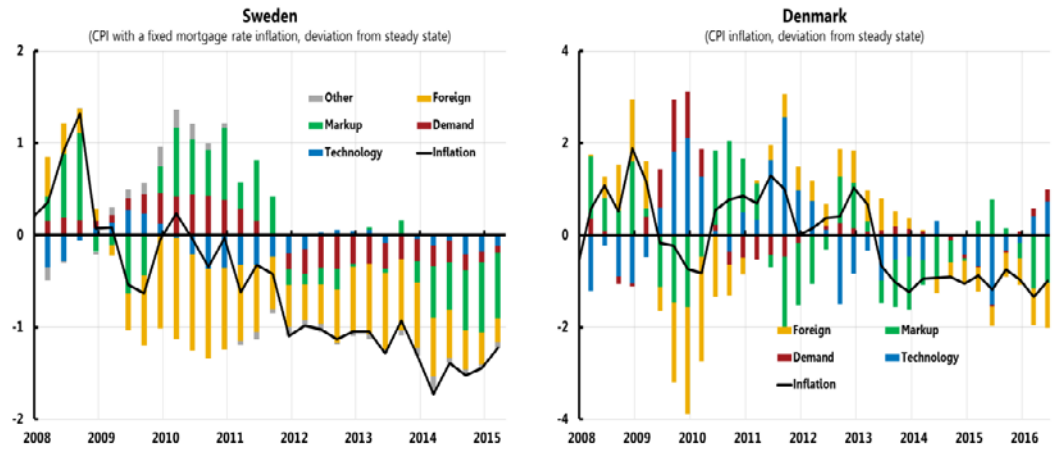


Source: Banco de España, Bundesbank.

They indicate that foreign shocks, which reflect shocks originating in the "rest of the euro area", were the only ones to have had a similar impact on inflation in both countries. For the other three shock blocks, their contribution to inflation diverged significantly. Although this result might be attributable to the fact that the decompositions are based on different models, they also reflect idiosyncratic economic developments in both countries, such as productivity gains in Spain due to reallocation away from the construction sector, and demand pressure in Germany related to favourable labour market developments. As for the recent decline in inflation, the results for the individual countries confirm the earlier conclusion that this has been predominantly driven by the contribution of mark-up shocks, including those that occurred in the "rest of the euro area" countries.

Figure B9.3

Historical decomposition of inflation (in deviation from baseline) in selected non-euro-area EU countries



Source: Sveriges Riksbank, Danmarks Nationalbank.

The last part of the exercise aimed to analyse how low inflation in the euro area spreads to non-euro-area EU Member States. It used Sweden and Denmark, two small open economies with strong trade and financial linkages with the euro area. The results of the inflation decomposition, which was performed with RAMSES II, a model for Sweden, (see Adolfson et al. (2013)) and a DSGE model for Denmark (see Pedersen (2016)), are presented in Figure B9.3. It shows that the low inflation observed in recent period in both countries can be explained by low inflation in the euro area, illustrated by the part explained by foreign shocks, and also by a negative contribution from mark-up shocks.

Box 10

Economic policy, spillovers and synergies in a monetary union at the effective lower bound[76]

This box analyses how a prolonged period of low inflation can affect the effectiveness of economic policy. The following simulations use the model of Arce et al. (2016), which extends the deleveraging model developed in Andrés et al. (2014) to a setting with two regions (Core and Periphery) forming a monetary union. These models draw on the literature about financial frictions in the form of debt ceilings and collateral requirements, and extend them to the case where loans to households and firms are long-term, meaning that in each period borrowers are only contractually obliged to repay a fraction of the outstanding principal (as opposed to the more usual assumption in the macroeconomic literature of full repayment at the end of each period).

The model is used to generate two different baseline scenarios: one in which Periphery suffers a negative financial shock (a reduction in the loan-to-value ratios required by banks to lend to households and entrepreneurs) which, because of the existence of long-term debt, triggers a process of gradual deleveraging with long lasting effects on output and inflation; and one in which this same financial shock is accompanied by negative demand shocks in both Core and Periphery which bring nominal interest rates in the monetary union to the effective lower bound for almost a year. Among the policy measures available in this setting, three have attracted particular attention: i) structural reforms in product and factor markets in distressed countries; ii) countercyclical fiscal policies in those economies with fiscal space; iii) non-standard monetary policy measures.

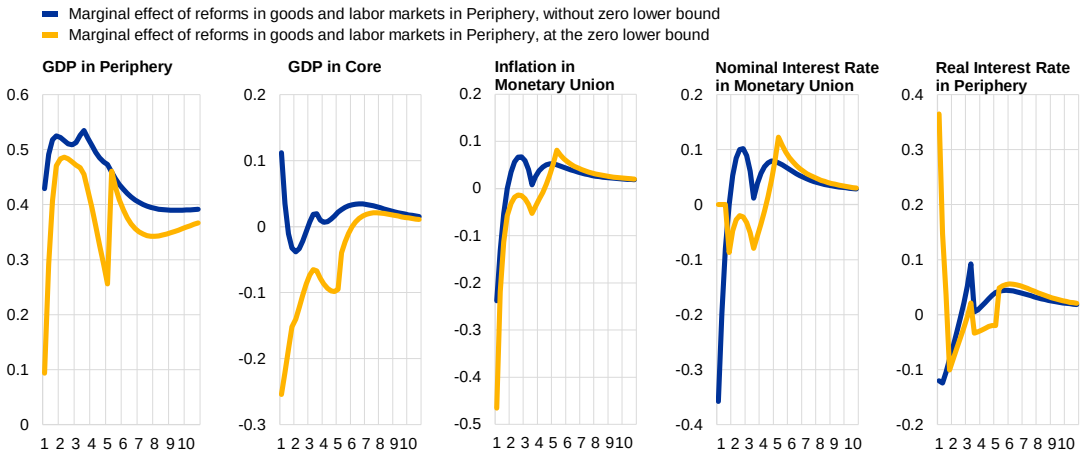
Figure B10.1 shows the marginal effect of structural reforms in the Periphery aimed at increasing competition in product markets and reducing labour market inefficiencies when these are implemented over each baseline scenario. These reforms improve the competitiveness of the Periphery in the long run, which leads to higher exports, employment and GDP. When the economy is at the effective lower bound though, a negative short-term channel appears as well: nominal interest rates cannot adjust to the fall in prices and the rise in real interest rates. In this model, the negative channel is outweighed by the anticipation of higher future output, and the overall effect is positive even in the short run. However, the effective lower bound does make an important difference: it reduces the short-run positive effects in the Periphery and gives rise to negative spillovers in the rest of the monetary union.

[76] Prepared by Samuel Hurtado.

Figure B10.1

Marginal effects of structural reforms in Periphery (with and without ELB)

Deviations from the respective baseline scenario. Horizontal axis in years.



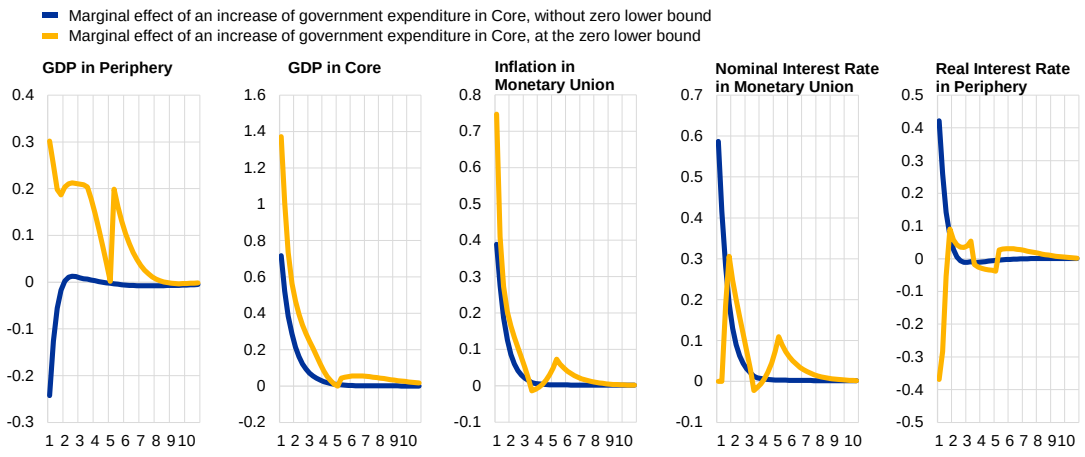
Source: Arce et al. (2016).

In the case of an expansion of public expenditure in the Core, though, the effects are actually more positive if the economy is at the ELB than in normal times. As reflected in Figure B10.2, a fiscal stimulus of this type has clearly positive effects on activity in the Core which are bigger when the economy is at the effective lower bound. Moreover, spillovers to the Periphery, which are zero or negative in normal times (the direct effect through external demand is compensated by the increase in nominal interest rates), become positive when the economy is at the effective lower bound.

Figure B10.2

Marginal effects of a fiscal expansion in the Core (with and without ELB)

Deviations from the respective baseline scenario. Horizontal axis in years.



Source: Arce et al (2016).

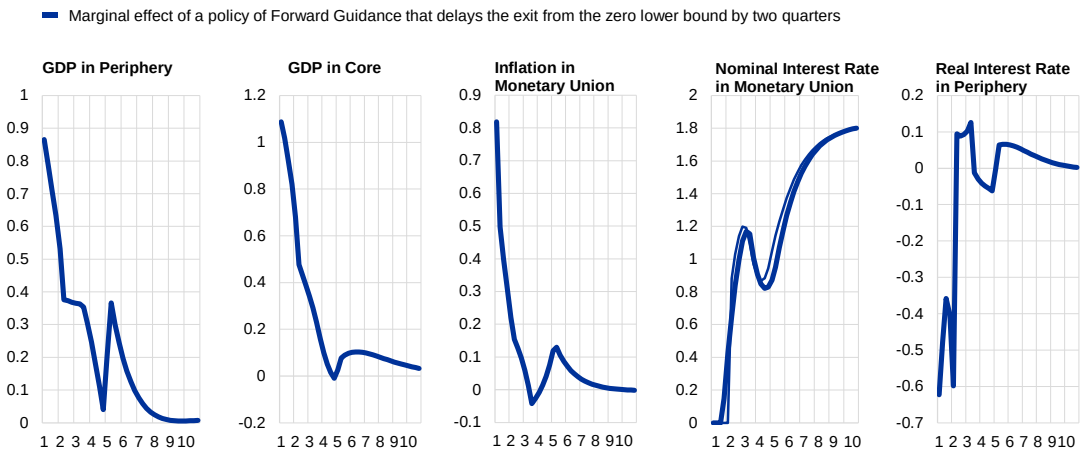
Lastly, Figure B10.3 depicts the effect that would be exerted by a commitment to hold nominal interest rates at 0% for six months longer than the usual rule of the central bank would dictate (the thin blue line), a policy commonly known as forward guidance. This measure has positive effects on GDP in both regions. The main channel through which this materialises is by means of a reduction in both current and expected real interest rates in both economies. The subsequent expansion in

activity prompts an increase in inflation in both regions which, along with the temporary immobility of the nominal interest rate, amplifies the decline in real rates.

Figure B10.3

Marginal effects of a policy of forward guidance

Deviations from the second baseline scenario (except for nominal interest rates, where the baseline scenario is represented by the thin line). Horizontal axis in years.



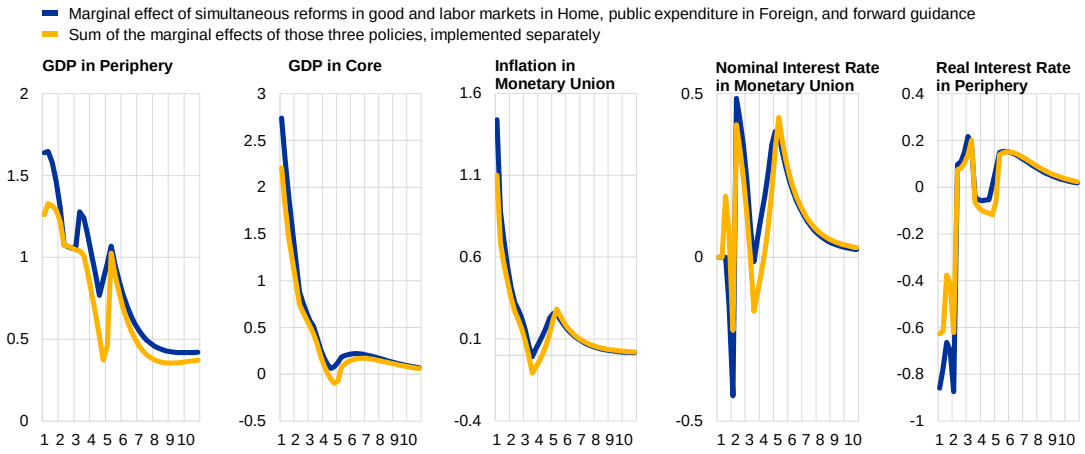
Source: Arce et al. (2016).

The foregoing exercises show that the three types of policies considered have the potential to alleviate the costs associated with negative real and financial shocks. A hypothetical joint implementation of these three types of policies is of particular interest, as is, most singularly, the possible presence of synergies between the policies. The non-linear nature of the model used in this section means that it is particularly well equipped to analyse this issue.

Figure B10.4

Marginal effects of three economic policy measures, implemented jointly or separately

Deviations from the second baseline scenario. Horizontal axis in years.



Source: Arce et al. (2016).

Figure B10.4 illustrates this aspect: the yellow lines represent the cumulative effect that would ensue from separately applying the three foregoing measures, whereas the blue lines show the total effect when the three measures are applied jointly. The main message from this exercise is

that joint implementation of structural reforms, countercyclical fiscal policies and non-standard monetary policy measures causes expansionary effects in the short run that are greater than those that would be obtained if these policies were applied separately. This indicates, therefore, that there are potentially significant complementarities or positive synergies between the three measures.

Box 11
Survey and market-based inflation expectations[77]

Survey-based inflation expectations. The quarterly ECB Survey of Professional Forecasters (SPF) provides quantitative HICP inflation projections for the euro area up to five years ahead, along with probability distributions. Consensus Economics also publishes monthly projections of mean average inflation for the current and the next year, for both the euro area and various individual countries. Twice a year, this economic survey also issues longer-term inflation expectations up to ten years (in fact, six to ten years). In contrast to such quantitative surveys, consumer surveys like those by the EU Commission are qualitative exercises that have to be mapped onto actual inflation forecasts using estimated historical relationships. The choice of this quantification process can lead to inflation forecasts that are different in level, but share the same trends.[78] Furthermore, the forecast horizon of the EU Commission's consumer survey is only one year ahead, and is insufficient to check the credibility of the medium-term monetary policy target. Accordingly, we will mainly focus here on quantitative surveys, typically SPF-based measures of inflation expectations.[79]

Market-based inflation expectations. The other main source of information for inflation expectations is obtained from the prices in markets for inflation protection. Typically, three inflation-derived instruments can be used: inflation-linked bonds, inflation-linked swaps and inflation options (inflation cap and/or floor).

- Inflation-linked bonds are bonds where the principal is indexed to inflation. The measure of inflation expectations is the inflation compensation or breakeven inflation rate (BEIR), which is the difference between the nominal yield of a bond and the real yield on an inflation-linked bond of similar maturity and credit quality.
- Inflation-linked swaps are financial products where one party pays a fixed rate (the inflation-linked swap rate or ILSR) while the other pays a floating rate linked to the move in an inflation index over the period of the swap. A measure of market inflation expectations is then given by the ILSR.

77 Prepared by Aidan Meyler (ECB).

78 Based on internal ECB Staff analysis.

79 Some country-specific survey data can also be used. See Box 7 and Fritzer and Rummler (2015), which is based on a survey of 2000 Austrian household conducted by the Oesterreichische Nationalbank.

- An inflation cap (floor) is a financial asset where the buyer receives payment at a given maturity when inflation is higher (lower) than a given rate of inflation (the strike rate).[80] In other words, an inflation cap (floor) provides protection against inflation being higher (lower) than the strike rate. The market prices of such products provide information on both market expectations of inflation and the risk surrounding this baseline scenario, and can be used to extract risk-neutral probability densities for future inflation outcomes (see Natoli and Sigalotti (2017a) and (2017b); Gimeno and Ibáñez (2015)). However, although it has grown significantly in recent years, liquidity in the market for inflation options remains limited and trades are often concentrated on a small number of strikes, making the use of these instruments as measures of inflation expectations less developed than BEIRs and ILSRs.

[80] See the box on 'Assessing the anchoring of longer-term inflation expectations', ECB Monthly Bulletin, July 2013, for a detailed description.

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