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Understanding low inflation in the euro area from 2013 to 2019: cyclical and structural drivers

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Abstract

From 2013 up to the launch of the ECB's strategy review in January 2020, inflation in the euro area was low and over-predicted. This low inflation during the years 2013-19 can be attributed to a combination of interconnected factors. Cyclical developments account for a substantial share of the fall in underlying inflation, mainly in the first part of the low inflation period. Additionally, there is evidence that an underestimation of the amount of economic slack and less well-anchored longer-term inflation expectations, in combination with monetary policy in the euro area being constrained by the effective lower bound, have played an important role in the long period of subdued inflation. Ongoing disinflationary structural trends (such as globalisation, digitalisation and demographic factors) are likely to have had a dampening effect on inflation over the last few decades, but were in themselves not the main drivers of low inflation in the euro area from 2013 to 2019. However, as they could not have been easily offset by interest rate policy in an effective lower bound environment, they might also have contributed to the more subdued inflation dynamics in the euro area from 2013 to 2019.

JEL codes: C51, E31, E32, E37, E52, F62, J11, J30.

Keywords: Monetary policy review, HICP inflation, underlying inflation, low inflation, effective lower bound.

Executive summary

A robust new strategy hinges on a thorough understanding of why inflation has been persistently low − and below the ECB's inflation aim − for nearly all of the period from 2013 to the launch of the ECB strategy review in January 2020.

This paper aims at providing a holistic view on the role of the cyclical and structural drivers of low inflation in the euro area from 2013 to 2019. It includes an analysis of the effects of major economic shocks such as the global financial and sovereign debt crises, which caused a twin recession in the euro area in 2009 and 2012, widening the output gap and putting downward pressure on inflation. In addition, long-standing structural trends such as globalisation, digitalisation and demographic change may have either intensified or developed a stronger influence on goods, services and labour markets with a direct effect on prices that may affect inflation beyond the short term. Understanding inflation developments also needs to take into account the decline in the equilibrium real interest rate, which has brought nominal policy rates close to the effective lower bound for more than ten years and limited the conventional monetary policy response to disinflationary shocks, while the persistence of low inflation has contributed to lower inflation expectations. These factors are interlocking and no single one can in itself explain the low inflation period.

In 2013 at the start of the period under review − after the twin recessions − euro area inflation declined across most measures. Energy prices played an important role in the drop in headline inflation at the beginning of this period. Underlying inflation also decreased and remained subdued throughout 2013-19. Analysing underlying inflation through the lens of the Phillips curve shows that cyclical developments can account for a significant share of the fall in underlying inflation – but mainly in the first part of the low inflation period when levels of economic slack were high. This confirms that the Phillips curve has been "alive", but that other factors beyond cyclical drivers played a role in keeping underlying inflation subdued as well. The importance of such other factors has been reflected not only in negative Phillips curve residuals but also in a decline of the persistent component of headline and underlying inflation, as well as in a systematic and substantial overestimation of inflation.

Structural trends such as globalisation, digitalisation and demographic change are likely to have had a dampening effect on inflation over the last decades. Globalisation has increased gradually, especially since the early 1990s, but has not accelerated much since 2013. Its influence on past inflation developments can only be measured over a longer period of time and it is, in itself, unlikely to have been the main driver of low inflation in the years 2013-19. A more recent phenomenon has been digitalisation, which can affect inflation directly through the prices of information and communications technology (ICT) products and their share in the household consumption basket, as well as indirectly through firms' pricing behaviour, market power and concentration, and productivity and marginal costs. Empirically, both the direct and indirect effects of digitalisation seem to have influenced inflation – but only with a marginal negative impact. With respect to demographic change, ECB staff model analysis shows that if monetary policy does not fully internalise the downward impact of ageing on the equilibrium real interest rate, it is likely to be tighter than intended, thus generating a potential disinflationary bias. The effects of secular trends such as globalisation, digitalisation and demographic change can normally be internalised and offset by the monetary authority. In the low inflation period, however, being at the effective lower bound limited the available monetary policy space and might have allowed secular trends to have a tangible negative effect on inflation in the euro area from 2013 to 2019.

Two additional factors could be crucial for understanding the low inflation period in the euro area: (i) unexpected positive supply developments, which led to an underestimation of economic slack and (ii) a de-anchoring of inflation expectations following a low interest rate, low inflation environment. Hidden slack, which goes beyond the level of slack indicated by conventional measures, could be one factor that kept inflation from rising more strongly. For example, positive supply shocks from the labour market stimulating employment and growth potential could have been important reasons behind an underestimation of economic slack, thereby holding inflation down. On top of this there is evidence that medium-term inflation expectations have become less well anchored to the ECB's inflation aim – as reflected by decreases in survey-based and market-based (corrected for inflation risk premia) measures of inflation expectations. Such a decline in inflation expectations can reinforce a low inflation period via price and wage-setting decisions of firms and households.[1]

In sum, a combination of interconnected factors explains the persistently low inflation over the years 2013-19. Cyclical developments can account for a significant share of the fall in underlying inflation – but mainly in the first part of the low inflation period. Model-based simulations confirm the view that underestimating the amount of economic slack and a de-anchoring of longer-term inflation expectations, among other factors, could also have contributed to persistently low inflation in the period 2017-19, especially as monetary policy has at the same time been constrained by the effective lower bound. In an effective lower bound environment, ongoing disinflationary structural trends (such as globalisation, digitalisation and demographic factors) could not have been easily offset by interest rate policy and might have also contributed to the subdued inflation dynamics over the years 2013-19.[2]

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1 See Work stream on inflation expectations (2021).

2 For the implications of the new monetary policy strategy see, for example, Holm-Hadulla et al. (eds.) (2021).

1 Introduction and main findings

Euro area inflation was persistently low from 2013 to 2019. This holds not only for Harmonised Index of Consumer Prices (HICP) headline inflation, which averaged 1.0% from 2013 to 2019, substantially below 2%, but also for a broad range of inflation measures, including wages, producer prices and indicators of underlying inflation. Other advanced economies also recorded inflation rates which were persistently below target during this period. During the low inflation period between 2013 and 2019, inflation developments (excluding the volatile energy component) were systematically over-predicted in the Eurosystem/ECB staff macroeconomic projections, as well as in forecasts by other institutions such as the European Commission and the Organisation for Economic Co-operation and Development (OECD) and in private sector forecasts.

The strategy review conducted in 2020-21 necessitated a thorough understanding of why inflation has been persistently low – and below the ECB's inflation aim – since 2013. Inflation outcomes result from the interaction between economic developments, both conjunctural and structural, affecting inflation and the central bank's response to such developments in the pursuit of maintaining price stability. Understanding low inflation in the euro area therefore requires us to analyse the effects of major economic shocks such as the global financial and sovereign debt crises, which caused a twin recession in the euro area in 2009 and 2012 and put downward pressure on inflation. But also structural trends such as globalisation, digitalisation and demographic change have influenced goods, services and labour markets and have had a direct effect on prices that may affect inflation beyond the short term. To understand inflation developments we also need to take into account the decline in the equilibrium real interest rate[3], which has brought nominal policy rates close to the effective lower bound (ELB) for more than ten years and has limited the conventional monetary policy response to disinflationary shocks.[4] These factors are interlocking and no single one can in itself explain the low inflation period.

This paper aims to provide a holistic view of the role of the cyclical and structural factors that have driven inflation dynamics in the euro area since 2013, while monetary policy has been close to the effective lower bound.[5] Chapter 2 reviews developments in euro area inflation through the lens of the Phillips curve. Chapter 3 assesses the role of structural trends for inflation developments. Chapter 4 discusses the role of supply shocks and inflation expectations in an

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3 There is broad consensus that a decline in productivity growth, demographic factors and persistently higher demand for safe and liquid assets in the wake of the global financial crisis have contributed to lowering the equilibrium real interest rate. Combined with persistently low rates of inflation, the fall in the equilibrium real interest rate has increased the incidence and duration of episodes in which nominal policy interest rates are close to the effective lower bound, often requiring the deployment of additional policy instruments to maintain price stability.

4 For a discussion see, for example, Hartmann and Smets (2018), Part 3.3.

5 The paper builds on earlier work on the topic, including Ciccarelli and Osbat (2017) on the drivers of low inflation in the euro area over the years 2013-16 and Nickel et al. (2019) on understanding low wage growth in the euro area and European countries.

effective lower bound environment. Chapter 5 provides a brief outlook for structural forces after the pandemic.

The main findings of this paper are as follows:

Cyclical developments can account for a significant share of the fall in underlying inflation – but mainly in the first part of the low inflation period. High levels of economic slack in the period from 2013 to 2017 after the twin recessions put downward pressure on inflation. However, inflation remained low even when conventional measures of economic slack suggested that the economy had been growing faster than potential for a few years.

Structural trends like globalisation, digitalisation and demographic change are likely to have had a dampening effect on inflation over the last decades, but were in themselves not the main drivers of low inflation in the euro area from 2013 to 2019.

The underestimation of economic slack, as well as inflation expectations being less well anchored to the ECB's inflation aim, might help towards understanding the recent period of low inflation (i.e. 2017-19) in the euro area. There might have been hidden slack, i.e. an underestimation of economic slack as measured by the gap between actual and potential output for example. Also, positive supply shocks from the labour market stimulating employment and GDP could have significantly contributed to an underestimation of potential output and hence of economic slack. A further important factor could be the pronounced fall in longer-term survey-based and market-based (corrected for inflation risk premia) measures of inflation expectations from levels close to 2% over the low inflation period.

Persistently low inflation over the years 2013-19 can be explained by a combination of interconnected factors. Model-based simulations confirm the view that underestimating the amount of economic slack and a de-anchoring of longer-term inflation expectations can result in a persistent shortfall in inflation, especially when monetary policy is constrained by the effective lower bound. These factors can decisively contribute to understanding why inflation has remained low, also in the later part of the low inflation period (2017-19). Similarly, ongoing disinflationary structural trends (such as globalisation, digitalisation and demographic factors) are likely to have had a dampening effect on inflation over the last few decades, but were in themselves not the main drivers of low inflation in the euro area from 2013 to 2019. However, as they could not have been easily offset by interest rate policy in an effective lower bound environment, they might also have contributed to the more subdued inflation dynamics in the euro area over the years 2013-19.

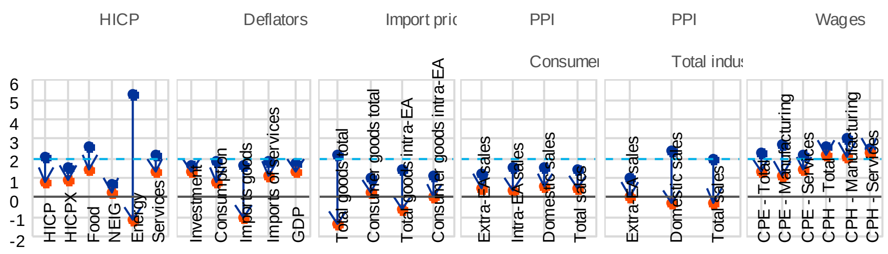
2 Low inflation through the lens of the Phillips curve

Euro area inflation declined across most measures after the sovereign debt crisis (see Chart 1). Headline HICP inflation was on average 2.1% from 1999 to 2012 and dropped to an average of 1.0% from 2013 to 2019 (see Chart 2, left panel). Average HICP inflation excluding energy and food also declined by 0.6 percentage points from 1.6% to 1.0%, dominated by a substantial decline in services inflation. All measures of price pressure along the pricing chain, ranging from wages and import prices to producer and consumer prices, showed lower averages after 2013.

Chart 1

Difference between average inflation during the years 2000-2012 and 2013-19

(annual percentage changes)



Sources: Eurostat and ECB staff calculations.
Notes: The blue dots denote the average inflation rate between 2000 and 2012 and the red dots that between 2013 and 2019. Total industry for the Producer Price Index (PPI) and import prices exclude construction. The latest observations are for December 2019 for monthly data and the fourth quarter of 2019 for quarterly data.

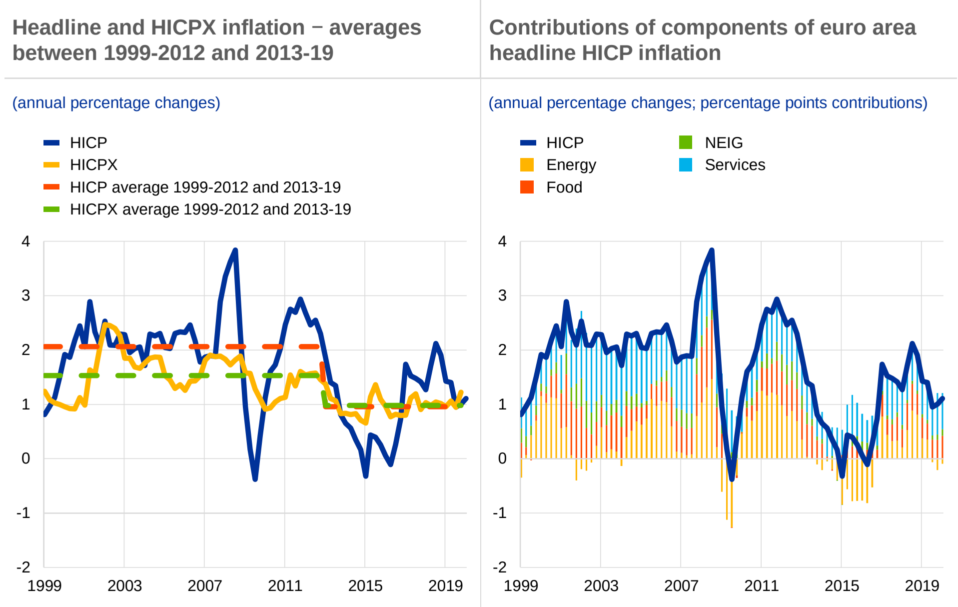
Energy prices played an important role in the drop in headline inflation at the beginning of the low inflation period. While the average contribution from energy inflation to headline inflation was 0.5 percentage points in the period from1999 to 2012, it substantially dropped to around zero in the years 2013-19 (see Chart 2, right panel). In the first part of the low inflation period (starting in 2013), the contributions of energy inflation were persistently negative.

Indirect effects from energy prices also dampened non-energy inflation in the first part of the low inflation period. Oil price changes not only have direct effects on HICP inflation through consumer energy prices, but also indirect effects through the production and distribution costs of domestically produced goods and of imports of intermediate and final consumer goods. Estimates based on the ECB's New Multi-

Country Model[6] suggest that, in the period from 2013 to mid-2016, indirect effects from oil prices pushed down HICP inflation excluding energy by 0.3 percentage points. Taken together, the direct and indirect developments in oil prices in the more recent period explain about 0.7 percentage points of the decline in headline inflation in the period from 2013 to mid-2016.

Chart 2

Inflation developments in the euro area



Sources: Eurostat and ECB staff calculations.
Note: The latest observation is for the fourth quarter of 2019.

Underlying inflation (measured as HICP excluding energy and food)[7] was also heavily affected by the consequences of the twin recessions. In the aftermath of the global financial crisis, heightened sovereign risk concerns led to a rise in sovereign spreads and a tightening of fiscal policies. These developments contributed to a renewed widening of the output gap, which according to the European Commission's estimates only closed in 2017 (see Chart 12 in Chapter 4).

Fiscal tightening in the context of the sovereign debt crisis also had a bearing on inflation developments in the euro area. Counterfactual scenarios developed by the Work stream on monetary-fiscal policy interactions (2021) show that additional fiscal spending after the twin crises would have ensured a quicker closure of the output gap and would have pushed inflation closer to the ECB's inflation target. This suggests that a well-coordinated fiscal-monetary policy mix can stabilise the real economy quicker and lift inflation towards its target more effectively. The importance of mutual fiscal and monetary support is particularly important when monetary policy is constrained by the ELB or in tail events of repeatedly adverse shocks.

6 See Dieppe et al. (2011) for more details on the model.

7 See Work stream on inflation measurement (2021) for a deeper discussion on measures of underlying inflation.

The Phillips curve remains "alive" (but rather flat) and developments in economic slack can account for a significant share of the fall in inflation. The Phillips curve is the workhorse model for analysing the cyclical drivers of inflation and relating inflation to economic slack. Empirically, the Phillips curve is usually specified in terms of domestic inflation, which is why the standard econometric models refer to HICP excluding energy and food (HICPX) as a measure which is predominantly determined by domestic developments.[8] Estimates from a "thick modelling" Phillips curve framework[9] yield significant slack coefficients of the expected sign: conditional on inflation expectations and external prices, slack and inflation appeared to co-move broadly in line with economic theory – with higher amounts of slack leading to lower inflation.[10] Estimates of the slope of the Phillips curve range from around 0.05 to 0.24 for measures based on output gaps, and from around -0.05 to -0.37 for measures based on the unemployment rate and unemployment gaps (see Chart 3, left panel). These ranges of estimates imply that – depending on the model − a change in the output gap of between around 4 percentage points (for the models with the steepest PC) and close to 20 percentage points (for the models with the flatter PC) would be required to change inflation by one percentage point.[11] Overall, the slope estimates point to a rather "flat" Phillips curve, both in the output and in the unemployment space, but nevertheless explain a significant share of the low inflation period after 2013. As shown in Chart 3, right panel, the large amount of slack in 2013 following the double-dip recession was an important driver of low inflation after 2013. Lower inflation expectations and external prices also contributed to low inflation until mid-2018.

However, the Phillips curve relationship cannot fully explain inflation developments in more recent years. This is highlighted by the series of mostly negative and relatively large residuals since late 2017 (see Chart 3, right panel and Box 1 on the possible sources of a shift in the Phillips curve).[12]

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8 See European Central Bank (2017).

9 "Thick" modelling relies on a large set of specifications, defined by iterating across measures of slack, inflation expectations and external prices. This insures against model uncertainty. See Bobeica and Sokol (2019) as well as Eser et al. (2020), who also discuss how the "Phillips correlation" in this reduced-form model relates to the structural Phillips curve.

10 The exercise was also conducted with market-based and consumer-based measures of expectations, yielding qualitatively similar results in terms of residuals.

11 The range covers both fixed-parameter and time-varying parameter models. For the latter, the average estimate for 2019 is considered.

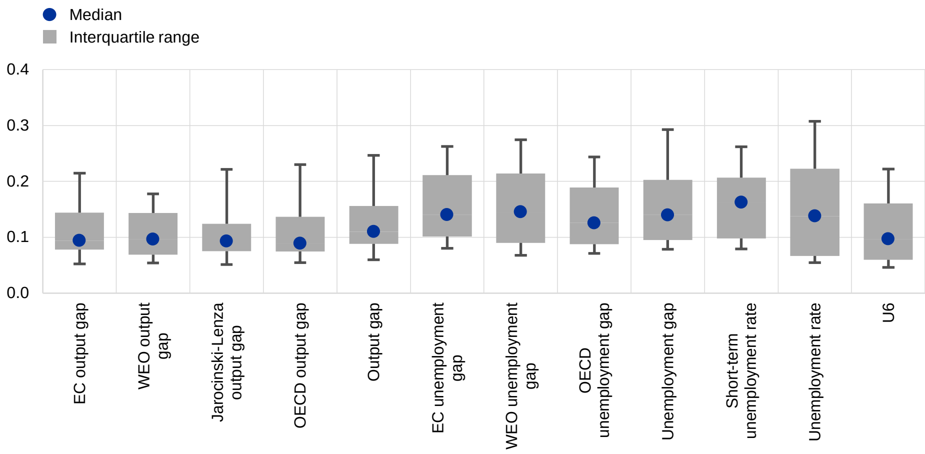
12 Recent papers (see, for example, Hazell et al. (2021) and McLeay and Tenreyro (2019) on the Phillips curve relationship in the US show that using a multi-region model to estimate the slope of the aggregate Phillips curve from regional estimates would yield better identification of the slope parameter. The identification approach by McLeay and Tenreyro (2019) was also applied in Eser et al (2020), indicating that the slope of the Phillips curve in the euro area is not "flat", but at the same time cannot fully explain the low inflation from 2013 to 2019.

Chart 3

Phillips curve in the euro area

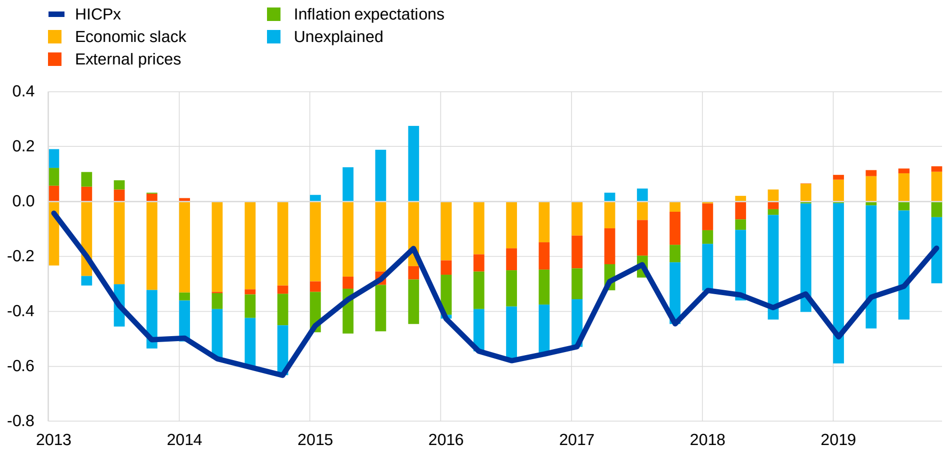
a) Estimated Phillips curve slope across all specifications – HICPX

(coefficients)



b) Thick modelling Phillips curve decomposition of HICP excluding energy and food

(annual percentage changes and percentage points contributions)



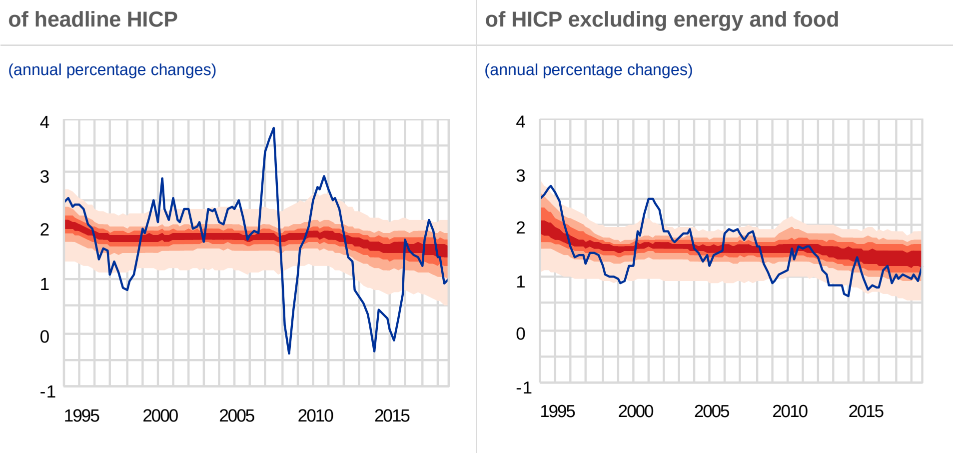
Sources: European Commission, Eurostat, International Monetary Fund (IMF), OECD, and ECB staff calculations.
Notes: Panel a): The sign of the coefficients for unemployment rates/gaps have been inverted after estimation for comparability. The range of specifications for each slack measure includes different measures of inflation expectations and of external price variables. The sample is from the first quarter of 1999 to the fourth quarter of 2019. Panel b): All values are in terms of deviations from their averages since 1999 or later, depending on the specification. The bars show average contributions across all the models included in the thick modelling exercise. Details are provided in Bobeica.and Sokol (2019). The HICPX series used is seasonally adjusted and displays a kink in 2015 due to a methodological change.

The persistent component of inflation has declined in recent years, pointing to the importance of factors beyond the business cycle. One way of analysing the persistent unexplained deviation of inflation from the level implied by cyclical developments is to estimate a suite of Phillips curve models that links the deviation of inflation from a time-varying mean (instead of the deviation from a constant mean) to a measure of economic slack. The combined results show that the persistent component of headline inflation, i.e. the time-varying mean, declined from 1.8% in the second quarter of 2013 to 1.6% more recently (see Chart 4). Similarly, the persistent component of HICP excluding energy and food fell from 1.6% to 1.3% in the same period. The uncertainty around these estimates is sufficiently large for a non-declining persistent inflation component to also lie within the uncertainty range.

However, the whole distribution has shifted downwards, supporting the view of a decline in the persistent component. In this context the probability that the persistent component was below 1.5% increased from 10% up to mid-2013 to 37% at the end of 2019 (see Box 2 for a detailed discussion on the estimations).

Chart 4

Persistent component



Sources: ECB staff calculations.
Notes: Panel a): Combined trend inflation density estimates from four specifications of two models (Phillips curve and semi-structural). Panel b): Combined trend inflation density estimates from five specifications of three models. The latest observation is for the fourth quarter of 2019.

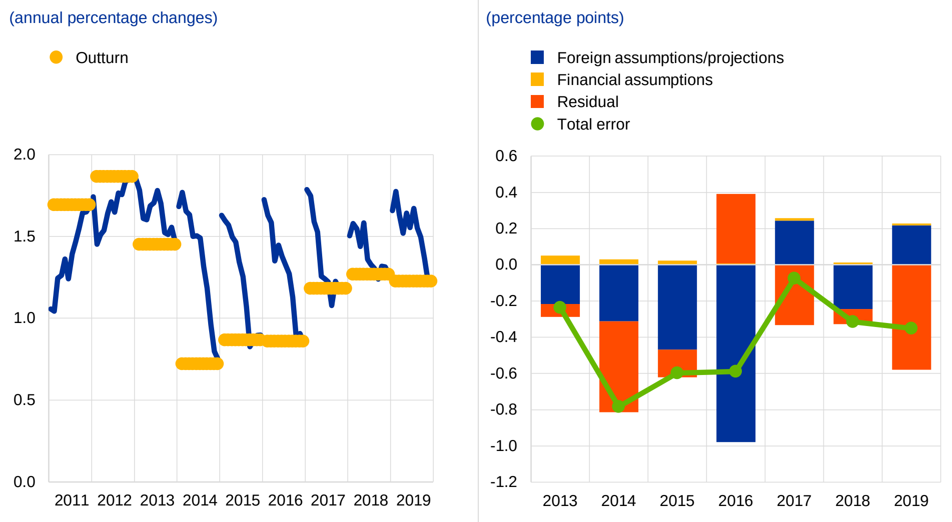
Besides being low, inflation was also persistently overestimated in the Eurosystem/ECB staff macroeconomic projections. In the years 2013-19, inflation was systematically over-predicted in successive forecast rounds (see Chart 5, left panel and Box 3). A large part of the forecast errors for inflation excluding energy and food can be accounted for by errors in the technical assumptions (such as oil prices, exchange rates or fiscal policy stance) and in the projections for the global economy (see Chart 5, right panel, blue bars). At the longer end of the horizon, another source of the systematic over-prediction of HICP inflation was judgement. Decompositions of the forecast errors with structural shocks assign an important role to foreign developments (see Chart C in Box 3), as well as supply shocks (especially in the first part of the low inflation period), in the persistent over-prediction of inflation. These findings indicate that low inflation was not only driven by external factors (such as low energy prices), but that domestic factors also played a role.

Chart 5

Projections and projection errors for HICP excluding energy

HICP excluding energy projections and outturns

Two-year ahead projection errors for HICP excluding energy – role of conditioning assumptions



Sources: ECB staff macroeconomic projections and Eurostat.
Notes: The left chart shows the evolution of the projections for each year together with the outturn. Errors in the right chart are defined as outturn minus projection from the March ECB staff projections of the previous year. The decomposition is based on the basic model elasticities taken from the macroeconometric models used to produce the Eurosystem staff projections. Foreign refers to errors in assumptions/projections for commodity prices, exchange rates, competitor's prices and foreign demand. Financial refers to interest rates and stock prices.

What other factors caused the below-target inflation? Did structural factors contribute to lowering the persistent component of inflation or was slack underestimated? What was the role of inflation expectations? The rest of the paper addresses these questions against the background of the constraint imposed on monetary policy by the effective lower bound in interest rates.

Box 1

What are possible sources of a shift in the Phillips curve?

It is challenging to compile a single coherent narrative and quantification of the drivers of HICPX inflation over the past decade, as highlighted by the persistent and relatively large residuals in the Phillips curve-based decomposition in Chart 3, right panel. Theoretical arguments and empirical analyses[13] point to a number of factors that could lie behind those residuals. A drift in inflation expectations, persistent supply shocks (including global ones), impaired wage-price pass-through or an underestimation of the true degree of slack in the euro area can all "shift" the Phillips curve, blurring the positive correlation of activity and inflation – that is, making it *appear* flatter. This box looks more deeply into a number of these explanations.

One possible explanation for the residuals could lie in the gradual decline of average HICPX inflation itself. As shown in Chart 4, and further discussed in Box 2, there is econometric evidence of a gradual decline in the mean of HICPX over the 2013-19 period. However, the combination of

13 Much of this work was originally conducted jointly with NCBs (Ciccarelli and Osbat (2017); Nickel et al. (2019)).

fixed-parameter models underlying Chart 3, right panel is unable to capture that feature of the data. In normal times, we tend to associate low-frequency movements in HICPX inflation with more secular factors, such as the impact of globalisation or demographics, that might, by choice, be accommodated by monetary policy. But given the effective lower bound constraint, the drift over the more recent period could also reflect forces that impact the natural rate. These forces, such as more persistent global demand headwinds or supply shocks, would manifest in inflation drifting down because of the reduced monetary policy space.

Inflation expectations could also partly explain the residuals.[14] Especially longer-term survey measures of inflation expectations have drifted (or shifted) downwards around the period 2013-19. Such developments already play a role in Chart 3, right panel, as shown by the sizeable drag of inflation expectations (red bars) to HICPX inflation over parts of that period. But the modelling uncertainty around that is quite high (see Bobeica and Sokol, 2019), which suggests that inflation expectations could play a more prominent role and plausibly account even for some of the unexplained residuals.

Inflation expectations can be an autonomous driver of inflation, but are more likely to reflect other developments, such as adverse shocks hitting the euro area coupled with monetary policy being constrained by the effective lower bound. Their dynamics could indicate a loss of confidence in the central bank's ability to stabilise inflation around its target, or merely reflect an increased sensitivity of such measures to news about the economy. The two hypotheses are usually very difficult to disentangle empirically.[15] However, it is clear that adverse shocks that cannot be fully offset by monetary policy due to the effective lower bound constraint can lead to very persistent deviations of inflation (and agents' inflation expectations) from steady state, as can be shown in model simulations (see Section 4.1).

Each regression underlying Chart 3, right panel includes an indicator of external inflationary pressure, either extra-euro area import prices or the oil price in euro. The substantial residuals that are present despite the inclusion of import prices could be due to factors, including structural ones, beyond import prices. A separate role for global slack in the Phillips curve can be framed in terms of increased contestability of markets, especially labour markets. In this setting, global slack is viewed as a supply factor, entering the domestic marginal cost over and above import prices. Empirically, Borio and Filardo[16] found support for this mechanism, and Auer, Borio and Filardo[17] also found that increasing global value chain integration is an important channel for the transmission of global slack to domestic inflation. However, the evidence on global slack in the Phillips curve remains mixed.[18] There is also some suggestive evidence of a link between the trade balance and domestic price pressures.[19]

Supply shocks, especially those also affecting the behaviour of wages, could also be at play. In principle, labour costs are a fundamental source of cost-push inflation due to the relatively large share of the wage bill in production costs. At the same time, however, an improvement in demand conditions in the economy could directly boost pricing power, with wage inflation lagging price

[14] The impact on inflation expectations may have signalled uncertainty about the effectiveness of unconventional monetary policy measures (see Ciccarelli and Osbat (2017)).

[15] Ciccarelli and Osbat (2017).

[16] Borio and Filardo (2007).

[17] Auer et al. (2017).

[18] Béreau et al. (2018) and ECB (2017), especially Box 2.

[19] Galstyan (2019); Eser et al. (2020).

inflation. Empirical results on the dynamic correlation of wage growth and inflation are thus often mixed.[20] Recent work by ECB and Eurosystem staff also pursued the hypothesis that wage-price pass-through is state-dependent, finding that wage increases pass-through to inflation faster, and to a larger extent, following a demand shock than they do after a supply shock (Hahn, 2019). That would suggest an important role of supply shocks over the "missing inflation" period, as also indicated by other structural models (e.g. Bobeica and Jarocinski, 2019).

An alternative way of accounting for the recent residuals in Chart 3, right panel relies on the notion of hidden slack. Using a small Bayesian dynamic factor model for the euro area, Jarocinski and Lenza (2018) estimate the deviations of output from its trend that are consistent with the behaviour of inflation, i.e. that prevail assuming the existence of a stable and non-flat Phillips curve. The version that forecasts inflation best out of sample implies that after the 2011 sovereign debt crisis, the output gap in the euro area far exceeded more traditional estimates (Chart 12), while versions featuring a secular stagnation-like slowdown in trend growth, and hence a small output gap after 2011, do not capture inflation developments as well.

Hidden slack could point to the relevance of omitted factors, for example global factors not fully captured by external prices in other modelling approaches (see above). At the same time, labour market slack might not be fully captured by unemployment rates. While most available indicators of labour market slack and capacity utilisation do point to very little, if any, remaining slack by the end of 2019, there might be limitations to those standard indicators, even when allowing for discouraged workers and part-time workers who are seeking full-time employment, as computed in the "U6" measure.[21] For example, Lombardi, Riggi and Viviano (2020) show that the long-standing drop in workers' bargaining power has weakened the relationship between inflation and a standard output gap.

Finally, a "genuine" flattening or steepening of the Phillips curve slope, even after controlling for factors such as those outlined above, could also have occurred. Theoretical models that allow for nonlinearities in nominal adjustment imply that the Phillips curve itself should be non-linear. For example, if downward adjustments of prices and wages are "stickier" than upward adjustments, then the Phillips curve will become flatter as inflation declines.[22] Furthermore, optimising models of price and wage changes, in which nominal adjustments are more likely when they are more valuable, imply that the Phillips curve will be flatter at low trend inflation rates.[23] Other mechanisms rather rely on the slope being related to the state of the cycle, for example through threshold effects or other devices.[24]

Overall, however, the econometric evidence for a 'genuine' flattening or steepening is not very convincing for the more recent period. VAR analysis, which closely follows a recent paper on the US Phillips curve (Del Negro et al., 2020) and studies impulse responses to an excess bond premium shock before and after the financial crisis, finds that confidence bands for both real and nominal variables largely overlap for the two samples and are generally wide, contrary to what one would expect if the Phillips curve slope had meaningfully changed. Moreover, time-varying

[20] See Eser et al. (2020) for a list of references.

[21] See Work stream on employment (2021) and Nickel et al. (2019).

[22] See Benigno and Ricci (2011), Lindé and Trabandt (2019) and Gautier et al. (2021). This kind of explanation might also lie behind the common finding that over very long-time horizons (decades), Phillips curve estimates in many advanced economies tend to fall (see, for example, Banque de France, 2018).

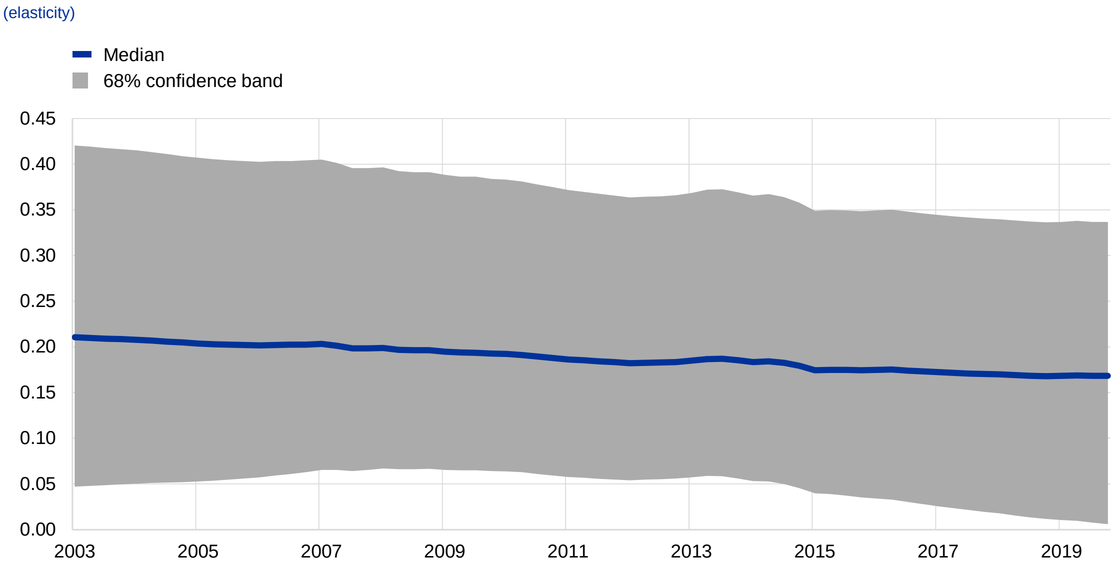
[23] Costain et al. (2019).

[24] See Box 2 in Bobeica and Sokol (2019) for a short review.

estimates of reduced-form Phillips curves are highly uncertain, and do not typically show meaningful signs of a flattening of the coefficient on economic slack around the low inflation period (Chart A).

Chart A

Evolution of the coefficient on economic slack (the “slope” of the Phillips curve) across a pool of time-varying Phillips curve specifications



Sources: Eurostat, European Commission and ECB staff calculations.
Notes: The models in the pool are estimated using data since 1999, and the pool of models includes the same set of explanatory variables as the models underlying Chart 3. For specifications based on the unemployment rate or gap, the coefficient has been inverted for comparability purposes. For details on the methodology, see Primiceri (2005) and Del Negro and Primiceri (2015).

Box 2

Phillips curve-based estimates of the trend or persistent component of euro area inflation

Understanding the evolution of inflation trends is crucial for assessing medium to long-term risks to price stability. This box analyses the dynamics of the trend or persistent component of inflation, using both terms interchangeably. The trend component refers to a highly persistent, slowly moving time-series component of inflation that is not directly affected by short to medium-term fluctuations, such as cost-push shocks or the business cycle. From a Phillips curve perspective, the trend component can be seen as a − possibly time-varying − intercept term. Importantly, the trend component does not refer to secular or structural phenomena but only reflects time-series properties of the data. The trend component of inflation is estimated using a suite of models, all of which incorporate a Phillips curve relationship that links inflation in deviation from its trend to a measure of economic slack. This box provides model-based evidence on the changing path of trend inflation but does not seek to identify all possible driving factors.

Various pieces of evidence suggest that the trend or persistent component of inflation in the euro area might have declined in recent years. Unless accounted for in inflation projections, a declining path of trend inflation can complicate the conduct of monetary policy. For example, workhorse models routinely used to interpret inflation dynamics, namely Phillips curves with constant coefficients, result in sizeable negative residuals, suggesting that the prevailing levels of economic slack cannot fully explain the subdued levels of inflation between 2013 and 2019.[25] Further, some papers have found that, in the recent period, popular ("statistical") estimates of the more persistent components of inflation show declines, and Phillips curve models allowing for time-varying (declining) intercepts result in more accurate out-of-sample inflation forecasts.[26]

The trend or persistent component of inflation is an unobserved variable and its estimates are necessarily model-specific. A wide range of estimation approaches have been used for it in the literature.[27] This box combines the results from three different models developed by the ECB to hedge against model uncertainty. All three models embed a Phillips curve relationship that links inflation in deviation from a possibly time-varying trend component (which we call the inflation gap) to a measure of economic slack. All three models have been tested and validated in out-of-sample forecasting exercises. The Bayesian methods and the Kalman filter employed to estimate the models enable a straightforward combination of the results, relying on draws from the distribution of the unobservable states, e.g. that of trend inflation.

The first is the dynamic factor model of Jarocinski and Lenza (2018) which was developed to estimate the euro area output gap on the basis of a set of real activity variables and HICP excluding energy and food, a measure of domestic price pressures. The second is a Phillips curve model with time-varying inflation trend and time-varying coefficients and variance,[28] following the methodology of Chan, Clark and Koop (2018). The third is the semi-structural unobserved components model of Tóth (2021), which combines a multivariate filtering approach with a Cobb-Douglas production function. In this model, inflation is decomposed into trend and cyclical components which are estimated jointly with the output gap.

For these models, the trend component of inflation is estimated for four price indices over 1995-2019: (i) headline HICP, (ii) HICP excluding energy and food (HICPX inflation), (iii) HICP excluding energy and (iv) the GDP deflator. Chart 4 in Section 2 shows the main results for HICP and HICPX inflation. These combine the trend estimates of inflation from the different models with equal weights to provide "summary" measures, also highlighting the uncertainty involved in the estimation. The combinations for HICPX inflation contain a result of the dynamic factor model for a baseline (where inflation is anchored to the ECB's inflation aim), as well as trend inflation specifications with fixed and time-varying anchors from the other two models. For the other price indices, results from the dynamic factor model are not available.

The summary measure suggests that trend inflation – where inflation is measured by HICP excluding energy and food − is likely to have declined somewhat, by around 0.2 to 0.3 percentage points (at the median) between 2013 and 2019, although the uncertainty around the trend estimates has increased over the recent period[29] and a non-declining trend inflation profile is well within the plausible range of results. Employing headline HICP or HICP excluding energy yields a similar pattern, while the GDP deflator results in a more stable trend.

[25] See, for example, Figure 1 in Ehrmann et al. (2020).

[26] See Box 1 in this Occasional Paper but also Ciccarelli and Osbat (2017), Stevens and Wauters (2018), Correa-López et al. (2019), Hasenzagl et al. (2019), Hindrayanto et al. (2019), Banbura and Bobeica (2020).

[27] See, for example, Cogley et al. (2010), Faust and Wright (2013), Ascari and Sbordone (2014), Clark and Doh (2014), Yellen (2015), Mertens (2016), Mertens and Nason (2020).

[28] See Banbura and Bobeica (2020).

[29] For the last several quarters in the sample, this increase in uncertainty at least partly reflects the fact that two-sided filters (or smoothers) − which have been used to extract the persistent component from observable inflation − tend to provide less precise estimates at the end of the sample.

Across models and specifications, the estimates obtained by employing a fixed nominal anchor produced more stable and less uncertain estimates. If, however, trend inflation is assumed not to be anchored by inflation expectations or a constant, both the Phillips curve and the semi-structural models estimate that the trend component of inflation has declined since 2011. It is worth noting that actual inflation has been close to, or below, its estimated trend component over the past decade, which is in line with an estimated negative output gap in the euro area for most of this period.

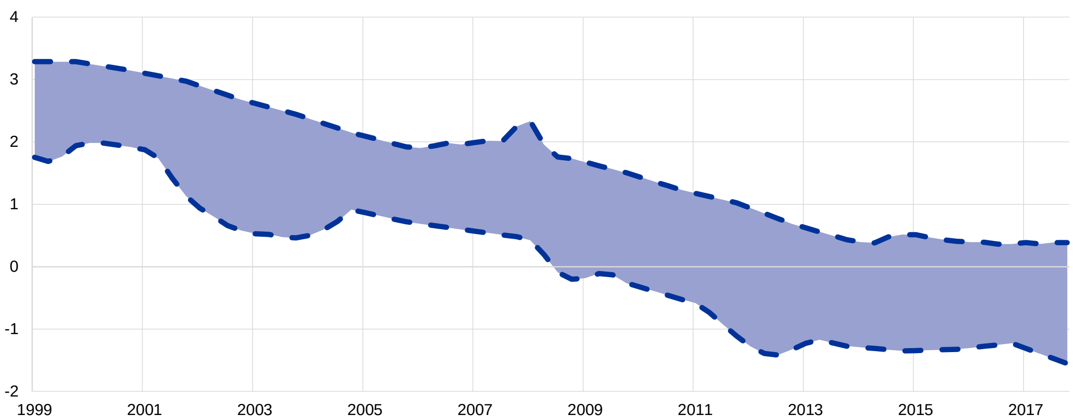
A possible decline in the trend component of inflation raises potential concerns for monetary policy. Since the decline is not a direct consequence of business cycle developments or other transitory fluctuations, it could possibly reflect a downward drift in the perceived inflation target or a perception that the central bank has a more limited ability to meet its target than in the past. Even if the drivers remain unidentified, such a decline in the persistent component is relevant for projecting inflation over the medium term, which in turn is central to monetary policy.

In this vein, the decline in the trend component of inflation as outlined above roughly coincides with the estimated decline in the natural real rate of interest (see Chart A) to regions where the effective lower bound on the short-term nominal interest can be binding, further limiting the ability of monetary policy to exert upward pressure on inflation in the context of economic slack.[30] This may at least partly explain why there has been some likelihood of a downward sloping drift in trend inflation in recent years.

Chart A

Range of euro area natural real interest rate estimates

(percentages)



Note: The range is based on estimates from Fiorentini et al. (2018), Brand and Mazellis (2019), Jarocinski (2017), Hledik and Vlcek (2018), Holston et al. (2017).

Overall, the estimates introduced in this box provide tentative evidence of a decline in the trend or persistent component of inflation since 2013, although the uncertainty around the trend estimates has increased over the same time period. It must be acknowledged that the methods presented have their limitations. Declining trend inflation is not the only factor that may help to explain the observed inflation dynamics in the context of the workhorse Phillips curve frameworks, and it is likely that more factors are empirically relevant at the same time. Among other things, economic

30 For more details on this issue, see, for example, Rostagno et al. (2019).

slack may have been mis-measured or the slope of the Phillips curve may have declined (see Box 1). Furthermore, the models employed in this box do not identify the drivers of the estimated decline in trend inflation. However, regardless of the exact causes, a decline in trend inflation may signal that policymakers potentially need to address drivers of the inflation process that are beyond business cycle fluctuations in terms of persistence.

Box 3

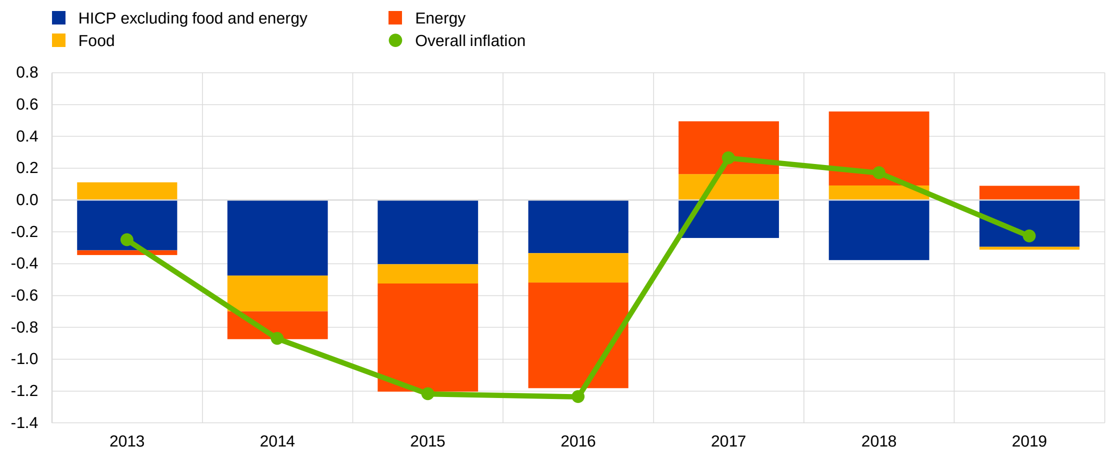
Projection errors for underlying inflation – stylised facts and a structural interpretation

During the period of low inflation between 2013 and 2019, HICP inflation excluding energy was systematically over-predicted in the Eurosystem/ECB staff macroeconomic projections. In the first years of the sample, these over-predictions amplified the errors made for the energy component, while between 2017 and 2019 they compensated for higher than expected energy inflation. The projections for headline HICP inflation, which is the main variable of interest in the macroeconomic projections, were therefore much more accurate during the second half of the sample (see Chart A). The Eurosystem/ECB staff were not alone in making such errors – other institutions such as the European Commission, the OECD and private sector forecasters made errors of a similar magnitude for underlying inflation and consistently in the same direction over this period.[31]

Chart A

Two-year-ahead projection errors for headline HICP inflation

(percentage points)



Source: ECB staff projections.
Notes: Positive projection error stands for under-prediction and vice versa. All data refer to percentage point errors in the annual rates of change for the March ECB staff projections for the next calendar year.

Around half of the over-predictions of underlying inflation relate to errors in the conditioning assumptions. Chart 5, right panel shows the two-year-ahead projection errors for HICP excluding energy since 2013 and decomposes each error into the part which can be attributed to errors in the conditioning assumptions (such as oil prices, exchange rates, interest rates) and a residual related

31 See European Central Bank (2019) "The performance of the Eurosystem/ECB staff macroeconomic projections since the financial crisis", Economic Bulletin, Issue 8.

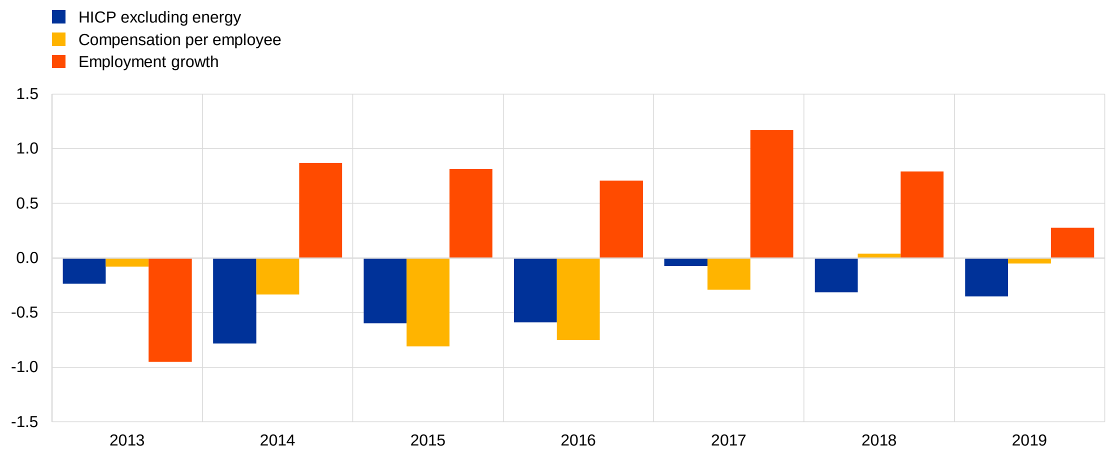
to all other factors.[32] According to this decomposition, on average since 2013, around -0.2 percentage points of the error (a little less than half of the average overall error) cannot be explained by conditioning assumptions and could relate to many of the factors proposed for explaining the period of low inflation described above. As in the Philips curve decomposition shown in Chart 3, right panel, the unexplained component increased notably towards the end of the sample.

Errors in projecting underlying inflation have also coincided with systematic errors in projecting labour market quantities and prices (see Chart B). Persistent large under-predictions were made for employment dynamics since 2014, while wage growth was over-predicted for most of the period since 2013. While this can be partly explained by a failure to anticipate the increase in part-time working, similar systematic biases are observed in the projection errors for hours worked and compensation per hour. Such a combination of under-prediction of labour volumes and over-prediction of wages suggests a role for positive labour supply shocks[33]. Indeed, the growth of the labour force was under-predicted, but only for the period since 2016 and only to a much smaller extent than employment.[34]

Chart B

Two-year-ahead projection errors for HICP inflation excluding energy and labour market variables

(percentage points)



Source: ECB staff estimates.
Notes: Positive projection error stands for under-prediction and vice versa. All data refer to percentage point errors in the annual rates of change for the March ECB staff projections for the next calendar year.

Another way to analyse projection errors is to estimate their drivers using a structural model. The New Area-Wide Model (NAWM)[35] is used regularly in the Eurosystem/ECB staff forecasting process to produce shock decompositions of the baseline numbers and can be similarly applied to decompose the projection errors into fundamental shocks. Chart C shows the average error from

32 The impact of errors in assumptions is based on the standard elasticities used by NCBs' macro-models for constructing the Eurosystem staff projections. A caveat to this approach is that the staff projections also include judgement when taking on board the technical assumptions, implying that using the standard elasticities may either over or underestimate the role of the technical assumptions in explaining the errors, depending on the sign of the judgement included. The analysis does however offer an approximate order of magnitude, especially over longer samples.

33 These favourable supply developments, especially in the labour market, are likely an outcome of labour market reforms after the global financial crisis. See, for example, Anderton and Di Lupidio (2019).

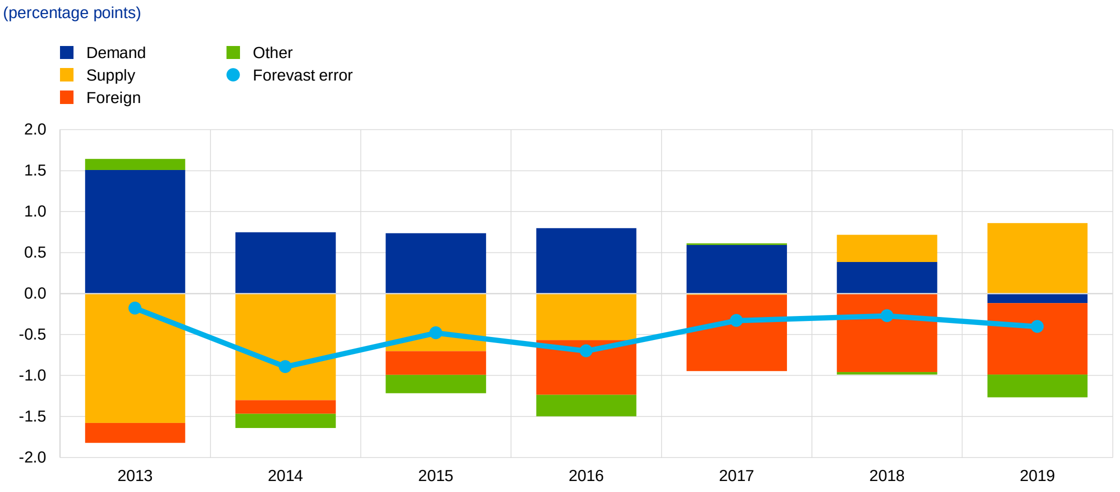
34 See Nickel et al. (2019).

35 See Christoffel et al. (2008) and Coenen et al. (2018).

the staff projections compiled two years previously for HICP excluding energy.[36] In general, demand shocks contributed positively to the errors over this period in a rather systematic way. Regarding the contribution of the rest of the shocks, two phases can be defined: the first covering the period 2013-16 when supply-side shocks contributed negatively, more than compensating the impact of the demand shocks, and the second from 2017 to 2019, when the international environment was characterised by the group of shocks with a more sizeable negative contribution to HICP inflation excluding energy.

Chart C

HICP excluding energy NAWM shock decomposition of the average two-years-ahead projection error



Source: ECB staff estimates.
Notes: The charts show the difference between the NAWM shock contributions of the two-years forecast and the shock decomposition of the December 2019 Broad Macroeconomic Projection Exercise (BMPE) which is taken as the realised value for computing forecast errors.
Results should be analysed with care as there have been three re-estimations of the NAWM over the period. The final vintage (December 2019 BMPE) refers to NAWM II decompositions, which may make it difficult to compare the decompositions in detail.
Demand shocks include the domestic risk premium, export preference and import demand shocks, shocks to government spending and the short-term interest rate shock (monetary policy shock). In addition, NAWM II vintages incorporate the long-term interest rate (shock to banks' survival rate) and the lending rate (shock to retail banks' markdown). Supply shocks include technology shocks, namely transitory, permanent and investment specific technology shocks, as well as markup shocks including wage and domestic price markups and import and export price markups. The category "foreign" captures shocks to foreign demand, foreign prices, US three-month interest rate, competitors' export prices, oil prices and a foreign risk premium shock. For the NAWM II it also includes the US ten-year interest rates shock). Finally, the category "other" includes measurement errors and residuals from bridge equations.

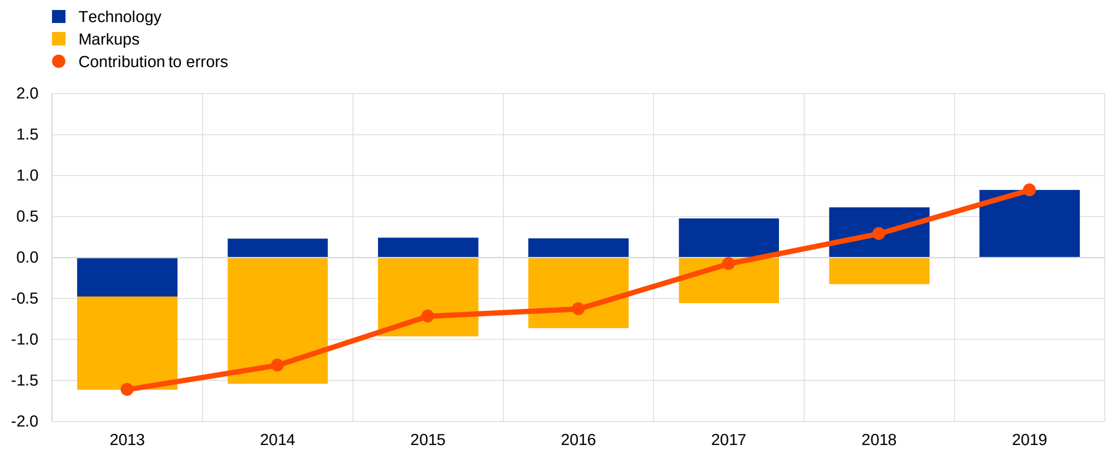
Chart D zooms in on the contributions of the supply side to these errors, breaking them down into two subgroups: (i) technology (shocks more closely related to trend growth, the production function and capital accumulation) and (ii) markups (shocks linked to price formation). Two features stand out: the negative contribution of markup shocks in 2013-17 that lowered pricing power following the sovereign debt crisis, and increasingly positive contributions of the technology shocks in 2017-19 owing to a rise in digitalisation and e-commerce as analysed in the following chapter.

[36] HICP excluding food and energy is not available in the NAWM set-up.

Chart D

HICP excluding energy NAWM shock decomposition of the average two-years-ahead forecast error: supply contribution

(percentage points)



Source: ECB staff estimates.
Notes: The charts show the difference between the NAWM supply shock contributions of the two-years-ahead forecast and the shock decomposition of the December 2019 Eurosystem Staff projections which are taken as the outturn to compute projection errors. Results should be analysed with care as there have been three re-estimations of the NAWM over the period. The final vintage (December 2019 BMPE) refers to NAWM II decompositions, which may make it difficult to compare the decompositions in detail. Technology shocks include transitory, permanent and investment specific technology shocks, while markup shocks cover wage and domestic price markups and import and export price markups. The category "foreign" captures shocks to foreign demand, foreign prices, US three-month interest rate, competitors' export prices, oil prices and a foreign risk premium shock. For the NAWM II it also includes the US ten-year interest rate shock).

Despite the usual caveats in the interpretation of structural models[37], some features of the data captured by this model align with the analysis made in the first part of the box. For instance, the positive errors in GDP and, in particular, private consumption in the period 2014-17 would have led to higher inflation, but were compensated by negative errors in compensation per employee, unit labour costs and GDP deflator that mirror the negative contribution of the markup shocks. Regarding the final part of the sample, negative errors on productivity are reflected in the positive contribution of technology factors to inflation. Finally, the negative contribution of the external environment connects directly with the contribution of the external conditioning variables to the negative bias in the projections of HICP excluding energy.

[37] This is a general equilibrium structural analysis; the correspondence with the observed variables is not straightforward and requires all the variables and their relative movements to be considered.

3 Structural trends and inflation

3.1 Globalisation, digitalisation and inflation

Secular structural trends such as globalisation, digitalisation as well as demographic change can have a persistent impact on inflation. Globalisation and digitalisation can either directly affect the price dynamics of certain goods and services (e.g. of imported goods or digital products) or more indirectly affect price dynamics by changing the market structure in goods, services and labour markets (e.g. by affecting pricing power and markups). While the monetary policy response will ultimately determine whether such persistent relative price shocks have a permanent effect on inflation, the ability of monetary policy to offset such effects can be impaired, particularly in a structurally low interest rate environment in which the conventional monetary policy response may be constrained.

Globalisation increased gradually over decades and its influence on past inflation developments can only be measured over a longer period of time. Chart 6 shows globalisation and inflation trends since 1970 and indicates that as globalisation increased, average inflation rates in advanced economies decreased. However, it is not clear whether there is a causal relationship between these developments. Average inflation rates in advanced economies declined markedly in the 1980s, before falling more slowly from the 1990s onwards as globalisation intensified. As Box 4 explains, many advanced economies shifted to inflation-targeting regimes during this time and stable inflation became the consensus in the conduct of monetary policy. So globalisation in itself is unlikely to have been the main driver of the low inflation in the recent period.[38]

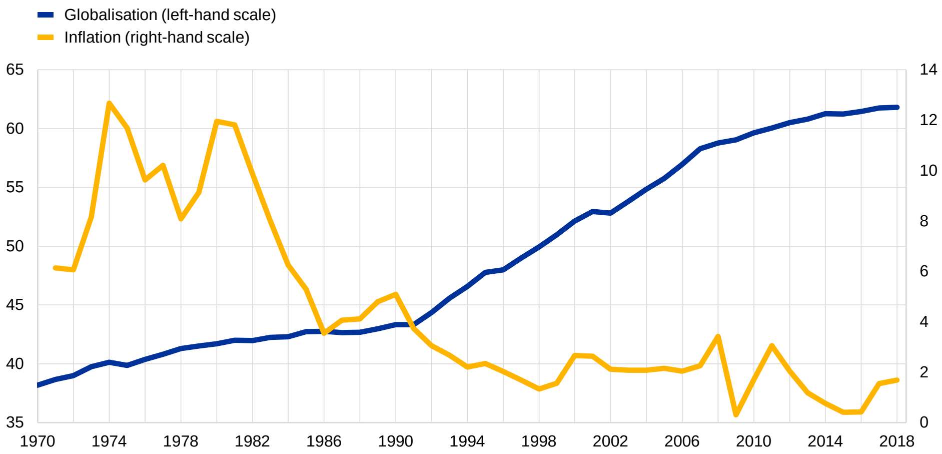
Globalisation captures at least three different trends: (i) increasing trade integration in the form of lower average tariffs and higher global value chain participation, (ii) financial openness and (iii) informational globalisation (digitalisation). Each of these megatrends can bring about changes in the price dynamics in advanced economies through cost reductions and changes in the market structure and competitive landscape, affecting also the bargaining power of workers. An aspect common to all three is that they increase the propagation of global shocks to the domestic economy.

[38] See European Central Bank (2017).

Chart 6

Median inflation rates in advanced economies and the KOF Globalisation Index

(left-hand scale: index; right-hand scale: annual percentage changes)



Sources: ECB staff calculations, KOF Swiss Economic Institute and national sources.
Note: Headline median inflation of 22 OECD countries and the KOF Globalisation Index.

Nevertheless, globalisation has been proceeding for decades and cannot explain the persistently low inflation in the euro area since 2013. There is not much evidence that globalisation accelerated after the sovereign debt crisis. If anything, the globalisation process has slowed down and, in some cases, even reversed since the financial crisis. As shown in Box 4, evidence points rather to a limited impact of globalisation on core (HICPX) inflation and cannot explain the persistently low inflation in the euro area since 2013.

A more recent phenomenon is digitalisation. Accounting for all channels through which digitalisation affects inflation and wage growth is challenging. Looking at it within a Phillips curve framework, digitalisation may affect the slope and the position of the curve, but the direction of the impact is ambiguous a priori (see Box 5 on how digitalisation can affect inflation through the lens of the New Keynesian Phillips curve). There are still few studies providing quantitative estimates for the impact of digitalisation on the slope and position of the Phillips curve and the prevailing evidence is uncertain. Adoption of new digital technologies is likely to lead to structural changes in the labour market, with the dynamics of employment and the share of low-skilled workers having implications for inflation.[39] From a general equilibrium perspective, aggregate wage growth will tend to rise with the productivity gains from the adoption of new technologies. However, in the short term, low-skilled workers will be displaced and the aggregate effect on wage growth will depend on the extent to which the economy's structure and policies will be able to upgrade the skill level of the labour force and generate high-skill jobs.[40] The impact of digitalisation will depend importantly on its effect on market power in labour and product markets. The academic debate on this, both theoretical and empirical, is still open, as also discussed in Workstream on digitalisation (2021) and in Box 5.

[39] See McKinsey (2020).

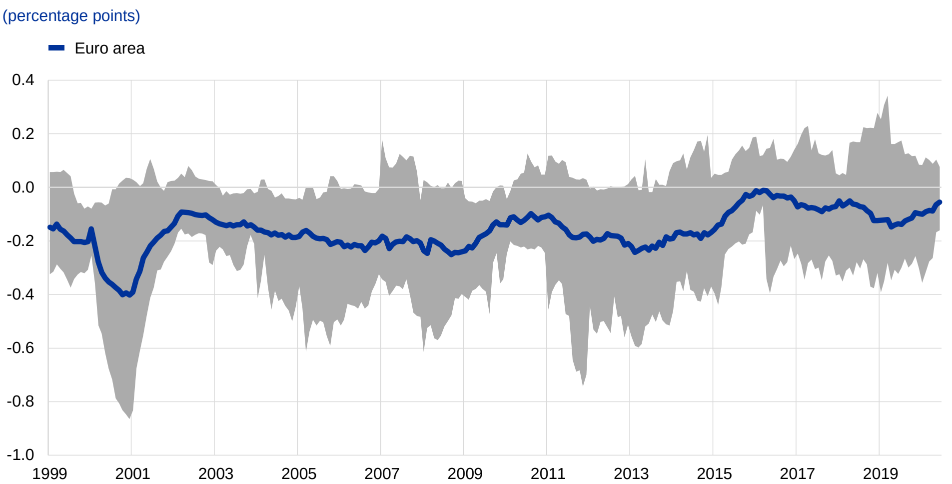
[40] See also Work stream on digitalisation (2021).

One way to look empirically at the impact of digitalisation on market power is by analysing markups. The increased competition would tend to lower markups but there is evidence, especially from the United States, that the markup distribution is very skewed, with a handful of firms accounting for an increase in aggregate markups over the past few decades. The consequences of a market structure with a few high-markup and many low-markup firms for the behaviour of inflation are not clear. New results for the euro area by Kouvavas et al. (2021) show that aggregate markups were driven up by the increase in the markups of high-markup firms, as they were in the United States, but less steeply. They also show that the lower-markup firms pass through supply and monetary policy shocks to inflation more than high-markup firms. If digitalisation favours the development of high-fixed cost, high-barrier-to-entry firms, which can preserve higher markups, this could reduce the cyclicality of inflation in those sectors.[41] The aggregate effect on inflation will then, all else being equal, depend on the sectoral composition of production and consumption and the size of the high-markup firms' share within them.

The direct effects of digitalisation on inflation are easier to quantify as they occur via the falling prices of digital consumer products. The direct negative contribution of the price decrease in digital products to the euro area annual HICP inflation rate was on average -0.15 percentage point per year over the period from 2002 to 2018 (see Chart 7).[42] Prices for the ICT intensive products declined each year as of 2000, with the impact being larger until around 2015 and somewhat decreasing thereafter. In terms of timing, this slowdown of the negative contribution of digital products to inflation speaks against it being a major contributor to the low inflation in the most recent years.

Chart 7

Direct impact on HICP inflation via price of ICT goods and services



Sources Eurostat and ECB staff calculations.
Note: ICT items are defined as the sum of (i) audio-visual, photographic and information processing equip, (ii) telephone and telefax equipment and (iii) telephone and telefax services The range corresponds to the 19 euro area countries. The latest observation is for June 2020.

41 See Kouvavas et al. (2021).

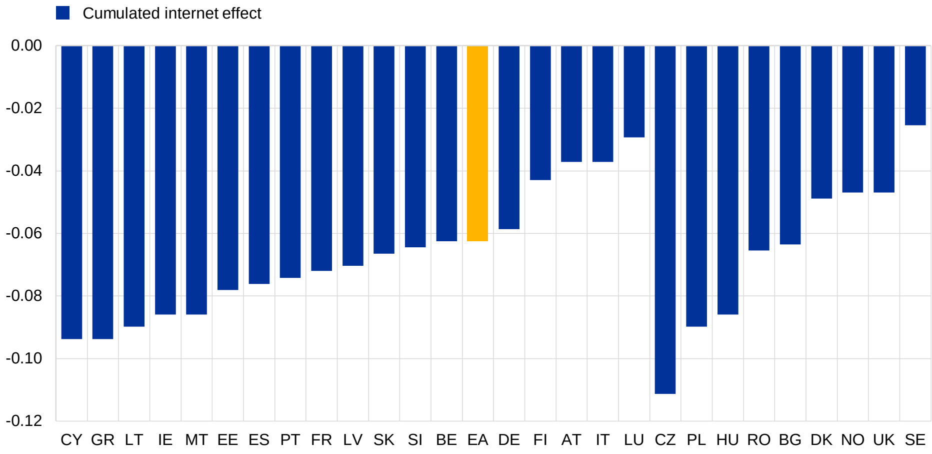
42 A caveat of this analysis is the non-harmonised treatment of quality change in ICT products across national HICPs (see Work stream on inflation measurement (2021)).

Beyond cost-saving, one indirect effect of digitalisation on inflation runs via higher competition owing to increased price transparency. E-commerce increases price transparency for consumers and can lead to higher price competition in goods and services that can be purchased online. E-commerce has different degrees of diffusion across euro area countries, allowing us to estimate its effect on various components of inflation. ECB estimates suggest that e-commerce has a small disinflationary effect on non-energy industrial goods, which include many of the goods that are most often bought online (see Chart 8). The estimates are heterogeneous across countries, reflecting different degrees of penetration of e-commerce.

Chart 8

Average annual effect of e-commerce on the inflation rate of non-energy industrial goods

(percentage points, 2006 to 2018)

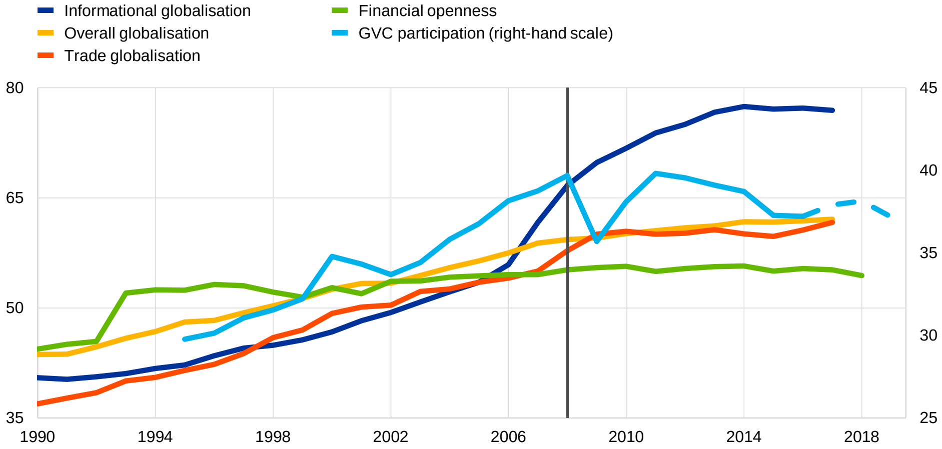


Sources ECB calculations based on own estimates and Eurostat data.
Note: See Anderton et al. (2020) for details on the estimation.

As globalisation and digitalisation are closely linked, their separate impacts on inflation are difficult to distinguish. Digitalisation has empowered aspects of globalisation related to the management of distributed supply chains and is blurring traditional distinctions between tradeable and non-tradeable goods by making some services tradeable (and the respective markets contestable). Since 2008, for example, the international flow of information and communication has increased considerably (see Chart 9). Both globalisation and digitalisation tend to support closer integration and interactions among economic agents, and so complement each other in many aspects. However, they may also substitute each other, for example because domestic robots can lead to re-shoring. These mechanisms make it challenging to identify their separate contributions to relative prices and inflation. Also econometrically, it is difficult to disentangle the effects of globalisation and digitalisation because they are trends that tend to move similarly and there is as yet no structural modelling approach that seeks to identify their separate effects on inflation.

Chart 9
Globalisation indicators

(percentage points)



Sources: KOF Swiss Economic Institute, OECD TiVA, Chinn-Ito (2006), ECB calculations.
Notes: Overall globalisation is the KOF overall index. Trade globalisation is the KOF de jure trade index (includes tariffs, agreements, regulations and taxes). Financial openness is a GDP PPP weighted average of the Chinn-Ito index in 31 economies worth +80% of world GDP (rescaled 1980=40). Informational globalisation is the KOF de facto informational index. Global value chain (GVC) participation as the ratio of GVC-related trade to gross exports. GVC-related trade is defined as the value added that has crossed at least two national borders (Borin and Mancini, 2017). Values for GVC participation between 2016 and 2018 are based on ECB estimates. The latest observations are 2017 for information globalisation, overall globalisation and trade globalisation, 2018 for financial openness, 2019 for GVC participation.

Taken together, globalisation and digitalisation have somewhat contributed to the low inflation environment of the past decades, but other factors have also been at play and their contribution to the most recent low inflation environment is uncertain. One such factor, which in principle should be captured by the Philips curve, is the impact of the demographic transition and its relation to the natural rate of interest.

3.2 Demographic transition, the natural rate of interest and inflation

Most European countries are undergoing a demographic transition characterised by declining fertility and mortality rates. The implications for the labour force are striking. In the euro area, the supply of labour among those aged 20 to 64 is expected to fall by 9.7% between 2016 and 2070, despite a projected increase in the labour force participation rate that will rely on increased participation of women, older workers and migration.[43] The old-age dependency ratio (people aged 65 and above relative to those aged 15 to 64) in the EU is projected to increase from about 31% in 2018 to about 54% in 2070. There is some empirical evidence that demographic transition can have an effect on inflation, though the transmission channels from demographic change to inflation are not very obvious. One hypothesis is that the impact on inflation arises from the central bank not taking fully into account the effect demographic change has on the natural rate of interest. Equally,

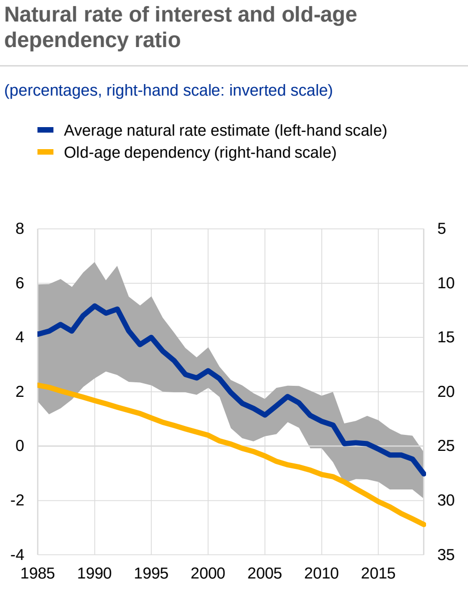
43 See Nickel et al. (2019) for a discussion of the role of these factors on wage growth in the euro area.

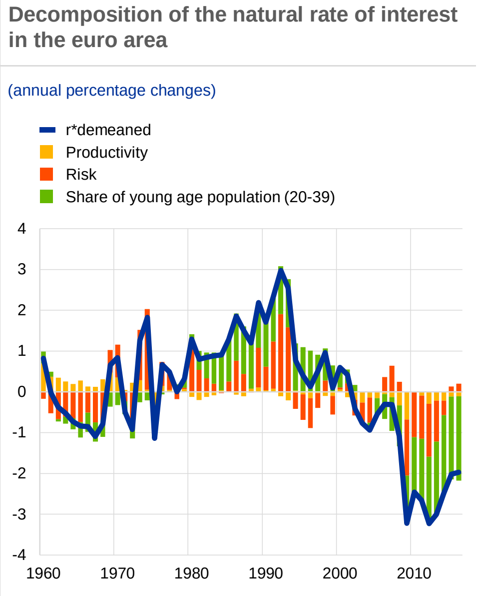
as is the case for globalisation and digitalisation, the effective lower bound may also play a role.

Many studies indicate that demographic change lowers the natural rate of interest.[44] From the point of view of monetary policy, the most important persistent, structural change has been the decline in the natural rate of interest. The range of estimates of the natural rate for the euro area after the financial and sovereign debt crisis has dipped into negative territory. The range of estimates for the euro area went from 0.5% to 2.2% on average from 1999 to 2012 to largely negative territory, from -1.5% to 0.6%, as of 2013 (see Chart 10, left panel). Analysis based on a variety of models showed that this was driven by a mix of factors: along with a decline in productivity growth, a surge in risk aversion after the global financial crisis and a rise in markups, demographic developments were also an important determinant (see Chart 10, right panel)[45]. The relevant demographic development here is the ageing of the society, as the baby boomer generation born after World War II is leaving the work force and entering retirement. This decline occurred against the background of a continuous increase in the old-age dependency ratio (see Chart 10, left panel).

Chart 10

Natural rate of interest





Sources: Eurostat and Brand et al. (2018).
Notes: Left panel: The old-age dependency ratio is defined as the ratio of the number of elderly people (i.e. aged 65 and over) compared to the number of people of working age (i.e. 15-64 years old).

A structural model with overlapping generations helps to understand the impact on inflation of a monetary policy that does not internalise the impact of

[44] A recent study (Mian et al., 2021) challenges the finding that demographic shifts due to the aging of the baby boom generation explain the decline in the natural rate of interest and points out that rising inequality is the more important factor explaining the decline in the natural rate of interest.

[45] See Brand et al. (2018) and Fiorentini et al. (2018).

the demographic transition on the natural interest rate.[46] In other words, not accounting for this source of persistent downward inflation generates a "disinflationary bias", stemming from a decrease of the natural interest rate by about 0.85 percentage points between 1990 and 2030. When a Taylor-type monetary policy rule features a constant natural interest rate, inflation decreases persistently going from about 2% (which the model assumes as the target) in 1990 to about 0.5% in 2030 using the UN (2017) demographic projections. This decrease seems to match the declining path of low-frequency inflation, particularly since the global financial crisis of 2007. However, using a less naive monetary policy rule where the central bank updates its estimate of the natural rate regularly, albeit with a delay, the disinflationary bias is reduced. The bias will largely remain to the extent that the central bank perceives that the natural interest rate is too high and therefore constantly conducts a tighter policy than intended. The model does not account for the effective lower bound, but if the natural rate of interest falls even below zero, the effective lower bound naturally makes it more difficult for the central bank to undo the bias, even if it were to correctly estimate the natural rate.

On the basis of ECB staff model analysis, monetary policy that does not fully internalise the downward impact of ageing on the natural interest rate is hence likely to be tighter than intended, thus generating a potential disinflationary bias. This reasoning must be counterbalanced by the potentially opposite effect of globalisation and digitalisation on the natural rate, to the extent that they increase productivity.

In general, the effects of secular trends on inflation developments depend crucially on the central bank's response and were likely more pronounced during the low inflation period as the ECB was constrained by the effective lower bound. Monetary authorities can normally internalise and offset the effects of such secular trends (globalisation, digitalisation, demographics), whether emerging through the natural rate, because of their impact on productivity, or through the increased sensitivity to shocks, because of their impact on market power. The available monetary policy space at the effective lower bound is therefore an important factor in explaining why secular trends may have tangibly affected inflation from 2013 to 2019. Box 6 addresses this interaction with the monetary policy space at the effective lower bound.

Box 4
Globalisation and inflation

This box looks at the impact of globalisation on inflation and the extent to which it might have acted as a disinflationary force across advanced economies, especially in the euro area. While the role of external factors (e.g. commodity prices) on inflation outcomes has been widely documented, the idea that globalisation might affect inflation in a more fundamental way, rather than simply causing temporary shifts in the level of inflation, has gained traction in the literature. It is argued that by increasing the interconnectedness of the world economies, globalisation in its broadest sense (i.e. trade, informational and financial globalisation) entails the propagation of shocks in one

[46] See Lis et al. (2020).

economy to other countries, thus influencing domestic macroeconomic outcomes. Overall, evidence presented in this box shows that globalisation has not been a major driver of inflation outcomes across advanced economies, including the euro area. In particular, the impact of globalisation on both headline and core inflation has been economically small, meaning that tailwinds to inflation from a reversal or slowdown of globalisation would be very limited.[47]

The interest in the disinflationary role of globalisation stems from the observed co-movement of inflation rates across advanced economies amid the growing internationalisation of goods, services and financial markets. From 1970 until the global financial crisis, average headline inflation rates in advanced economies declined from around 10% to 2% and have remained below that level since 2014. From the early 1990s onwards, the pace of globalisation accelerated significantly and entered a period of "hyper-globalisation", which led to the progressive reduction of (cross-border) frictions to the flow of people, capital, goods, services, information and knowledge. Globalisation stalled after the global financial crisis owing to a slowdown in the speed of economic integration (see Chart 6).[48]

International inflation co-movements may be explained by three sets of factors: (i) the evolution of the monetary policy regime, (ii) common shocks and (iii) structural changes, some of which are related to globalisation.

The shift to inflation-targeting regimes in the early 1990s played an important role in the convergence of inflation outcomes towards low and stable levels across advanced economies. This shift succeeded in taming persistently high inflation rates and anchoring inflation expectations.[49] At the same time, the pursuit of low and stable inflation also benefited from a higher level of central bank independence as the consensus emerged around a reduction of political pressure in the conduct of monetary policy.[50] The successful taming of inflation under inflation-targeting frameworks until 2007 was tested by the global financial crisis.[51] Inflation rates remained subdued and interest rates approached the effective lower bound thereby constraining the available monetary policy space to bring inflation back to target.

Ciccarelli and Mojon[52] document the large co-movement in headline inflation rates in OECD countries and show that global inflation accounts for about 70% of the cross-country variance of inflation. The authors find that the inclusion of global inflation consistently improves domestic inflation forecasts. In a similar vein, Mumtaz and Surico[53] find that the global factor was more prominent until the mid-1970s, while it declined thereafter.[54] Underlying these co-movements are,

47 See also Work stream on globalisation (2021).

48 This slowdown reflected compositional effects stemming from the increasing weight of emerging market economies in global economic activity, as these economies have a lower trade intensity; a moderation in global value chain (GVC) expansion which partly pre-dated the global financial crisis; and diminishing support from trade finance, with profound implications for the structure of the global economy.

49 During this period many monetary authorities shifted towards an inflation-targeting regime, either explicitly or implicitly, in a trend that has been referred to as the "globalisation of central banking". See Arrigoni et al. (2020).

50 In this context, the adoption of explicit inflation targets promoted accountability and constrained discretionary policy thus counterbalancing the flexibility stemming from greater independence. See Dall'Orto Mas, R. et al. (2020).

51 Rogoff 92003); Williams (2014).

52 Ciccarelli and Mojon (2010) develop three alternative measures of global inflation: a cross-country average of inflation rates, the aggregate OECD inflation and a measure based on static factor analysis.

53 Mumtaz and Surico (2012).

54 Taking a longer historical perspective, Gerlach and Stuart analyse data from the 1850s and argue that the role of international inflation on domestic prices, excluding the "Great Inflation" period, has remained remarkably stable over time. See Gerlach Stuart (2021).

however, common shocks, of which fluctuations in oil and non-oil commodity prices are typical examples. In many economies, these drive headline inflation developments at the same time as central banks typically seek to stabilise medium-term inflation, without fully insulating inflation outcomes from the impact of these (largely temporary) shocks.[55] Chart B depicts the evolution of the estimated (unobserved) common factor, in the spirit of Ciccarelli and Mojon, in headline inflation across countries and the estimated contribution of oil prices since the early 1970s.

Chart A illustrates that, for a sample of advanced economies, fluctuations in oil prices played an important role in explaining the international co-movement in inflation during the 1970s. Their importance started to diminish in the late 1980s thus pointing to a role for other factors related to the closer integration of the world economy. These include higher international competition in intermediate goods, the integration of the labour force of very large emerging economies such as China in the global production system and the adoption of technologies that make it easier to spread production across national boundaries.[56] All these changes occurred against the background of the monetary policy regime shift discussed above.[57] When looking specifically at euro area inflation developments since 2012, Chart B shows that this global common factor contributed to some extent to explaining headline inflation, but not core inflation (as measured by HICP excluding energy and food). In particular, since the sovereign debt crisis euro area, the euro area output gap has largely explained core inflation, though its importance started to diminish in 2015, despite the improvement in domestic demand conditions. One proposed explanation is that globalisation might have affected inflation in ways not directly captured by global inflation per se.

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55 Lane (2020).

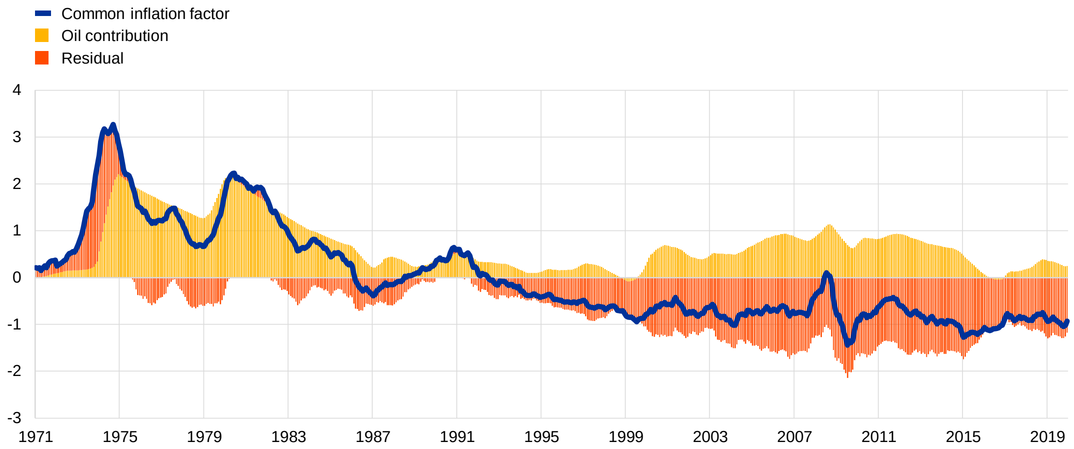
56 For a discussion of these factors, see Forbes (2019).

57 The relatively diminished contribution of oil prices to the common inflation component is confirmed also when the relationship is estimated as of the early 1990s, or when including food prices or when month-on-month changes are employed. Lane, ibid., points out that the transmission of fluctuations in commodity prices to domestic inflation is, however, neither automatic nor uniform across countries. With an independent monetary policy regime and hence flexible exchange rates, there is no deterministic relationship between international relative price movements and overall inflation rates. For example, while the oil price is globally quoted in US dollars, the pattern of movements in the USD/EUR exchange rate has meant that the oil price in euro has been much less volatile than the oil price in US dollars.

Chart A

Global inflation and commodities

(standardised annual percentage changes; percentage point contributions)

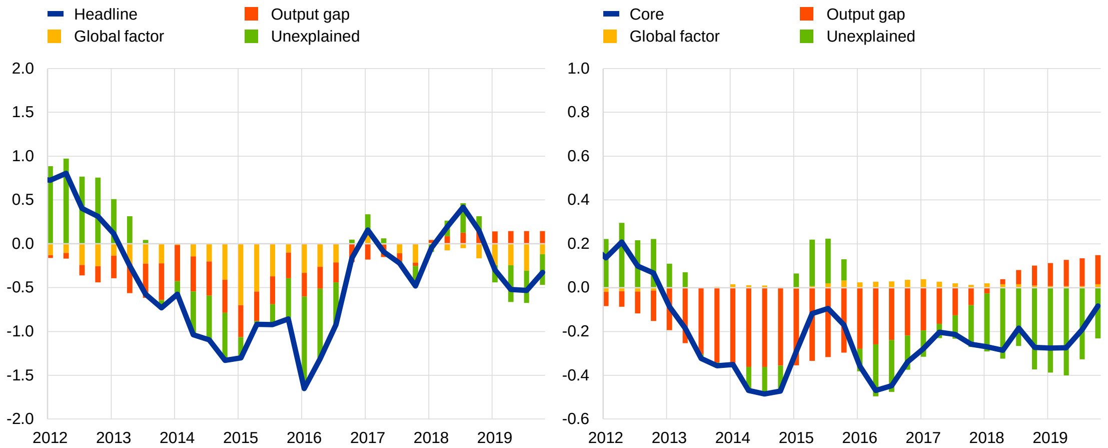


Sources: National sources and ECB staff calculations.
Notes: The common factor is demeaned. The estimation sample runs from January 1971 to December 2019. The blue line reflects the zero mean common factor in global inflation as derived by replicating the principal component approach of Ciccarelli and Mojon (op. cit.) for a sample of 34 advanced and emerging economies. The yellow bars reflect the contributions of oil prices derived as in Yellen (2015). The coefficients are estimated by a linear regression of the common factor on oil prices. The red bars are the residual contributions.

Chart B

Euro area HICP and global inflation

(standardised annual percentage changes; percentage point contributions)



Sources: Eurostat, national sources and ECB staff calculations.
Notes: All series are in deviation from their sample averages. The two charts represent the decomposition of the annual rates of Euro area HICP and HICP (ex. energy and food) derived from a regression on one autoregressive term, the output gap, the common demeaned factor and its first lag, The estimation sample runs from 2000Q1 to 2019Q4. The common factor in global inflation is derived by replicating the principal component approach of Ciccarelli and Mojon (op. cit.) for a sample of 33 advanced and emerging economies. The green and yellow bars reflect the contributions of the common factor and the slack measures respectively, derived as in Yellen (2015). The blue bars are the residual contributions

.Structural changes in the economy can influence inflation dynamics by feeding into the more persistent component of inflation. The structure of the economy matters for inflation outcomes because it determines price and wage-setting dynamics. Changes in the structure of the economy fall broadly into two main categories. First, changes that are domestic in nature but affect national economies in similar ways, thus resulting in a common inflation pattern across countries. Demographic changes, which may influence inflation through multiple channels, are an example of this type of structural change.[58] Second, changes of a global nature that increase the interdependence of the world economies, the prime example being the economic and financial globalisation which has taken hold since the 1990s.

The influence of globalisation on inflation outcomes has been widely debated by policymakers and academics alike. In a standard Phillips curve framework, external forces (e.g. foreign demand, foreign prices) feed into inflation through pressures on domestic slack and/or through import prices of final goods or intermediate goods. Moreover, as trade integration mainly influences the price of tradeable goods relative to non-tradeable goods, the impact on average inflation rates over the medium term is limited. Arguments have been growing that foreign factors have a more direct role in explaining inflation fluctuations and that traditional Phillips curve models should be augmented with measures of global slack. However, empirical evidence on how global slack influences the response of inflation to domestic cyclical conditions is mixed. In particular, little support is found for including measures of global slack and measures of integration in global value chains in Phillips curve analyses of the euro area inflation.[59]

To investigate the influence of globalisation, in its broader sense, on euro area inflation, the Phillips curve "thick modelling" approach used in Section 2 can be adapted to also consider the contribution of alternative indicators of globalisation (e.g. global value chain participation, or aspects less related to trade and more to information flows, institutions or even culture) to HICP (excluding energy and food) inflation. As the multi-faceted phenomenon of globalisation is difficult to capture, the analysis relied on the measures of globalisation made available by the KOF Institute. These measures try to capture different aspects of globalisation such as trade and financial openness, but also social and cultural aspects. Each measure is computed both de facto, using hard data, and de jure, looking at institutions and regulations. The analysis also uses measures of trade globalisation that are based on world input-output tables and capture the degree of a country's integration in global value chains. Chart C shows the results based only on the measures of globalisation that were significant in the econometric analysis. The left panel reports the results based on "hard data": the global value chain-based and de facto KOF measures, whereas the right panel reports the results based on the de jure measures only. The hard-data based measures show that the contribution of globalisation to inflation was smaller than average over the period under review, since the sovereign debt crisis, but this contribution was far too small to explain the low inflation period: the large systematic residuals documented in Section 2 remain. A similar picture emerges from the de jure measures after the sovereign debt crisis, with a more sizeable contribution in 2013-14, which, however, only depends on a single indicator: financial globalisation, which had a blip in some countries.

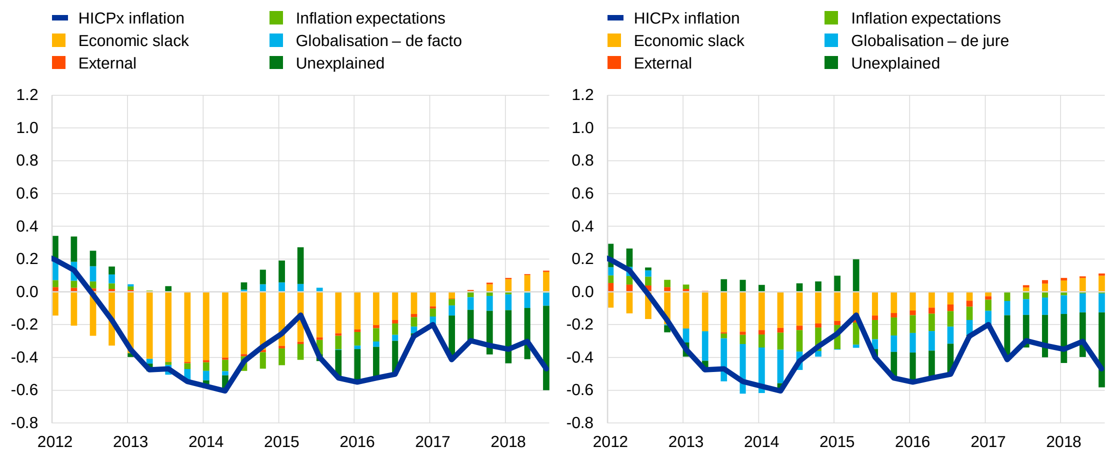
58 See, for example, Lis et al. (2020).

59 See European Central Bank (2017) and Nickel (2017).

Chart C

Thick modelling of the Phillips Curve: the contribution of indicators of globalisation

(annual percentage changes; percentage point contributions)



Sources: Eurostat, KOF, OECD, and ECB staff calculations.
Notes: All series are in deviation from their sample averages. Many indicators of globalisation are available only annually and up to 2018 or 2019. They were projected forward using an AR(1) autoregressive process and then interpolated; they appear in the regressions as quarter-on-quarter growth rates, annualised.

Finally, it could be argued that globalisation, by changing the structure of the world economy, could alter the inflation formation process and so affect the more persistent component of inflation across advanced economies. Global economic integration in its various dimensions (e.g. labour, trade in final and intermediate products) may act as a persistent and positive supply shock, leading to sustained disinflationary pressures and shifting the Phillips curve downwards. But it may also affect the market structure by increasing competition within many markets, causing structural changes that would influence the inflation process and possibly flattening the Phillips curve. Researchers have looked at the possibility that globalisation might affect inflation in a more fundamental way rather than simply causing temporary shifts in the level of inflation.[60] Attinasi and Balatti[61] analyse this issue in detail and find that the impact of globalisation (i.e. trade, financial and informational globalisation) on the persistent component of inflation is limited and economically small. In particular, the authors show that, also when looking separately at goods and services inflation, the negative, but relatively small, correlation between globalisation and the persistent component of inflation across advanced economies is confirmed. This distinction is motivated by the fact that, on the back of the rise of financial and informational integration, services have become more tradeable and their share in consumption baskets has grown. Available evidence suggests that indicators of globalisation are significantly correlated with overall persistent inflation, mainly through the goods component, whereas they appear to have offset services inflation, thereby reducing the total effect. At the same time, estimates of specifications including domestic variables (e.g. output gap and labour cost) suggest that these indicators are robustly significant and domestic factors continue to play an important role in driving price dynamics. This evidence shows no large difference in the effects of globalisation before or after the financial crisis, or between the euro area economies and other advanced economies.

60 See Forbes (2019).

61 See Attinasi and Balatti (2021).

Box 5
Digitalisation and inflation through the lens of the New Keynesian Phillips curve

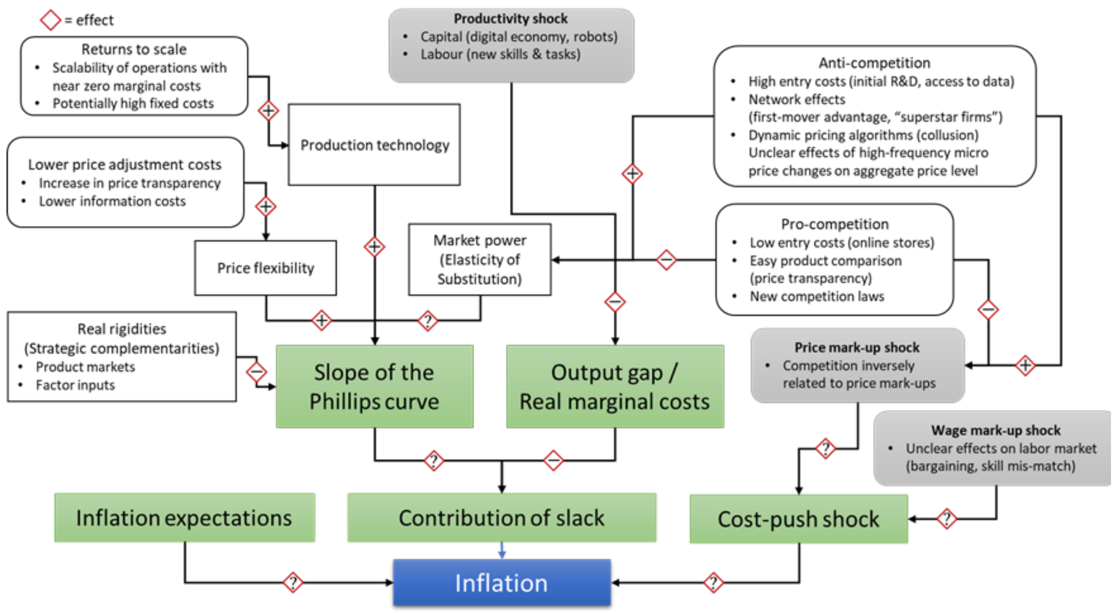
Digitalisation is one of the major drivers of long-term changes of the economy and affects inflation via numerous channels. As discussed in Anderton et al. (2021),[62] these channels can be looked at through the lens of the New Keynesian Phillips curve framework:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \hat{y}_t + \epsilon_t$$

where π_t is current inflation, $E_t \pi_{t+1}$ is inflation expectation, $\hat{y}_t$ is the output gap (as a proxy for marginal costs) and ϵ_t is a cost-push shock. β is the discount factor and κ is the slope of the Phillips curve. Some aspects of digitalisation can affect the deep parameters that are behind the slope, others can be thought of as a persistent supply shock (productivity and cost-push shocks). This is illustrated in Chart A; for details, see Anderton et al (2021).

The green boxes in Chart A indicate the various components of the Phillips curve, square boxes refer to deep structural parameters and grey round boxes are shocks to the Phillips curve.

Chart A
Effects of digitalisation on inflation – stylised overview of important channels



Source: Authors' visualisation.

The effect of digitalisation on the slope of the Phillips curve, i.e. its sensitivity to aggregate demand pressures, is ambiguous. It may enhance firms' price flexibility or change production technology but it may also affect market power in an ambiguous way.

Amazon is a good example of how digitalisation may increase price flexibility and increase the slope of the Phillips curve. Amazon is both a seller of product varieties and the provider of digital market infrastructure for other sellers (the online marketplace). Access to the online marketplace increases

[62] See Work stream on digitalisation (2021).

price transparency for firms and consumers. For firms, it lowers information and menu costs to set or reset their optimal price. It also reduces firm entry costs as it becomes easier to create online stores and acquire customers. For consumers, the marketplace offers a wide variety of easily comparable products from many different firms. This reduces information frictions and increases the degree of substitutability across similar products, increasing competition by lowering barriers to entry. The enhancement of price flexibility enables firms to react more rapidly to shocks, steepening the Phillips curve.

At the same time, Amazon has an asymmetric position in this marketplace. In general, the market power of firms is asymmetrically affected by the digitalisation process. "Platform" firms like Amazon are able to collect fees from other firms and customers participating in their digital marketplace. Amazon can do so because it has full control of its ecosystem, which is extremely costly to replicate. This provides it with an informational edge over competing sellers, mitigating the pro-competition and transparency effects of the digital marketplace.

Besides market structure, production technology matters too. Relative to physical production, online firms may have less steeply declining returns to scale as they are able to scale up operations at near zero marginal costs. This change in production technology enables firms to provide large amounts of output at low additional costs, which will steepen the Phillips curve.

Digitalisation not only affects the slope of the Phillips curve, but might also be a source of persistent supply shocks. In fact, it could be characterised as a persistent technology shock, lowering the costs of production by increasing the efficiency of capital and labour. As such, digitalisation increases potential output of the economy, leading to a negative output gap due to nominal rigidities.

In fact, digitalisation may trigger a series of potentially offsetting price and wage markup shocks that shift the Phillips curve in an ambiguous way, with different models providing different theoretical predictions.[63] One important aspect is whether digitalisation increases or decreases market power. In some markets prone to higher concentration firms may exploit their market power, charge higher markups for their product variety and put upward pressure on inflation. However, in other markets increased competition among many firms in the digital marketplace, lowers firms' ability to charge sizeable markups over their marginal costs, which puts downward pressure on inflation. The effects on wages is ambiguous, see Nickel et al. (2020).[64] On the one hand, wages may rise due to higher wage premia for high skilled workers, job creation and better search and matching. On the other, digitalisation may lead to job destruction, offshoring, outsourcing and an on-demand economy of low-skilled workers, putting downward pressures on wages.

From a model-based perspective, long-term inflation expectations do not change in a more digitalised economy as they are determined by the monetary authority. However, in the short run inflation expectations may deviate from the central bank's inflation target if the central bank cannot fully offset these supply shocks. Box 8 shows that persistent shocks to headline inflation (irrespective of their source) may lead to a de-anchoring of inflation expectations as happened around 2015, for example.

[63] See Anderton and Cette (2021) for a discussion of alternative models.

[64] Nickel et al. (2020).

Box 6
Trade integration and price Phillips curves in euro area countries

This box examines the responsiveness of consumer price inflation to domestic conditions in euro area countries and whether this correlation is affected by trade openness and participation in global value chains. A standard representation of a hybrid new Keynesian Phillips curve is estimated in a panel of the 19 euro area economies, proxying marginal costs with economic slack and using quarterly data over 1999-2019. This exercise does not focus on identifying causal relationships but on uncovering (conditional) correlations; the estimate of the slope of the Phillips curve should hence not be interpreted in a structural sense. At the same time, as documented by McLeay and Tenreyro (2020) for the United States and by Eser et al. (2021) for the euro area, the fundamental identification problem inherent in time-series estimation of the Phillips curve is alleviated in a panel setting in a monetary union, where common time effects can capture the impact of common monetary policy in offsetting demand shocks.[65] During the sample period, most euro area countries exhibited rising levels of openness and were relatively more integrated in global production chains than other large economies like the United States, also on the back of increasingly interconnected production chains within the European Union and integration in a monetary union.[66] Estimations are carried out by regressing the quarter-on-quarter change of the HICP excluding energy and food on the unemployment gap, past inflation, and two lags of the import deflator.[67] The unemployment gap is interacted with measures of trade openness and integration in cross-border supply chains, to investigate whether these globalisation measures affect the slope of the Phillips curve.[68]

Trade integration may not only affect inflation levels but also change the price-setting behaviour of firms and thus the way inflation responds to domestic conditions, though its overall effect is a priori ambiguous. For example, rising exposure to global competition may limit the scope for firms to pass domestic costs on to consumers in order not to lose competitiveness or market share. However, greater integration and openness to trade can also affect market concentration and favour larger and more productive players which might be relatively more protective of markups. The findings of this box, while not making causal statements and largely leveraging on cross-country variation, support the argument that, overall, rising exposure to global competition may limit firms' scope for passing on their costs to consumers.

For the panel of euro area countries, a high dependence on export markets and high global value chain participation are associated with a lower correlation of inflation with the domestic business cycle (Chart A, left and middle panels). The estimated coefficients turn out significantly lower for observations with relatively higher global value chain participation and trade openness (Chart A, yellow bars). The coefficients displayed in Chart A are interpreted as identifying relative differences across euro area countries, rather than aggregate euro area results over time. From a cross-

65 McLeay and Tenreyro, (2020), and Eser et al. (2020).

66 See, for example, Gunnella et al. (2017).

67 The dependent variable is the annualised quarter-on-quarter growth rate of underlying inflation, while the import deflator is taken in year-on-year growth rates. Regressions also include a rich set of fixed effects accounting for a country's macroeconomic cycle and idiosyncratic shocks affecting all countries.

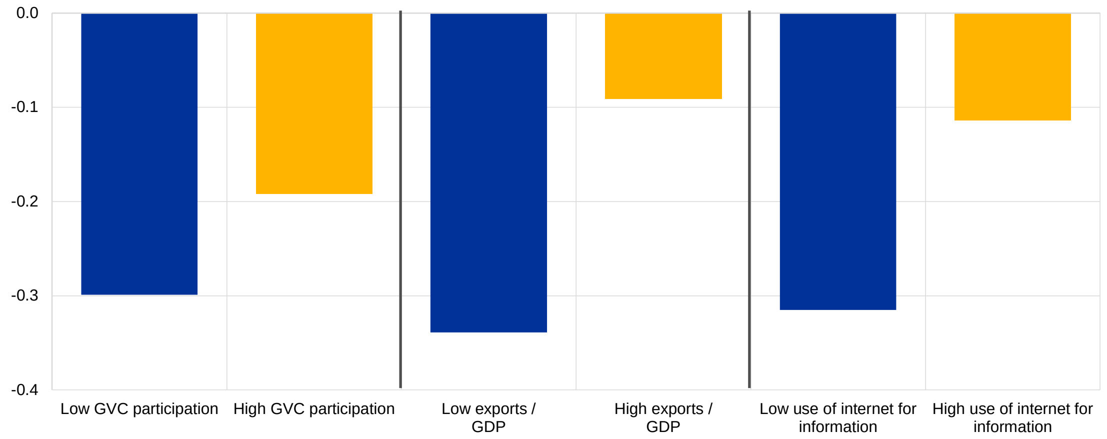
68 Trade openness is computed as gross exports of goods and services as a percentage of GDP. Global value chain (GVC) participation is measured as the share of GVC-related trade in total gross exports (Borin and Mancini, 2017), where GVC-related trade is defined as the sum of exported domestic value added that is re-exported by a direct importer (forward GVC trade) and foreign value added embedded in own exports (backward GVC trade). For a better interpretation of interaction terms, levels of GVC participation and openness are expressed as dummies equal to 1 if the underlying observation is higher than that of the panel long-term median. Underlying values are also taken in deviation from their long-term averages, in order to consider their relative importance from a historical perspective. Similar results for openness are obtained measuring trade as the average between exports and imports.

country perspective, trade integration channels thus appear to be relevant especially for the smaller euro area countries, which are generally more open and embed a larger share of foreign inputs in their exports.[69] However, the country-specific time variation in trade integration variables is smaller than the cross-country variation (which drives the estimated coefficients shown in Chart A).[70] Furthermore, as discussed above, a panel setting can at least partially account for common monetary policy via common time effects,[71] allowing us to uncover stronger correlations compared to univariate analyses. It is therefore likely that the contribution of trade integration in lowering the correlation between activity and prices for individual countries or the euro area aggregate is subject to high uncertainty and plausibly negligible, in line with results displayed in Box 2 and Box 4.[72] In other words, the panel result that trade integration dampens the correlation between slack and inflation reflects different levels of trade integration across countries, rather than a process that unfolded through time, and is thus coherent with the time-series result that, in the euro area, the slope of the Phillips curve has not changed substantially.

Chart A

Global factors affecting the slope of price Phillips curves in a panel of euro area countries

(estimated coefficients of the unemployment gap)



Sources: Eurostat, ECB, World Input-Output Database, and authors' calculations.
Notes: Results from a reduced-form estimation of a Phillips curve in a panel of 19 countries over 1999-2019, where the lagged unemployment gap is interacted with a dummy equal to 1 if the underlying value of GVC participation, exports of goods and services as a percentage of GDP, or the percentage of individuals finding information about goods and services online (in deviation from its long-term average) is higher than that of the panel long-term median. The dependent variable is the annualised quarter-on-quarter growth rate of underlying inflation. Other controls include lagged inflation, the two lags of the import deflator, as well as country-period and year fixed effects. Coefficients of interaction terms are statistically significant. GVC participation is computed as the share of GVC-related trade in total gross exports (Borin and Mancini, 2017), where GVC-related trade is defined as the sum of exported domestic value added that is re-exported by a direct importer (forward GVC trade) and foreign value added embedded in own exports (backward GVC trade). The sample for GVC participation ends in 2016, with values for 2015 and 2016 based on authors' estimates. Digitalisation data are broadly available from 2004.

Certain aspects of digitalisation that enhance global integration are also found to weaken the correlation between underlying inflation and domestic conditions in euro area countries. Adapting the previous analysis, similar results are obtained using measures of informational globalisation (e.g. the use of internet for e-commerce or for finding information about goods and services; Chart

69 The GVC participation of the euro area as an aggregate (i.e. excluding intra-euro area flows) is instead lower and comparable to that of the United States, which highlights the importance of regional supply chains (see for example ECB Working Group on Global Value Chains, 2019).

70 For example, in our sample the average cross-sectional standard deviation in GVC participation is about 2.4 times higher than the average within-country standard deviation.

71 While not all 19 countries in our sample have belonged to the euro area since 1999, the extent of the convergence process (e.g. participation in the ERM II) or the existence of currency boards with the euro could have mitigated policy divergences for countries before euro adoption.

72 This also resonates with the cross-sectional analysis in Bianchi and Civelli (2015) and confirms results obtained for central and eastern European (CEE) EU countries in Attinasi and Balatti (2021).

A, right panel). These variables capture technological developments fostering the cross-border flow of information or lowering entry costs into global markets that may affect business dynamism, competition, and price transparency.[73]

In the euro area, economic integration has a strong regional character as a significant share of trade is exchanged within the monetary union and euro area countries are on average more involved in regional than global production chains. This raises the question whether both intra- and extra-euro area trade are associated with a lower correlation of core inflation with slack. This may have implications for the overall relation between activity and inflation, since the retrenchment in global trade has recently been partly offset by an acceleration of regional integration within the euro area. By running the analysis above and differentiating trade flows, results provide some suggestive evidence that both higher intra- and extra-euro area trade openness are correlated with a lower sensitivity of inflation to activity.

By stabilising inflation over the business cycle, monetary policy could obscure a relationship between global integration and the correlation of consumer prices with domestic conditions. Limits to monetary policy space in the neighbourhood of the effective lower bound could hence have made globalisation forces relatively more binding in recent times. This cannot be explored by using only euro area countries with virtually the same monetary policy. The sample is therefore expanded to include the other eight non-euro area EU Member States[74], Japan, the United Kingdom, and the United States. The sample is then split into two halves according to the level of monetary policy-relevant rates (relative to their historical averages) in each country. Monetary policy space for a given country and a given year is defined as high if the respective policy rate is higher than that of the median across all countries, and otherwise low. Finally, price Phillips curves are estimated in the two subsamples of high and low policy space, including interaction terms of the unemployment gap with global integration measures. For this exercise, the euro area is considered in moving composition, and data on a country's previously relevant policy rates are used for the time before euro adoption, if the latter is after 1999.[75]

When accounting for different levels of policy space in the larger panel described above, relatively higher trade integration is associated with a lower estimated slope of the Phillips curve, for observations where the policy space was relatively more limited. Similar results are obtained when considering digitalisation variables, too (Chart B). In particular, when monetary policy space was relatively smaller (Chart B, blue bars), the estimated slope of the Phillips curves is lower than when policy space was relatively larger (Chart B, yellow bars). Moreover, when global integration variables were relatively lower (Chart B, light-orange bars) the estimated correlation between inflation and the business cycle was higher and closer to the correlation estimated when globalisation forces were stronger but there was more monetary policy space. Baseline results are slightly different than above given the different sample but are broadly confirmed, hence providing some confidence against sample bias. Furthermore, the main results obtained without splitting the sample (the orange bars in Chart B) are also broadly in line with those displayed in Chart A. Finally, while global integration could also be correlated with a compression of the natural rate (thus

73 See, for example, Anderton et al. (2020).

74 Bulgaria, Czech Republic, Denmark, Croatia, Hungary, Poland, Romania and Sweden.

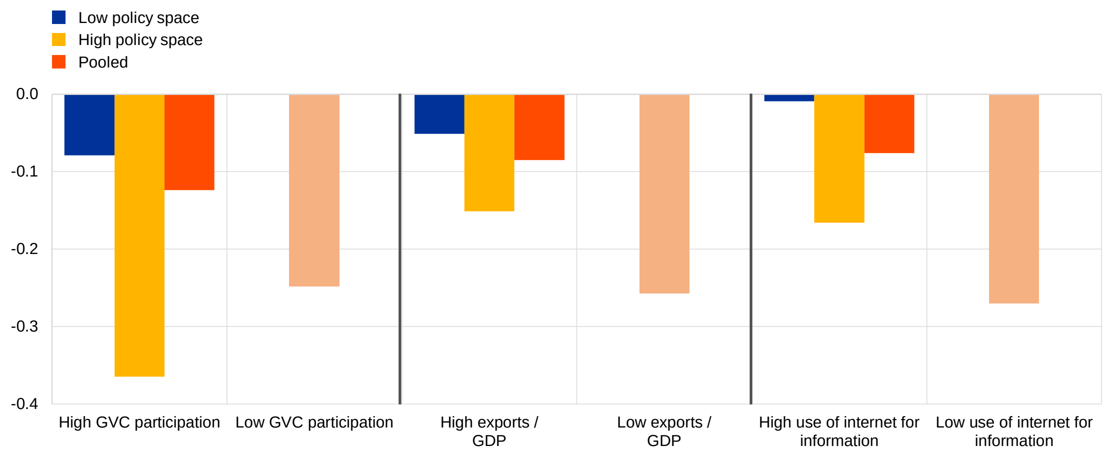
75 For the euro area, the main refinancing operations rate is used until September 2008 after which the deposit facility rate is used. For countries where a currency board with the euro was in place in the sample period, the relevant policy rate is assumed to be that of the euro area.

potentially biasing our estimates), evidence on the global fall of the natural rate tends to point more forcefully towards demographic trends as a key common driver.[76]

Chart B

The slope of the Phillips curves depending on policy space

(estimated coefficients of the unemployment gap)



Sources: Eurostat, ECB, World Input-Output Database, and authors' calculations.
Notes: Results from reduced-form estimations of a Phillips curve in a panel of 30 countries over 1999-2019, where the lagged unemployment gap is interacted with a dummy equal to 1 if the underlying value of GVC participation, exports of goods and services as a percentage of GDP, or the percentage of individuals finding information about goods and services online (in deviation from its long-term average) is higher than that of the panel long-term median. The dependent variable is the annualised quarter-on-quarter growth rate of underlying inflation. Other controls include lagged inflation, the two lags of the import deflator, as well as country-period and year fixed effects. Estimations for high (low) policy space are performed in the subsample of observations where monetary policy rates (in deviation from their long-term average) are higher (lower) than that of the median country in a given year. Coefficients of interaction terms are statistically significant except for the one for GVC participation, when policy space is high. GVC participation is computed as the share of GVC-related trade in total gross exports (Borin and Mancini, 2017), where GVC-related trade is defined as the sum of exported domestic value added that is re-exported by a direct importer (forward GVC trade) and foreign value added embedded in own exports (backward GVC trade). The sample for GVC participation ends in 2016, with values for 2015 and 2016 based on authors' estimates. Digitalisation data are broadly available from 2004.

A similar analysis at the sectoral level suggests that GVC integration channels are particularly relevant for manufacturing industries. The aggregate approach described above is complemented by the estimation of a sectoral Phillips curve panel where sectoral labour costs drive sectoral output price inflation.[77] By interacting sectoral labour costs with the change in GVC participation at the sectoral level, we find that the exposure to global competition lowers the correlation between sectoral wages and producer prices, and particularly so for manufacturing industries (relative to the rest of the business economy), which are the most integrated in GVCs, generally sell highly tradeable goods and are less local in nature. This increases strategic complementarities and the dependence of producer price inflation on global economic conditions. As GVCs are a sectoral phenomenon, the industrial composition of an economy is an important aspect in assessing how global factors may influence the responsiveness of inflation to the business cycle.

Overall, for a panel of euro area countries there is evidence that, all else being equal, global economic integration appears to have affected firms' price-setting behaviour, particularly when monetary policy space was relatively more limited. However, the small quantitative estimates imply that future structural transformations, such as new ways of organising production processes, would

76 See for example.

77 We regress growth of sectoral gross output deflator on growth of sectoral labour costs per worker, growth of sectoral deflator of import of intermediates and growth of sectoral mean labour productivity. Data are sourced from CompNet (7th Vintage dataset), where annual information is available for eleven euro area countries and 56 two-digit sectors (according to the NACE Rev. 2 classification) of the business economy, from 2005 to 2015.

have limited implications for the aggregate inflation of individual countries, even if they continue to shape price setting.

4 The role of supply shocks and inflation expectations in an effective lower bound environment

4.1 Model-based illustrations highlighting the role of the effective lower bound

As shown in Chapter 2, the empirical literature that allows for time variation in the slope of the Phillips curve does yield robust results. The thick modelling approach does not indicate statistically significant changes in its estimates of the slope of the Phillips curve. The same models shown in Chart 3 estimated with time-varying parameters yield a very flat slope parameter for the Phillips curve when using measures of output and a visible, but not statistically significant, decline when using measures based on unemployment.

In the absence of compelling evidence of a change in the slope of the price Phillips curve, two main hypotheses could explain the recent negative Phillips-curve residuals: (1) unexpected positive supply developments causing an underestimation of economic slack and (2) a de-anchoring of inflation expectations as a result of the low interest rate/low inflation environment. With respect to the first point, more favourable supply developments increasing potential growth could have led to greater slack than estimated in real time and more pronounced downward inflation pressures than projected.[78] Another explanation could be that longer-term inflation expectations have become less well-anchored and drifted downwards, leading price-setters to reduce their prices more often, or to a larger extent, or to increase them less often and to a smaller extent.[79] The response of longer-term inflation expectations to low realised inflation is more likely when private sector agents perceive an asymmetric central bank reaction function (limited willingness to respond) or when they think the central bank is running out of tools at the effective lower bound (limited ability to respond). In this case, price-setters come to terms with this perceived asymmetric reaction function of the central bank and their inflation expectations drift downwards with effects on their pricing behaviour.

Model-based simulations show that the combination of underestimating the amount of economic slack and a de-anchoring of longer-term inflation expectations can result in a persistent shortfall in inflation, especially when monetary policy is constrained by the ELB. The ECB's New Area-Wide Model (NAWM) is used to illustrate the two complementary hypotheses by carrying out

78 These favourable supply developments, especially in the labour market, are likely an outcome of labour market reforms after the global financial crisis. See, for example, Anderton and Di Lupidio (2019).

79 Inflation is mechanically determined by the frequency and size of price increases and decreases. The paper by authors of the PRISMA research network, Gautier et al. (2021), finds that over the past ten years the relative share of price increases in all price changes contributed the most to inflation variations in the euro area. Higher inflation was associated with more frequent price increases and less frequent price decreases but the size of price increases or decreases remained more or less the same.

counterfactual simulations around the baseline of the December 2013 BMPE (see Chart 11).[80] The first simulation shows that a larger negative output gap than the one incorporated in the BMPE baseline (by -0.5 percentage point at the start of the BMPE horizon) holds back the projected acceleration in inflation, whereas the momentum of GDP growth is stronger than projected, reflecting the more favourable supply-side developments included in the simulation.[81] The second simulation shows that a gradual downward shift in longer-term inflation expectations (by -0.4 percentage point, cumulatively, before the start of the BMPE horizon) perpetuates the period of persistently low inflation outcomes as (forward-looking) price and wage settlements are more muted based on the model's price and wage Phillips curves.[82] In this case, GDP growth is more sluggish than expected due to a deterioration in real financing conditions, which restrains private sector spending. The combined effect on annual inflation is about -0.2 percentage point, cumulated over the BMPE horizon, while the net effect on GDP is moderately positive. If monetary policy is constrained by the ELB on nominal interest rates, the combined effect on inflation is noticeably amplified by about one-third, while the upward and downward effects on GDP basically offset each another. When combined with a de-anchoring of long-term inflation expectations, more favourable supply conditions than assumed in the projections, which put additional downward pressure on inflation, can therefore help to explain the combination of substantial negative inflation forecast errors without substantial growth forecast errors.

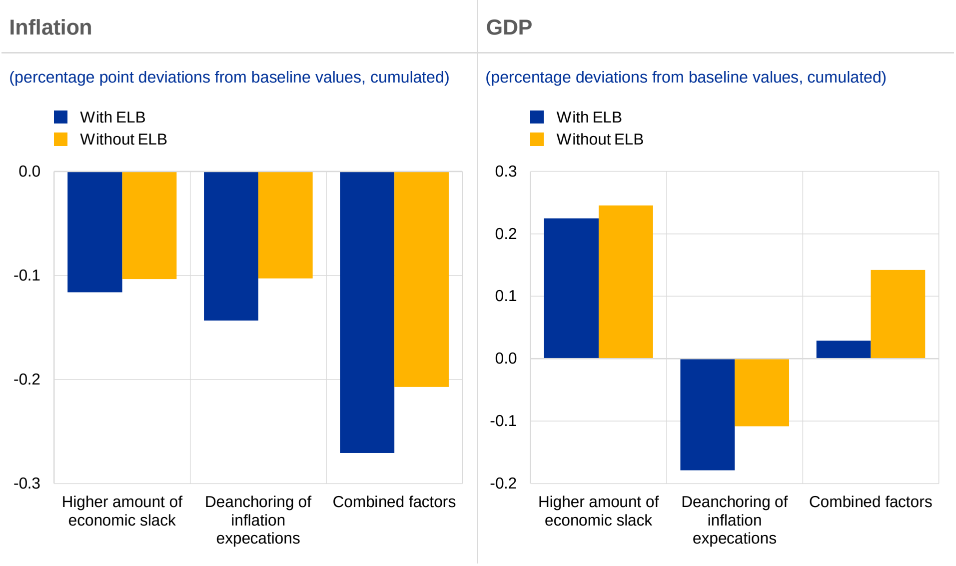
80 For a description of the NAWM, see Coenen et al. (2018).

81 Specifically, it is assumed that, at the beginning of the projection horizon, both private-sector agents and the central bank within the NAWM realise that potential output in the third quarter of 2013 is actually 0.5 percent above the figure incorporated in the projection baseline, which translates into a proportionate percentage-point downward revision of the output gap. This correction of the output gap is brought about by a sequence of upward revisions of potential by one-tenth of a percentage over a 5-quarter period before the start of the projection horizon.

82 The gradual downward shift in longer-term inflation expectations is implemented within the NAWM through an incremental decline in private-sector agents' perceptions of the central bank's inflation objective by one-tenth of a percentage in each of the four quarters before the start of the projection horizon. The perceived inflation objective provides the anchor for private-sector long-term inflation expectations. At the same time, it is assumed that the actual inflation objective of the central bank remains unchanged.

Chart 11

The consequences of underestimating economic slack and of a de-anchoring of longer-term expectations for inflation and GDP



Source: ECB staff calculations based on simulations with the New Area-Wide Model.
Notes: This chart reports the outcomes of counterfactual simulations of two potentially complementary hypotheses that can help explain the prolonged period of low inflation in the aftermath of the financial and sovereign debt crises and the recurrent negative inflation forecast errors made. The simulations are carried out around the baseline of the December 2013 Eurosystem projections, with and without taking into account an effective lower bound (ELB) on nominal interest rates.

4.2 Supply shocks and the hidden slack hypothesis

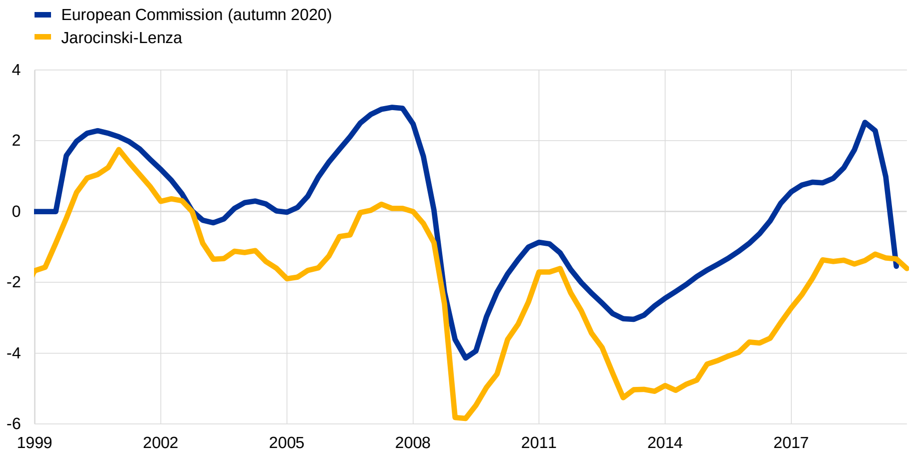
Is there evidence that "hidden" slack has contributed to lower-than-expected inflation in the euro area? Looking at the European Commission's estimates, potential output was indeed revised upwards retrospectively, but corresponding revisions in GDP growth implied a more optimistic output gap, especially since 2016 (not shown in the chart). The real time estimates of the output gap were actually not more optimistic than in autumn 2020. However, some models suggest a much higher degree of economic slack than standard measures.

Alternative model-based output gap estimates show much higher levels of economic slack during the low inflation period than conventional output gap estimates, for example. One of these measures is based on the model by Jarocinski and Lenza (2018), which is designed to minimise the inflation forecast error (see Chart 12).

Chart 12

Alternative output gap estimates

(percentage of potential output)



Sources: Eurostat, (B)MPE projections, Jarocinski-Lenza (2018) and ECB staff estimates.
Notes: The European Commission output gap is interpolated for quarterly frequency. The latest observations are for the fourth quarter of 2019 for the Jarocinski-Lenza output gap and autumn 2020 for the European Commission output gap.

The Jarocinski-Lenza measure for the level of economic slack has a good inflation forecasting performance for the low inflation period, potentially also based on capturing not only domestic slack but also global factors, going beyond the inclusion of external prices in other modelling approaches. Indeed, the information set used to extract the measure also includes euro area imports and exports. In this context one indication that the output gap may not have closed as early as 2017 is the increasing current account surplus of the euro area over this period.

Growth-stimulating positive supply shocks from the labour market are likely to have held inflation in the euro area down for some time after the sovereign debt crisis. One indication of this comes from the projection errors for wage growth and labour market quantities: wage growth turned out lower than expected until 2017, while employment growth surprises were positive. Such employment growth surprises could be related to demographic or social shifts, which also have an impact on the labour market, such as the increase in labour participation among older workers and women and increased migration.[83] Globalisation has also contributed to more integration and contestability in labour and product markets, likely reducing the bargaining power of workers and potentially hampering the ability and/or the willingness of firms to pass through costs to prices.

The wage Phillips curve no longer points to hidden labour market slack in the latter part of the low inflation period in the euro area, suggesting that the "missing inflation" in that period originated mainly from pricing behaviour in product markets. For the euro area, a thick modelling framework for wage growth analogous to the one employed for inflation points to a decrease of residuals in the period 2017 to 2018 (after a prolonged period of "missing" wage growth, as documented in Nickel et al. (2019)), suggesting in the latter part of the low inflation

[83] See Bodnár (2018).

period wage inflation has moved more in line with the predictions of the Philips curve based on traditional slack indicators.

Wage-price pass-through might be state-dependent and could have changed over the different phases of the low inflation period in the euro area. The impact of wage growth on price inflation depends on the source of the shocks driving the economy at each point in time: wage increases pass through to inflation faster and to a larger extent following a demand shock than a supply shock. This line of argument would suggest that while adverse demand shocks were dominating the behaviour of wages and HICPX – as would appear to be the case over the earlier part of the 2013-2019 period when slack largely accounted for both weak wage growth and weak HICPX inflation – inflation-specific supply shocks (e.g. negative markup shocks in product markets) could have broken that co-movement from around 2017 onwards. Furthermore, the pass-through from wage growth to inflation has been found to be weaker both in low inflation and low growth regimes (see Box 7 for a more detailed analysis).

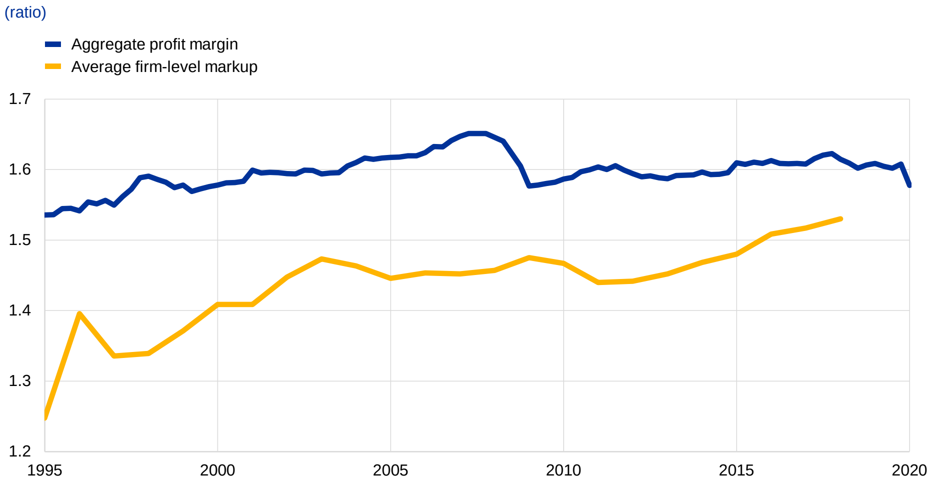
One piece of evidence corroborating the role of a missing pass-through from wages to prices in the latter part of the low inflation period lies in the compression of firms' profit margins. When wage and unit labour cost growth picked up strongly from mid-2017 onwards, firm's profit margins, which had already been lower than in the period before the crisis, were compressed further (see Chart 13). At least in an accounting sense, the reduced profit margins restrained the increase in domestic price pressures. Coupled with an estimated concomitant rise in markups,[84] this suggests that firms may have been reluctant to pass through cost increases into prices. One explanation could be the increasing share of firms with large market power. The mechanisms that might have led to an increase in market power are the subject of much debate, also in relation to structural forces like globalisation and digitalisation. For example, both have increased competition by expanding the range of available products and transparency in prices, but both have also created opportunities that are easier to exploit for larger firms that can bear the higher fixed costs of logistics or digital platform building. The net effect on market power is an empirical question.[85] As Box 7 suggests, a structural increase in markups can allow firms to price less cyclically, reducing the cyclicality of aggregate inflation and the pass-through of costs. Another possible reason why wage growth may have less of an impact on inflation could be the increased tradability of services, which has also been fostered by digitalisation: if services are more easily outsourced abroad, the contestability of labour market segments that were previously shielded from international competition increases, and the share of domestic labour costs decreases.

84 As documented in Kouvavas et al. (2021).

85 See Kouvavas et al. (2021) and Anderton and Cette (2021).

Chart 13

Markups and profits (total economy)



Sources Eurostat, ORBIS and authors' calculations.
Notes: Aggregate profit margin (at quarterly frequency) is computed as GDP deflator over unit labour cost, weighted by GDP over EA countries. Avg. firm-level markup (at annual frequency, preliminary) is computed from Orbis balance sheet data as estimated output elasticity of labour and materials multiplied by the ratio of sales to labour and material costs, weighted by sales across firms and by GDP over DE, FR, IT, ES, BE, LU, AT, PT and FI.

4.3 Have inflation expectations become less well-anchored?

The anchoring of inflation expectations plays a crucial role in any monetary policy strategy and in the conduct of monetary policy. This role results from the importance of inflation expectations for price and wage setting and hence inflation developments in an economy. As mentioned above, another reason for a shift in the Phillips curve may have been less well-anchored inflation expectations. The notion of inflation expectations (de-)anchoring is neither clear-cut nor easy to quantify. Interpretations of whether inflation expectations are anchored can differ depending on the approach used to define (de)anchoring as well as the measure used and the horizon that inflation expectations are considered over.

To analyse the impact that the credibility of and trust in the central bank has, a longer-term horizon for inflation expectations is considered (around five years and beyond). Within this time horizon the impact of temporary shocks, including, for example, energy prices, will have faded and inflation expectations should be largely anchored to the central bank's inflation aim.

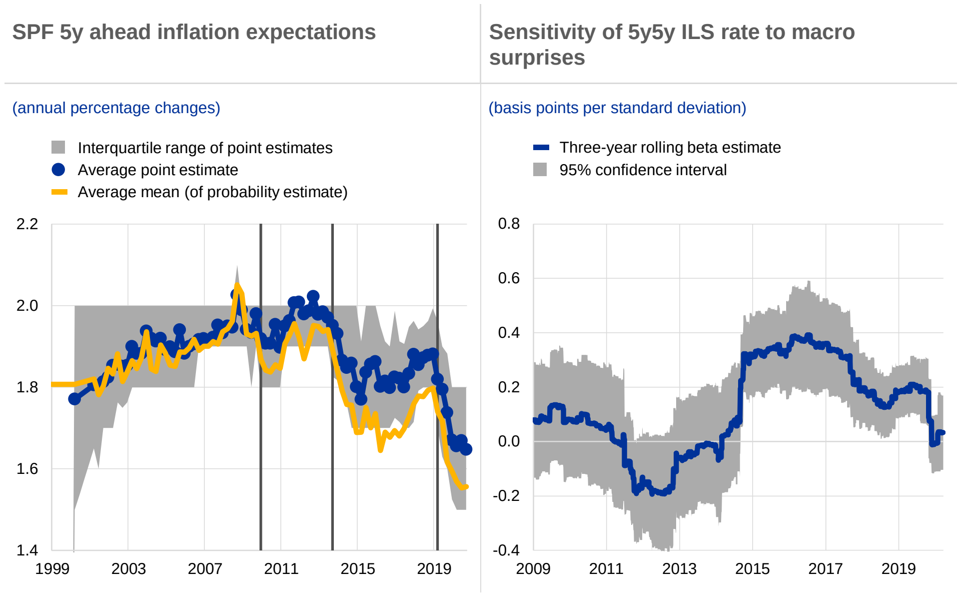
There is evidence that medium-term inflation expectations have become less well anchored to the ECB's inflation aim – contributing to the period of low inflation via their effects on wage and price setting. Survey-based and market-based measures corrected for inflation risk premia have fallen to slightly below the range that survey participants consider consistent with the ECB's definition of price stability (i.e. 1.7-1.9%)[86] since early 2019 from levels much closer to 2% before the

[86] See Box 4 in Work stream on inflation expectations (2021).

twin crisis (see Chart 14, left panel).[87] Moreover, the probability distribution has become more skewed to the downside. There is also some evidence that market-based measures of longer-term inflation compensation have become more responsive to actual inflation developments and macroeconomic news since 2013 (see Chart 14, right panel). Broadly speaking, there is increasing evidence from the data and support in the literature for the view that both survey and market-based longer-term inflation expectations have become less well-anchored.

Chart 14

Long-term inflation expectations



Sources: ECB SPF and Refinitiv.
Notes: LHS panel: The vertical lines denote break points detected by statistical time-series tests (Bai-Perron (2003)) applied to the SPF longer-term inflation expectations data originally by Dovern and Kenny (2020) and updated by A. Bessonovs (Bank of Latvia). These are: fourth-quarter 2009 break in uncertainty and balance of risks, third-quarter 2013 break in average mean of probability distribution and first-quarter 2019 break in average point estimate, in average mean of probability distribution and in uncertainty. The blue line shows the average of the reported individual point longer-term inflation expectations. The yellow line shows the average mean of the reported individual probability distributions. The grey shaded area shows the inter-quartile range of reported individual point longer-term expectations. RHS panel: The chart depicts the rolling beta estimates of the following model: $\Delta_{daily} ILS^{5y5y} = \alpha_t + \beta_t surprises + \varepsilon_t$.The size of the rolling window is three years. Surprises for each reporting period only include the first flash release of inflation, GDP and PMI for DE, FR, IT, ES and EA. Grey shaded areas denote when estimated pass-through coefficient was statistically significant.

Another important question is “whose expectations matter?”. Some hold the view that those of households and firms, which actually set prices and wages, are very important. However, data on consumers’ and firms’ inflation expectations are scarce. In fact, these expectations are central to the functioning of the economy and to the task of the central bank, and a better ability to gauge their anchoring would be very valuable. Unfortunately, available measures of households’ inflation expectations, also for individual euro area countries, are rather noisy and difficult to interpret in terms of level, pointing to an apparent upward bias relative to actual inflation but broad co-movement with inflation. The new ECB’s Consumer Expectations Survey (CES) has been developed with the aim of closing some of the euro area-wide data gaps going forward..

[87] See Corsello, Neri and Tagliabracci (2021).

Recent evidence suggests that central banks can make their policies more effective by influencing household expectations and more research is needed to better understand this process. One way central banks can anchor household inflation expectations is by investing in building greater public trust and institutional credibility. With respect to households, the new euro area consumer expectations survey will provide a further basis for understanding this process. However, more data are needed to study the process underlying firms' inflation expectations.

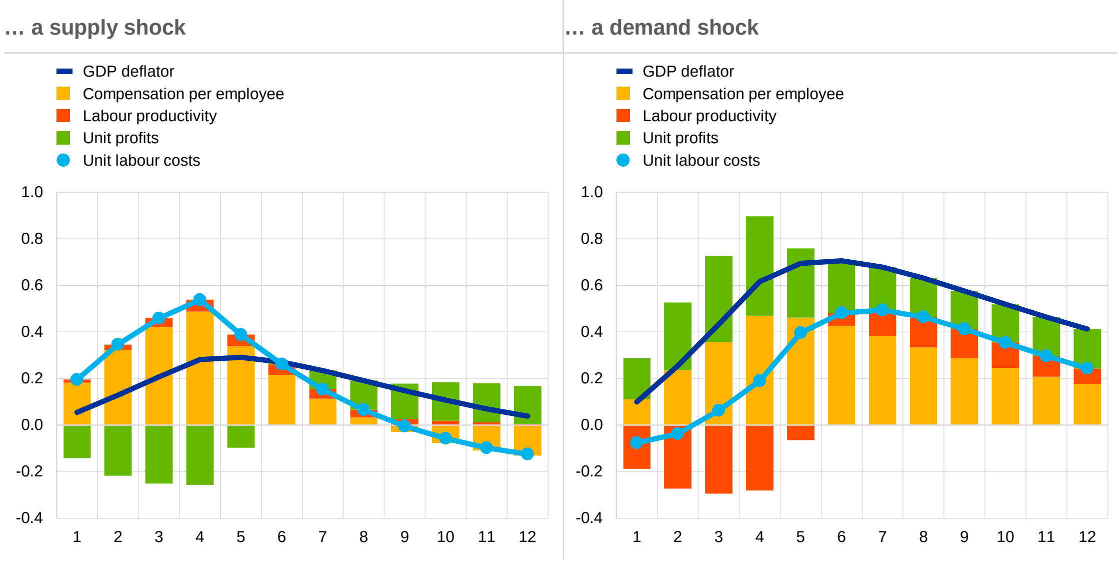
Box 7
Wage-price pass-through, profit margins and markups in the euro area

Labour cost developments are an important element in price setting, but empirically so far only a loose link between wage growth and consumer price inflation has been documented. While recent empirical evidence for the United States confirmed that the effect of wages on prices is weak to non-existent (see Peneva and Rudd, 2017), for the euro area recent research suggests that consumer price inflation consistently responds to wage growth. A set of features has been identified as being important for determining the pass-through from wage growth to consumer price inflation: not only the cyclical state of the economy, including the type of shock prevalent at each point in time, but also structural characteristics related, for instance, to the degree of market power. Against this backdrop, this box presents how these factors have shaped the pass-through from wage growth to inflation in the euro area based on recent macro evidence and on results using firm-level data.

The link between wage growth and inflation is stronger when demand shocks are more prevalent than supply shocks. From a theoretical perspective, the shock-dependent pass-through is grounded in new Keynesian models where the dynamic relationship between labour cost inflation and price inflation depends on the firms' optimal pricing response to wage increases. Gumiel and Hahn (2018) document this shock dependency for the link between wage growth and inflation within the New Area-Wide Model (Christoffel, Coenen and Warne, 2008). In response to an inflationary supply shock that increases wages (wage markup shock), firms only gradually pass on the cost increase to prices and profit margins fall (see Chart A, left panel). In response to an inflationary demand shock (domestic risk premium shock) which also increases wages, firms use the favourable demand conditions to pass on the cost increase over-proportionally so that profit margins increase (see Chart A, right panel). Hence, supply shocks lead to a dampened price adjustment, while in the case of demand shocks the price response is amplified by the profit margin response. Several studies explore the idea of shock dependency implied by theoretical structural models in more tractable smaller scale VAR models. In particular, the theoretical predictions are confirmed in empirical analyses based on VAR models both for the euro area (Hahn, 2019; Conti and Nobili, 2019) and the large euro area countries (Bobeica, Ciccarelli and Vansteenkiste, 2019).

Chart A

Stylised pass-through of a wage increase to the GDP deflator in the New Area-Wide Model following



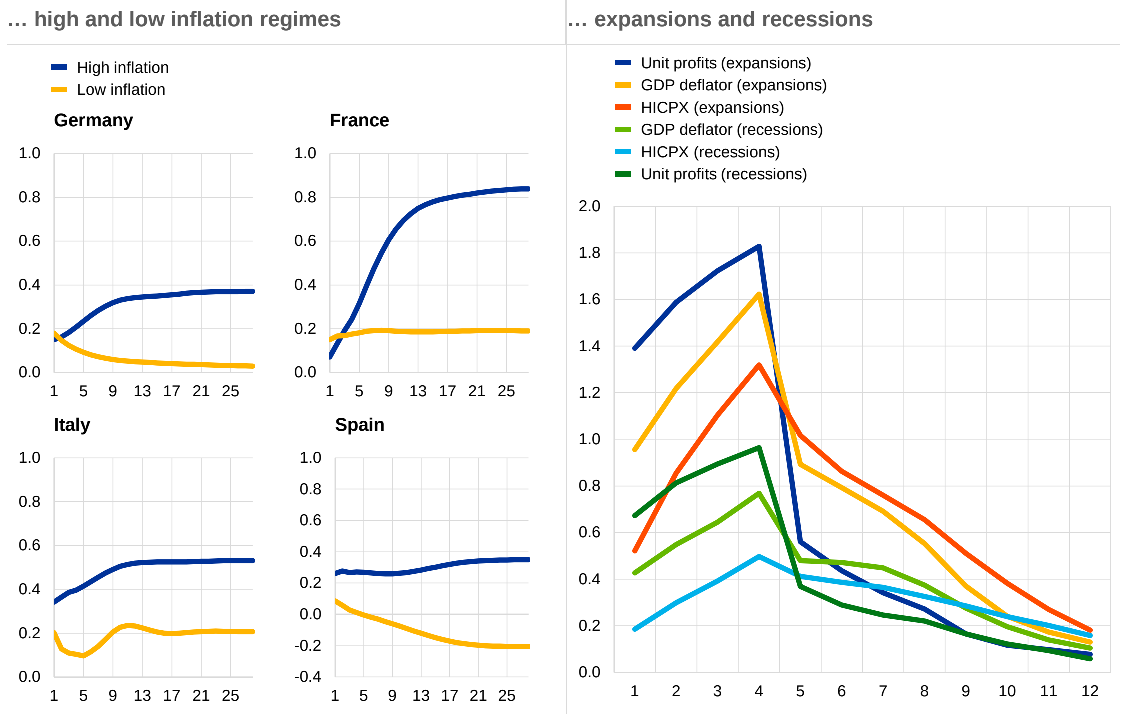
Source: Gumiel and Hahn (2018).
Notes: The x-axis indicates the quarters following the shock. The supply shock refers to a wage markup shock and the demand shock to a domestic risk premium shock in the New Area-Wide Model (Christoffel, Coenen and Warne, 2008). The magnitude of the shocks is normalised to a cumulated increase in compensation per employee of 1% over the first year following the shock. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP so that this component does not contribute to the changes in the GDP deflator.

The pass-through from wage growth to inflation has been found to be weaker both in low inflation and low growth regimes. In a low inflation environment, the persistence of low expected inflation can cause a weak pass-through (Taylor, 2000). This is confirmed empirically by Bobeica, Ciccarelli and Vansteenkiste (2019), who show that the wage-price pass-through in the biggest euro area countries depends on the inflation regime and is lower in a low inflation environment (see Chart B, left panel).[88] Hahn (2020) finds that the wage-price pass-through in the euro area also depends on the growth regime and in the case of demand shocks it is lower in recessions than in expansions on account of a lower relative response of profit margins (see Chart B, right panel). This does not apply to supply shocks.

88 These findings are corroborated by Boranova et al. (2019).

Chart B

Labour cost-price pass-through for



Source: Left panel: Bobeica, Ciccarelli and Vansteenkiste (2019); right panel: Hahn (2020).
Notes: Left panel: impulse response functions of inflation to a shock in unit labour cost inflation by means of a Choleski orthogonalisation with the variables ordered as follows: real GDP, unit labour costs, GDP deflator. Standardised multipliers are computed as the ratio of the cumulative responses of price and labour cost inflation over the considered horizons. Right panel: the x-axis indicates the quarters following the shock. Impulse responses refer to a demand shock. The magnitude of the shock is normalised to a cumulated increase in compensation per employee of 1% over the first year in both regimes. HICPX refers to the HICP excluding energy and food.

Apart from drivers at the business cycle frequency, several structural forces have likely shaped the strength of the link between wages and inflation. Such forces can be linked to globalisation, for instance (e.g. Basu, 2019), the rise of super-star firms (e.g. Autor et al., 2020), changes in business regulations, and to pricing power of firms (e.g. Boranova et al, 2019). For example, Bobeica, Ciccarelli and Vansteenkiste (2021) empirically document a declining pass-through from labour costs to prices in the United States and discuss the connection with structural changes related to a changing inflation environment (echoing a better anchoring of inflation expectations), increased trade integration (linked to globalisation) and increasing markups (linked to changes in market power).

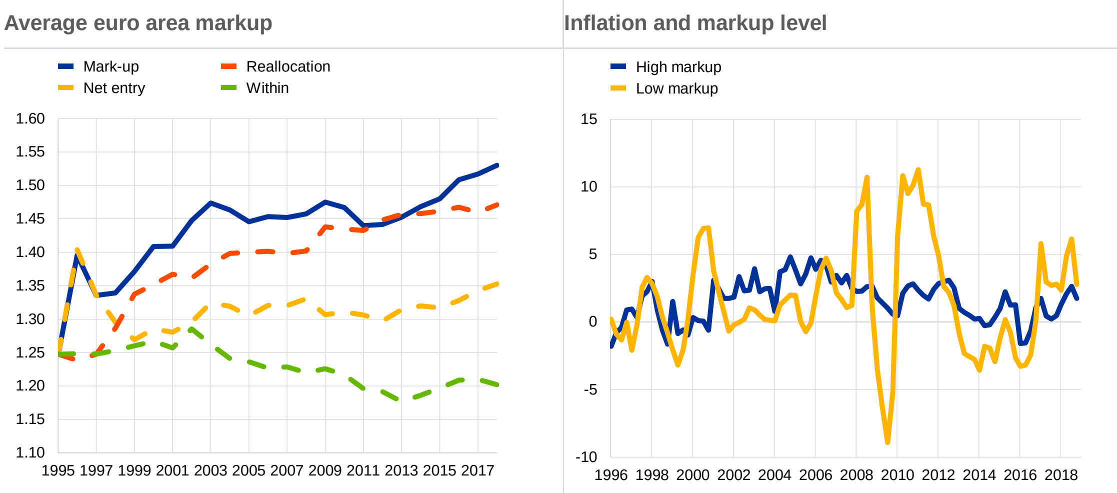
The global increase in market power is an important and widely discussed structural trend. For example, De Loecker and Eeckhout (2020) document that market power, proxied by average firm-level markups,[89] has increased globally over the last few decades. The increase in the euro area appears to be smaller than in the United States. Kouvavas, Osbat, Reinelt and Vansteenkiste (2021) find, based on firm-level markups estimated using the production function approach, that

[89] Markups are conceptually closely related to profit margins at the macro level: the markup is defined as price over marginal cost at the firm level, while the profit margin is the GDP deflator over unit labour cost at the aggregate level. The tightness of the relationship depends on how close marginal costs are to average (unit) costs, i.e., on the presence of fixed costs. Moreover, it depends on possible measurement differences across micro and macro data sources.

markups in the euro area increased by 28 percentage points between 1999 and 2018 (see Chart C, left panel).

Chart C

Average euro area markup (left panel) and inflation and markup level



Source: Kouvavas, Osbat, Vansteenkiste, Reinelt (2021).
Notes: Left panel: markups are estimated at the firm level as output elasticity of variable inputs divided by the revenue share of variable inputs. The euro area aggregate markup is measured by firm-level sales within countries and by GDP across countries. The dashed lines decompose the change in the aggregate markup following De Loecker, Eeckhout and Unger (2020). "Within" isolates changes in the trend due to firm markup changes with constant market shares. "Reallocation" captures changes in the aggregate markup that result from changes in firms' market shares, while keeping constant individual markups. Net entry is the residual component. Right panel: average inflation in manufacturing sectors, split by markup level. Low markup refers to the industries in the bottom 10% of the average markup distribution, high markup refers to the top 10%.

An increasing share of firms with large market power can lead to lower pass-through of labour costs to prices and, hence, less inflation volatility. Markups create a wedge between marginal costs and prices. Hence, larger market power allows firms to reduce the pass-through of costs to prices, as high markups can be used to buffer marginal cost changes, which firms with low markups would have to price in.[90] As such, a structural increase in their markups can allow firms to price less cyclically. Firms can optimally choose to do so for several reasons, such as (i) absorbing cost shocks into lower markups to preserve market shares and thus profits (Atkeson and Burstein, 2008), (ii) holding back price increases in order to keep the customer base (Chevalier and Scharfstein, 1996; Gourio and Rudanko, 2014) and (iii) strategic interactions between firms leading to stronger price rigidity (Mongey, 2019). Given the historical developments in the aggregate markups and the less cyclical pricing among high-markup firms, these structural changes could lead to decreased cyclicality of aggregate inflation and reduced pass-through of costs. Chart C (right panel) indicates that higher markups are associated with less cyclical inflation (Kouvavas, Osbat, Vansteenkiste and Reinelt, 2021): in industries where average firm-level markups are higher the producer price inflation index is more cyclical than in industries with low average markups.[91] Since increased average markup is driven by a reallocation of production to high-markup firms (see Chart C, right panel, red line), this structural shift could have contributed to decreased pass-through and less cyclical inflation.

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[90] There is a related literature that analyses the behaviour of constrained firms. There is conflicting evidence whether these firms tend to increase prices in a downturn to increase liquidity (Gilchrist, Schoenle, Sim and Zakrajsek, 2017) or tend to lower prices to sell off inventories to increase cash flows (Kim, 2020).

[91] Markups are measured at the firm level and then aggregated using sales and GDP weights. PPI data are matched on NACE categories.

Overall, the results indicate that the wage-price pass-through depends on the shocks prevalent at each point in time and on the state of the business cycle, as well as on the distribution of market power across firms.

Box 8
Inflation expectations and their role in interpreting low inflation

Inflation expectations are a key driver of actual inflation and are thus an essential part of the inflation generation process. They can influence actual inflation directly via price setting, but also indirectly via wage negotiations and consumption and investment decisions, given their impact on real interest rates. This box summarises the findings of the work of the Work stream on inflation expectations.[92]

The ECB's economic and monetary analysis has focused in practice on inflation expectations in surveys of professional forecasters and those implied by financial market prices. When using them for policy analysis it should be understood that the ECB's survey of professional forecasters provides figures for the expected level of inflation and the subjective probabilities surrounding it, while market-based inflation compensation measures are inferred from the prices that market participants pay in hedging against inflation (or deflation) risks. As such, these prices reflect not only the probabilities of different outcomes, but also a risk premium that investors are willing to pay to insure against the disutility associated with these outcomes.[93] Analysis of market-based measures of inflation expectations also needs to consider market distortions (or technical factors) that may blur their information content, particularly in times of stress. Differences between the levels of the two measures become considerably smaller when adjusting market-based inflation compensation measures for such risk premia. As the inflation risk premium has its own useful information content for policy analyses, policymakers need to look at both sources. Survey and market-based measures have also served as useful cross-checks on the Eurosystem's own inflation projections.

While it is households' and firms' inflation expectations that ultimately matter in the expectations channel of monetary policy transmission, data limitations and – at times – difficulties in interpreting such expectations have meant that in practice survey and market-based measures have been utilised as proxies. This approach is validated by some evidence that firms and trade unions input information from professional forecasters into their own expectation formation. However, the analysis of the role of expectations in monetary transmission would be greatly enhanced if it could rely more on data on households' and firms' expectations. This would make it possible to investigate how these agents form their expectations and would be a first step to investigating whether and how these expectations shape real economic decisions. It would also allow analysts to dig deeper into some of the puzzles inherent in available measures of household inflation expectations, such as the apparent upward bias compared with actual inflation. While this bias seems to be related to the fact that agents who are more uncertain typically report their inflation expectations using upwardly rounded figures, whether this inflation uncertainty affects actual decisions is a question

92 See Work stream on inflation expectations (2021).

93 Market-based measures of inflation expectations are therefore more accurately referred to as measures of "inflation compensation".

that still needs to be examined. Looking ahead, new survey data, particularly for households' expectations, should add to our understanding of their nature and formation.

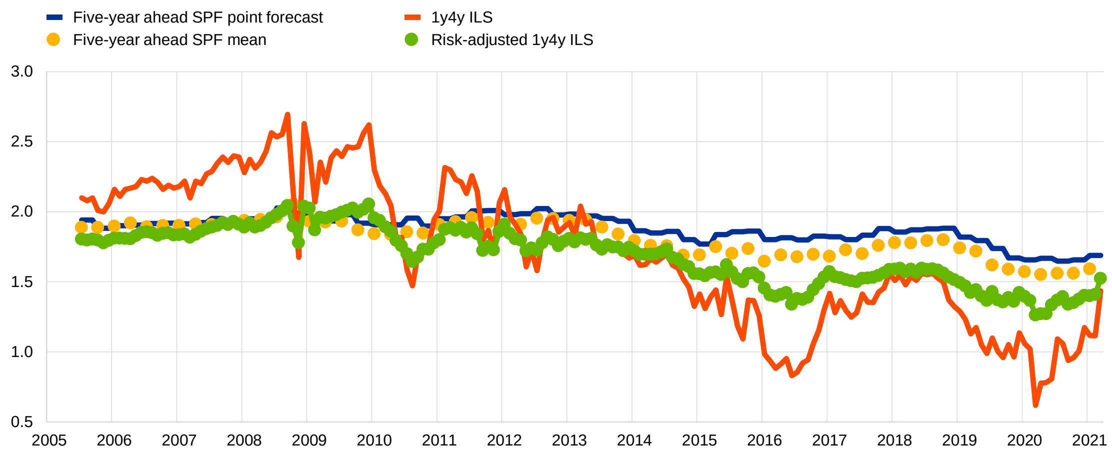
In the period since the global financial and European debt crises, longer-term inflation expectations in the euro area have moved down and there is some evidence that they have become less well-anchored. A key issue is the anchoring of longer-term inflation expectations and thus the question of which level inflation tends to gravitate to once the impact of shocks fades out. A further question is whether, should longer-term expectations become unanchored, they can be re-anchored as a response to monetary policy actions. Anchoring is a complex and multi-faceted concept and policymakers need to look at different metrics and assess possibly mixed signals at each point in time.

One potential metric for gauging (un-)anchoring is the level of inflation expectations itself. Chart A shows the evolution of survey (ECB SPF) and market-based indicators of euro area longer-term inflation expectations. Average longer-term SPF inflation expectations moved down in the period of low inflation and, starting in 2019, also moved to the bottom or slightly out of the 1.7-2.0% range that SPF respondents associate with price stability.[94] Formal break-point tests confirm this downward shift. This notion of less well-anchored expectations was even clearer for the levels of longer-term market-based measures – at least before adjusting for inflation risk premia. Raw market-based measures (for the same horizon as the SPF, namely the one-year ILS rate in four years' time) declined from a peak of 2.7% shortly before the global financial crisis to a low of 0.7% in March 2020 (at the onset of the Coronavirus pandemic) and have since recovered to around 1.5%. By contrast, the movement in "genuine" market-based inflation expectations (i.e. after adjusting for the estimated inflation risk premium) has been more limited over the same time span.

Chart A

Inflation expectations: survey- and market-based

(percentage)



Sources: Bloomberg, Refinitiv and Eurosystem staff calculations.
Notes: The risk adjustment is based on an affine term structure model and fitted to the euro area zero-coupon ILS curve. The estimation method follows Joslin et al. (2011). For details, see Camba-Mendez and Werner (2017).

94 When asked to quantify the ECB inflation aim in special questions in the third quarter of 2019 and the fourth quarter of 2020 rounds, the median responses implied an ECB price stability objective referring to a range of 1.7-2.0%. Nearly all respondents reported a range rather than a single point value, implying some difficulty in benchmarking against a specific value. The median lower end of the range was 1.7%, the median upper end was 2.0% and the median span of ranges (upper-lower) was 0.3 p.p. For further details see the fourth quarter of 2020 SPF Report.

Anchoring can also be assessed in terms of the responsiveness of longer-term inflation expectations to shorter-term developments. The relevant metrics point to positive, but only sporadically significant, relationships and some caution is required in their interpretation. For instance, while there is some evidence of a positive and statistically significant pass-through from short-term to longer-term ILS rates throughout the low inflation period, this might reflect a co-movement across horizons of premia. Other results using single equation models with stochastic volatility also show a positive, but only temporarily significant pass-through from short-term to longer-term SPF expectations during the global financial crisis and around the start of quantitative easing. The different timings highlight the problem that the responsiveness metric can in principle capture the effect of very persistent shocks, de-anchoring and/or re-anchoring. In practice, each metric has its strengths and weaknesses and they could also be interlinked if, for instance, responsiveness ceases once the level has adjusted.

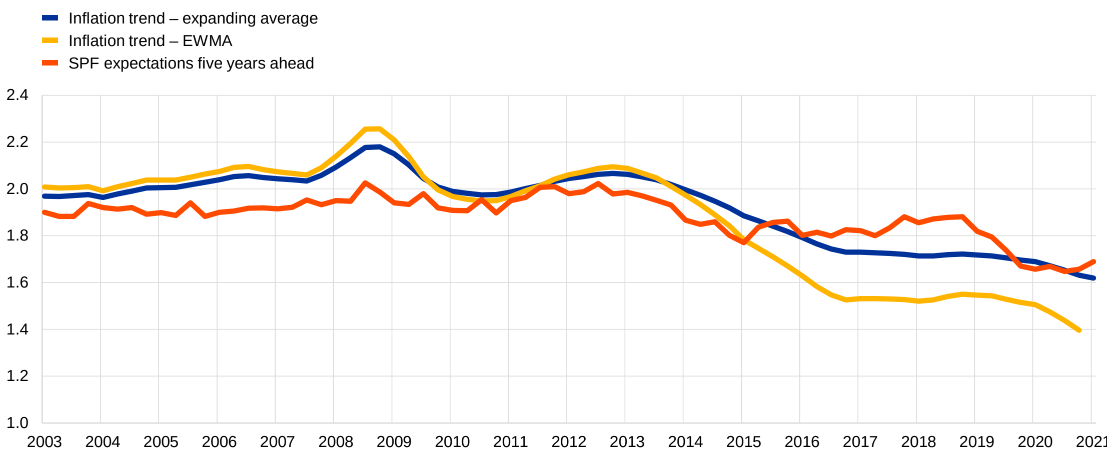
In recent years it appears that it takes longer after a shock for inflation expectations to reach their "steady-state" level. Modelling the term structure of the inflation expectations curve in Consensus Economics data up to ten years ahead suggests that in the period after the global financial crisis, the horizon at which shocks are expected to be fading out has lengthened at the same time as the data-implied steady-state inflation expectation has shifted downwards. It is not a priori clear what this duality implies for any overall assessment of de-anchoring.

There is also a fairly strong empirical association between longer-term inflation expectations and trends in actual inflation. This could be a sign that inflation trends are seen as a track record of central bank credibility in pursuing the inflation objective. This association broke in 2015 and it was only in 2019 that longer-term inflation expectations from the SPF started to fall to the by then already lower trend measures (see Chart B). This highlights the challenges of anchoring inflation expectations if inflation trends are persistently below target and suggests that re-anchoring efforts may have limited effectiveness if signs of successfully changing inflation trends do not become evident. This may be aggravated in view of model results suggesting that survey-based measures of longer-term expectations have been responsive to downward but not upward surprises in euro area inflation.

Chart B

SPF long-term euro area inflation expectations and measures of inflation trend

(percentage)



Sources: ECB SPF and Eurosystem calculations based on HICP.
Notes: The expanding average and the exponentially-weighted moving average (EWMA) are computed starting in 1999.

There is some evidence to suggest that monetary policy actions can lead to a re-anchoring of longer-term inflation expectations. Model-based analysis using market-based measures and distinguishing between a pure policy shock (e.g. an unexpected interest rate hike/cut) and an information shock (e.g. an unexpected change in the central bank's assessment of the macroeconomic outlook) suggest that pure policy shocks led to statistically significant increases in spot ILS rates across short- to medium-term maturities – but only in the period since the PSPP has been in place.

At the same time, there is also some evidence that central bank projections are an important information element in shaping private sector expectations. Regression analysis points to some residual influence of Eurosystem projections on subsequent Consensus Economics expectations, also after controlling for macroeconomic news emerging between the two forecasts (oil prices, inflation surprises and monetary policy measures). This implies that central bank projections are an important element in managing private sector expectations.

5 The outlook for structural forces after the pandemic

The global COVID-19 pandemic has brought about an acceleration of some of the aspects of digitalisation and (de)globalisation discussed Chapter 3. Beyond the cyclical conditions, the long-term impact will depend on how long the pandemic continues to affect social and work life. Some aspects have become well delineated, but what remains to be seen is if the emerging behaviours will remain in place for a long time or will be quickly reversed with a return to "normal" – i.e. patterns observed before the start of the pandemic. If uncertainty remains high, precautionary savings and demand for safe assets might increase, while their supply may be complicated by the increase in debt ratios across all advanced economies. These developments may put renewed downward pressure on the natural rate of interest.

In terms of digitalisation, the pandemic has accelerated the adoption of digital technologies that allow remote work – with potential effects on housing costs. If this persists it could also reduce the pressure of housing costs on inflation by allowing relocation to less urban areas. In turn this could trigger a second wave of globalisation based on de-localising services, if remote working spills over to the outsourcing of previously local white-collar jobs. Like the impact on housing costs, this would be disinflationary.

Post-pandemic manufacturing chains may be organised in a way that is more tolerant of higher costs, putting pressure on inflation. This could happen by means of partial re-shoring or a shortening of the length of supply chains. Even more importantly, it would involve changing the trade-off between efficiency and resilience, accepting higher cost structures in exchange for making the supply chain more robust to shocks.

Looking ahead, shocks related to climate change are likely to play an increasing role for the outlook for price stability through their impact on inflation and other macroeconomic indicators. The impact on inflation is not straightforward and is likely to be indirect. It will not only affect the level of inflation, but also its seasonality and volatility. Box 9 elaborates on the possible transmission channels of climate-related changes to inflation.

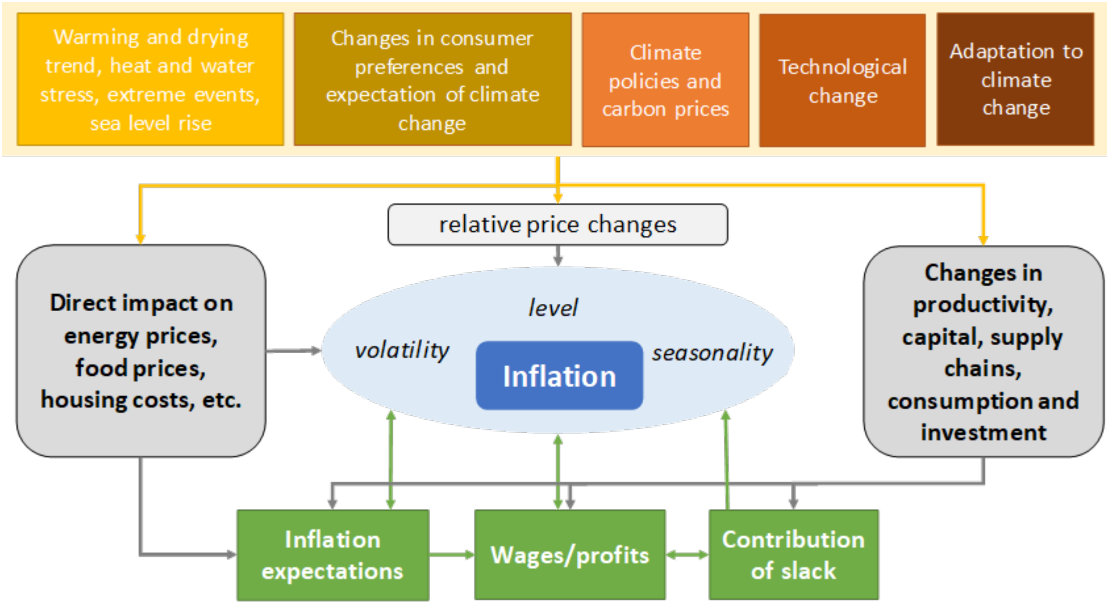
The determining factor is whether the effects of structural forces become embedded in longer-term inflation expectations and whether their contribution to long-term inflation will tend to differ between phases in which they act as anti- or pro-inflationary forces. The last decade has shown that shocks that push inflation below the central bank's aim are more difficult to neutralise than shocks that push it above it, because of the asymmetric policy space being constrained by the ELB.

Box 9
Considerations on the impact of climate change on inflation

Climate change can have an impact on the level and the volatility of inflation, but the impact on inflation cannot easily be quantified or projected owing to uncertainty about the identification, distribution and persistence of climate-related shocks (Coeuré, 2018). Given this uncertainty, a first step towards quantification is the clarification of the different drivers and mechanisms that tie climate change and inflation together. This box aims to take this first step by illustrating the climate-related drivers of inflation and their transmission channels.

Climate change can have an impact on inflation directly through physical changes in climate and climate policies, and indirectly through related macroeconomic impacts (see Chart A). Average global warming has exceeded 1°C and may reach 1.5°C within the next two decades (see Chart B, panel a; IPCC, 2021). Consequently, countries and their economies are increasingly exposed to climate change impacts, including more frequent and more extreme climate and weather events (see, for example, Chart B, panel b). This in turn has an impact on GDP growth, investment and consumption decisions as well as agricultural and labour productivity (see Chart B, panel c). Without ambitious emission reductions, global warming beyond 2°C is likely, with wide-ranging physical and economic consequences (see, for example, IPCC, 2021). However, complying with the Paris Agreement to limit global warming to well below 2°C through orderly, structural changes to the economy will also likely have implications for inflation given the extent of the necessary changes.[95]

Chart A
Impact of climate change on inflation – stylised overview of important channels

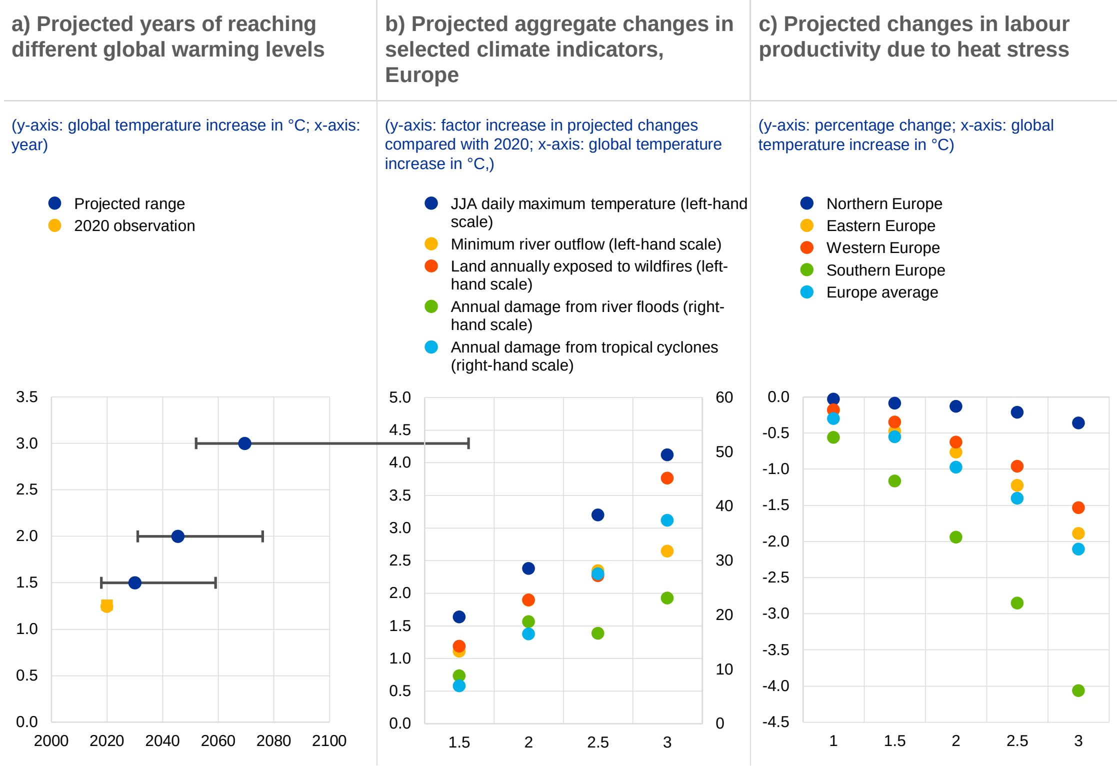


Sources: authors' visualisation.

[95] Annually necessary emission reductions beyond 2030 exceed reductions estimated for 2020, taking into account the impact of the COVID-19 pandemic (Elderson (2021)).

Chart B

Examples of climate-related drivers of inflation, and country heterogeneity of impacts



Sources: IPCC, NGFS Climate Analytics climate impact explorer (Climate Analytics, 2021), Copernicus Climate Change Services, ECB staff calculations.
Notes: Panel a): projected ranges include spread across different models and scenarios (IPCC, 2021, Table 4.5). 2020 observed ranges refer to estimates according to different datasets (Copernicus (2021)). All values are relative to the 1850-1900 average. Panel b): Factor increase in projected changes compared with 2020. European aggregate includes all European countries (area-weighted). All values are based on model projections and refer to median values across different model simulations, following the NGFS current policies scenario (NGFS, 2021). See Climate Analytics (2021) for an overview of limitations of the analysis and models. Panel c): percent changes compared with 1986-2006. Heat stress impact on labour productivity indicates "the percentage decrease in efficiency during regular working hours under hot and humid climate conditions, due to the reduced capacity of the human body to perform physical labour" (Climate Analytics, 2021). European average includes all European countries (GDP weighted). Northern, eastern, western and southern Europe include averages over euro area countries located in the respective regions. Regions are defined according to Climate Analytics. All values are based on model projections and refer to median values across different model simulations, following the NGFS current policies scenario (NGFS, 2021). See Climate Analytics (2021) for an overview of limitations of the analysis and models.

More frequent and intense extreme events may disrupt production, infrastructure and global supply chains (supply shock) and cause damage to household and corporate balance sheets, reducing consumption and investment (demand shock). These disruptions may be more temporary and local in case of single events[96], but could also lead to more permanent destruction of business activity in affected areas, or lead to more persistent, wider economic consequences in case of correlated or cascading events (e.g. Zscheischler et al., 2018; Raymond et al., 2020). A demand shock associated with high income losses or increased uncertainty can lead to downward price pressures. Price changes associated with supply-side effects may, in the first instance, change relative price developments, but depending on the extent of the event aggregate inflation can also be upwardly affected. Price pressures may also arise through the expectation of physical climate change impacts in specific regions. Empirical evidence suggests that impacts on prices are heterogeneous, depending on the type of extreme event and inflation sub-index. As opposed to upward price pressures on food, the impact on housing is reported to be negative (Parker, 2018), especially for

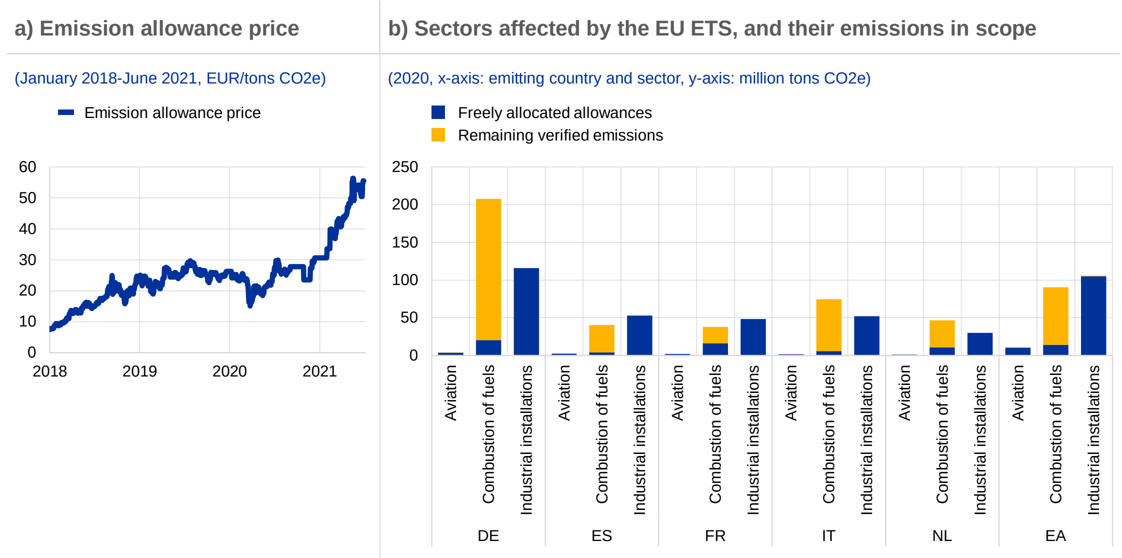
[96] For example, the hot and dry 2018 summer in Germany led to low river water levels, which is assumed to have created supply bottlenecks and resulting pressures on prices; see Coeuré (2018).

properties in areas affected by, or expected to be affected by, flood risk and rising sea levels (BCBS, 2021).

Fiscal measures to mitigate climate change tend to have a direct inflationary impact, especially in emission-intensive sectors such as energy, energy-intensive manufacturing or the automotive and transport industry. For example, a greater use of carbon taxes that are levied on the carbon content of fuels would be inflationary. The overall impact of such taxes on inflation will however depend crucially on the use of the additional revenue. If they are used to offset the loss in purchasing power by cutting other consumption taxes, such as electricity taxes or VAT, the overall effect would be low, whereas the use for additional government spending or cuts in direct taxes could even increase the effect on inflation.

Chart C

Emission allowance price and sectors affected by the EU Emissions Trading System (ETS)



Sources: Bloomberg, European Environment Agency, ECB staff calculations.
Notes: Panel a) shows the European Climate Exchange OTC. Panel b) illustrates which sectors on aggregate effectively bore the costs of increasing EUA prices: only "remaining verified emissions" need to be covered by purchased emissions allowances.

Within the EU ETS, inflationary pressure could result from increasing auction prices for allowances. Those allowances involve additional costs for producers, which have been shown to have a high pass-through to prices (e.g. Martin et al., 2016). Indeed, the price of emission allowances has increased drastically over recent months, from around €30 per ton of CO2e emitted in January 2021 to more than €50 per ton of CO2e emitted in June 2021 (see Chart C, panel a). Activities within the scope of the ETS include electricity and heat generation, energy-intensive industries[97] and domestic commercial aviation, but emissions by the latter two were largely covered by freely allocated allowances (see Chart C, panel b). With the beginning of "phase 4" of the EU ETS in 2021, the share of free allowances is set to decrease, with the exception of activities considered at high risk of relocating their production to non-EU countries ("carbon leakage", European Commission (2019)). Going forward, increasing allowance prices, together with a decreasing overall number of allowances and number of free allowances, could therefore have an impact on prices of

[97] Energy-intensive industries within the scope of the EU ETS include oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals (CO2), production of nitric, adipic and glyoxylic acids and glyoxal (N2O) and production of aluminium (PFCs) (European Commission (2021)).

energy, non-energy industrial goods and domestic aviation. Depending on the outcome of current discussions on revisions to the EU ETS, consumer prices related to heating and transport could also be affected more directly.[98]

Other key aspects include technological developments, and the way in which climate policies will affect costs of production and consumer habits and thus relative prices in the euro area and globally. Relative price adjustments between carbon-intensive and low-carbon goods and services are likely, particularly if changes in relative consumption demand do not immediately result in corresponding changes in relative supply. Generally, changes in relative prices are regarded as steering the allocation of resources and may therefore play a key role in structural changes in different sectors of the economy. Policies, technological changes, and changes in consumer behaviours can be deflationary, if they depress aggregate demand to a larger extent than they affect supply. For example, policies that promote environmentally friendly technologies could have a downward impact on inflation and even prices in these sectors. Technological developments such as improvements in the energy efficiency of renewable energies may also lower energy prices (Andersson et al., 2020).

Finally, climate change, or the expectation of climate change impacts, may have implications for the formation of inflation expectations. According to the NGFS (2020) inflation expectations might be de-anchored owing to climate change, for example due to higher volatility or more persistent shocks in headline inflation, or through more persistent changes in energy prices feeding into inflation expectations. This is not a far-fetched argument: past experience around 2015 showed that persistent shocks to headline inflation (irrespective of their source) may lead to a de-anchoring of inflation expectations (see Box 8).

98 See the European Commission's proposal for a review of the Emissions Trading System.

6 Conclusion

Understanding why inflation has been persistently low – and below the ECB's inflation aim – since 2013 requires a holistic assessment. Such an assessment needs to include the role of cyclical drivers (especially seen through the lens of the Phillips curve – see Chapter 2) and structural trends (like globalisation, digitalisation or demographic change – see Chapter 3). It should also cover the impact of positive supply shocks and look at how all these factors interact when monetary policy is at the lower effective bound (see Chapter 4). These factors are interlocking and no single one can explain the low inflation period on its own.

This paper finds that cyclical developments can account for a significant share of the fall in inflation – but mainly in the first part of the low inflation period. The global financial and sovereign debt crises caused a twin recession in the euro area in 2009 and 2012 and high levels of economic slack in the period from 2013 to 2017. Phillips curve analyses – linking developments in economic slack to inflation outcomes – find that these high levels of economic slack have put downward pressure on inflation and were the most important factor in the fall in inflation during the first part of the low inflation period. But this is only one part of the story of low inflation in the euro area. Inflation remained low also when conventional measures of economic slack suggested that the economy was growing faster than potential for a number of years, with slack appearing to have been completely absorbed by 2017/18 at the latest.

Although structural trends like globalisation, digitalisation and demographic change are likely to have had a dampening effect on inflation over the last decades, by themselves they can only contribute marginally to the low inflation period in the euro area analysed here. These secular trends have mostly been going on for decades – with little evidence of acceleration in recent years except in part for digitalisation and possibly also demographics. And for many years these structural factors did not prevent central banks from reaching their inflation targets. This suggests that, to the extent that these factors have indeed contributed to the recent period of low inflation, it must have happened through interaction with other factors (see also Work stream on globalisation (2021) and Work stream on digitalisation (2021)).

The underestimation of economic slack, as well as inflation expectations which are less well anchored to the ECB's inflation aim, might also help us to understand the recent period of low inflation in the euro area. While conventional measures of economic slack suggested that economic slack was completely absorbed in the latter part of the low inflation period, there might have been hidden slack, as conventional measures of potential output tend to track actual output too closely[99] and might therefore underestimate economic slack in the form of the gap between actual and potential output. Also, positive supply shocks from the labour market stimulating employment and GDP could have played an important role

[99] See, for example, Jarocinski and Lenza (2018).

in the underestimation of economic slack. A second important factor could be the pronounced fall in survey-based and market-based (corrected for inflation risk premia) measures of inflation expectations over the low inflation period from levels close to 2% before the twin crisis – reflecting that both survey and market-based longer-term inflation expectations have become less well-anchored (see Work stream on inflation expectations (2021)).

The evidence presented in this paper indicates that a combination of interconnected factors is required to explain persistently low inflation over 2013-2019. Cyclical drivers, notably the disinflationary impact of the 2009 and 2012 twin recessions, have interacted with ongoing structural trends (such as globalisation, digitalisation and demographic factors) in a context in which the effective lower bound means that disinflationary shocks cannot easily be offset by interest rate policy. The persistence of low inflation has also contributed to lower inflation expectations, which may have become less well anchored to the ECB's inflation aim. At the same time the amount of economic slack might have been underestimated. Model-based simulations confirm the view that underestimating the amount of economic slack and a de-anchoring of longer-term inflation expectations can result in a persistent shortfall in inflation, especially when monetary policy is constrained by the effective lower bound, and can therefore provide a decisive contribution to understanding why inflation has also remained low in the period 2017-2019.

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