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# Inflation in the euro area since the Global Financial Crisis

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Inflation in the euro area since the Global Financial Crisis

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# Inflation in the euro area since the Global Financial Crisis\*

By Dennis Bonam, Gabriele Galati, Irma Hindrayanto, Marco Hoeberichts, Anna Samarina and Irina Stanga

## Abstract

This study analyzes the behavior of inflation observed in the euro area over the past decade from a broad perspective. We first document changes in the inflation process, i.e. the dynamics of inflation and its response to shocks. We then discuss whether the Phillips curve is still a useful analytical paradigm. Next, we present evidence based on an Unobserved Components Model that the Phillips curve is “alive and well”, in the sense that estimates show a positive and significant relationship between slack in the economy and inflation. At the same time, there is evidence of a downward trend in inflation in a sample that covers the past decades (1985-2017). While this past trend can be associated with a decline over time in inflation expectations, other deeper factors may be also at work, including the ongoing globalization trend, the declining bargaining power of labor, technological progress and the rise of e-commerce, demographic changes and financial factors. The complex nature of these forces and their interaction underscores the uncertainty that characterizes the current macroeconomic environment, and future research is needed to analyze to what extent these forces are likely to persist. Finally, we discuss possible implications of our analysis for monetary policy.

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\* This paper provides an overview of work carried out by team members of a DNB workstream on inflation: Dennis Bonam, Irma Hindrayanto, Marco Hoeberichts, Mengheng Li, Floortje Merten, Anna Samarina, Irina Stanga and Gabriele Galati. We thank Christiaan Pattipeilohy, Peter van Els, Jakob de Haan, Jan Marc Berk, Sweder van Wijnbergen, William English, Andrew Harvey, Bart Hobijn, Ide Kearney, Kostas Mavromatis and Richhild Moessner for very useful comments and discussions.



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# 1 Introduction

In the wake of the Global Financial Crisis (GFC), inflation has remained low and relatively stable in most advanced economies, against the backdrop of the sharpest economic downturn since the Great Depression. Inflation expectations as measured by surveys or financial instruments, while exhibiting differences in volatility, have also remained low. As inflation rates kept undershooting their targets, central banks around the globe embarked on an unprecedented conventional and unconventional monetary easing. Until mid-2018, the ECB linked the duration of policy rates at the effective lower bound (ELB) and its non-standard measures to the euro area reaching “a sustained adjustment in the path of inflation which is consistent with our aim of achieving inflation rates below, but close to, 2% over the medium term”.

Over the past years, the global economy progressively recovered and headline inflation moved up, albeit to levels below its historical average. In advanced economies, consumer price inflation edged up to 2% in 2018, supported by domestic drivers – shrinking output gaps and tighter labor markets – and global drivers, most notably rising commodity prices (BIS, 2018; IMF, 2019). Many central banks saw a closing gap between actual and target inflation. In the euro area, the economy expanded for five consecutive years between 2013 and 2018. Since the end of the recession in mid-2013, euro area growth on average exceeded potential; the estimated output gap increased by almost 4 percentage points and reached positive territory. Growth was driven mainly by a strong expansion of domestic demand, which made it robust against increasing risks in the external environment. The medium-term inflation outlook improved. In parallel, headline inflation reached around 2% in June 2018. At the same time, core inflation remained stuck at levels around 1%.<sup>1</sup> In June 2018, the ECB stated that it had sufficient

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<sup>1</sup> The ECB defines core inflation – also termed underlying inflation – as the year on year percentage change in the euro area HICP special aggregate ‘all items excluding energy, food, alcohol and tobacco’. For a discussion of alternative measures of core inflation, see e.g. Ehrmann et al. (2018) and Ohlsson (2019).

confidence in inflation developments to announce the beginning of the phasing out of unconventional monetary policy. This announcement was the first step in the normalization of monetary policy in the euro area. In the following quarters, however, growth and inflation slowed, and in the course of 2019, the ECB first signaled that normalization would be delayed and then in September announced a new monetary stimulus package.

Looking back, the behavior of inflation over the past decade is puzzling in two respects. First, the strong decline in output and rise in unemployment during the Great Recession of 2008-2010 was not associated with a large drop in inflation. This phenomenon has been called the “missing disinflation puzzle”. Second, the broad recovery that took hold around 2013 in a context of still very accommodative monetary policy was not followed by a marked surge in inflation. This is known as the “missing inflation puzzle”.

In fact, professional forecasters at central banks and in the private sector have systematically failed to successfully predict the behavior of inflation for some time (de Haan et al., 2016). And while it is not unusual to observe forecast errors for inflation – particularly during periods of large swings in commodity prices as those observed in recent years – the large size and persistence of forecast errors and their clustering across countries since the crisis have been unusual.

The Phillips curve, which links inflation and slack in the macroeconomy, is an analytical framework that has been commonly used to address these issues, and lies at the heart of this Occasional Study. In recent years, there have been questions about whether the Phillips curve remains a valid framework for capturing inflation dynamics and informing monetary policy decisions.

In the words of Larry Summers (2017), a key question is whether the Phillips curve has been thrown off course temporarily, or whether the whole Phillips curve framework has broken down and we need a new paradigm.

The current debate is split along three different approaches to explore this question.<sup>2</sup> One view emphasizes measurement issues. According to this view, the properties of the Phillips curve have not changed once the amount of slack in the economy (and especially in labor markets) and inflation expectations are properly measured.

A second view focuses on the instability of the parameters of standard Phillips curve models over time. According to this view, inflation has come to be lower and more persistent, and recessions can generate disinflationary pressures which may be stronger than expected and more difficult for central banks to counter (Blanchard, 2016). This implies that both the extent to which and the timing with which changes in slack translate into changes in inflation may differ from the past. It also implies that the estimation of Phillips curve models could be usefully enhanced to account properly for long-term trends influencing the link between slack and inflation.

A third view highlights problems with the model specification of the Phillips curve. Taken to the limit, this view questions the usefulness for policy makers of traditional specifications of macroeconomic models such as the Phillips curve, arguing that they systematically do not work in practice and hence should be disregarded by central banks (Borio, 2018; Farmer and Nicolò, 2017; Summers, 2017; Tarullo, 2017).

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<sup>2</sup> Gordon (2018) and Mankiw and Reis (2018) overview this debate from a historical perspective.

In this study we show how these three problems – measurement issues, parameter instability and model specification – can be dealt with within a consistent framework based on an Unobserved Components Model (UCM). Research by Hindrayanto et al. (2019) that follows this approach shows that the Phillips curve is “alive and well” in the euro area, in the sense that estimates of its slope are positive and significant for euro area countries, falling within a 0.5-0.7 range. At the same time, this research highlights the presence of a downward trend in inflation in a sample that covers the past decades (1985-2017). The authors associate this past trend with a decline over time in inflation expectations. However, other deeper factors may also be at work and explain the downward trend in inflation. These include the ongoing globalization trend, the declining bargaining power of labor, technological progress and the rise of e-commerce, demographic changes and financial factors. The complex nature of these forces and their interaction underscores the uncertainty that characterizes the current macroeconomic environment, and future research is needed to analyze to what extent these forces are likely to persist.

Our analysis highlights several challenges for monetary authorities: the persistently low core inflation during a phase of robust real growth; the great uncertainty about the inflation process; the role of factors outside the direct control of central banks. From a policy perspective, these challenges point to two key questions. First, is there a risk that persistent deviations of inflation from target in spite of a massive monetary easing weaken monetary authorities' credibility and the effectiveness of monetary policy? In the case of the euro area, answering this question requires assessing whether long-term inflation expectations have remained anchored to the ECB's inflation aim. Overall, the jury is still out on this issue. Based on data up to September 2018, Hartmann and Smets (2018) conclude that the behavior of the mean or median of long-term inflation expectations shows

that expectations have remained broadly anchored. At the same time, they also point to the higher uncertainty and negative skew of inflation expectations since the GFC, indicating that market participants' view the risk of low inflation as having increased. Moreover, market-based measures of long-term inflation expectations declined markedly in the first half of 2019, prompting concerns that the anchoring of expectations has weakened. There is broad consensus among policymakers that inflation expectations need to be monitored carefully, and their measurement, dynamics and drivers need to be better understood.

And second, is there a need to adapt the current monetary strategy – the framework within which decisions on the appropriate monetary policy actions are taken to ensure the successful conduct of monetary policy – to address the above challenges?<sup>3</sup> In the policy debate and the research literature, alternative views on this question have emerged.<sup>4</sup> Much of this discussion has focused on the Federal Reserve, where a formal review of the monetary framework is underway.<sup>5</sup> Proposed modifications to the current monetary strategies include raising the inflation target (e.g. Blanchard et al., 2010; Ball, 2014), introducing average inflation targeting (e.g. Svensson, 1999) or temporary price level targeting (Bernanke, 2017, 2019). A different view emphasizes that disinflationary pressures resulting from forces such as globalization or technology reflect favorable supply side developments rather than unfavorable demand shocks (Borio, 2018). According to this view, the monetary strategy should be made more flexible by lengthening the horizon over which it would be desirable to bring inflation back towards target and/or by widening the band of tolerance of inflation around target.

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<sup>3</sup> A brief overview of monetary strategies of major central banks can be found in Board of Governors of the Federal Reserve System (2018).

<sup>4</sup> For a succinct overview of these views, see e.g. Williams (2018).

<sup>5</sup> Clarida (2019a,b) discusses the ongoing FOMC's review of its monetary policy strategy, tools, and communications.

This greater flexibility could also provide additional room for maneuver to address the potentially disruptive effects on the macroeconomy of financial boom- bust cycles.

The remainder of this Occasional Study is structured into four parts. Section 2 documents changes in the statistical properties of inflation in the euro area. Section 3 discusses how the Phillips curve provides an analytical framework to understand these observed stylized facts. In particular, we show how estimates of an UCM of the Phillips curve suggest that it is "alive and well", and at the same time reveal a downward trend in inflation. Section 4 then draws on the existing literature to review potential explanations of this trend. In particular, we discuss deeper factors such as globalization, changes in the structure of goods and labor markets, technological progress, demographic changes and financial factors. Section 5 discusses possible implications of our analysis for monetary policy.

## 2 Stylized facts on the evolving inflation process

We start our analysis by documenting stylized facts on the evolution of the inflation process, which captures the dynamics of inflation and its response to shocks. While we focus on possible changes since the Global Financial Crisis, we note that the issue of the changing inflation process is not new.<sup>6</sup> It has been discussed in depth in the context of the so-called Great Moderation, the period between the mid-1980s and the mid-2000s when inflation across the globe declined, and became less persistent and less volatile.<sup>7</sup> The consensus is that these patterns were driven by a combination of good luck (a lower volatility of the shocks), structural changes in the economy (resulting from globalization and technical innovation), and more successful monetary policy in anchoring inflation expectations (e.g. through the adoption of inflation targets). There is no consensus however on the relative importance of these drivers.

In this section we first provide some simple graphical information on headline inflation in the euro area and its trend. We then put the recent period of low and very briefly negative inflation into a historical context, and emphasize the difference between low inflation and deflation. Next, we document changes in the statistical properties of inflation by focusing on two main questions. Has the inflation process become more persistent over time, in the sense that the effects of transitory shocks to inflation have come to fade away more slowly? And has low (and negative) inflation been a broad phenomenon, in the sense that it has been visible across the sectoral distribution of price changes?

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<sup>6</sup> King (2013) makes this point in an insightful way.

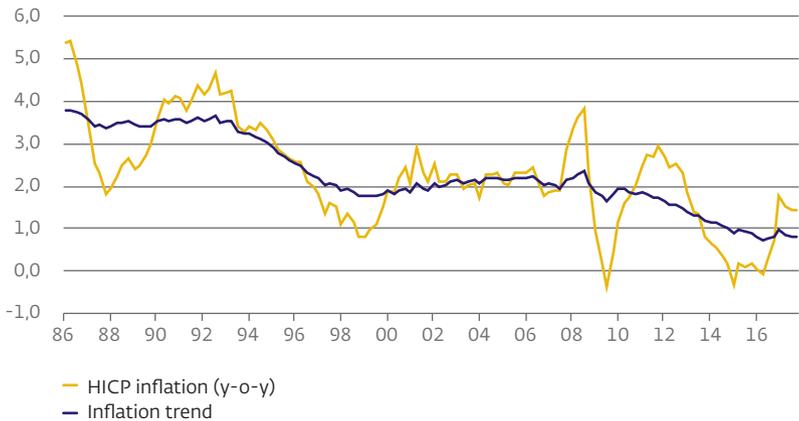
<sup>7</sup> See e.g. Stock and Watson (2003), Bernanke (2004) and Cecchetti et al. (2007). For an overview of work carried out by central banks on facts and drivers of inflation during the Great Moderation, see Amato et al. (2005).

## 2.1 Inflation, disinflation and deflation

Figure 1 reports euro area headline inflation together with its long-term trend, estimated from a UCM of the Phillips curve. It highlights several important facts. First, during the period of the Great Recession in 2009-10, euro area HICP fell sharply but quickly rebounded. As will be explained in more detail in the next section, the absence of a protracted decline in inflation during this period has been characterized as the “missing disinflation puzzle”.

**Figure 1 Euro area HICP inflation and its trend**

Percent



Notes: The trend is estimated by a UCM of HICP inflation and the unemployment rate for the euro area. For details, see Section 3.5.

Second, during much of the period since 2013 when the euro area economy rebounded, headline inflation fell visibly short of 2%, a phenomenon that – as discussed in the next section – is known as the “missing inflation puzzle”.

A third important fact highlighted by Figure 1 is that inflation has been broadly trending down since the 1990s. This fact will be discussed in detail in Section 3, in the context of the analysis of the Phillips Curve through the lens of an UCM.

Finally, on three occasions (in 2009, 2015 and 2016), the euro area experienced brief periods of negative headline inflation. A number of advanced economies – most notably the United States and the United Kingdom – went through similar episodes of negative inflation. Against this background, in the mid-2010s, central banks expressed concerns about deflation risks, and in some cases motivated exceptional monetary policy measures by these concerns, particularly in the presence of high levels of debt (e.g. Draghi, 2014).

It is important to stress the distinction between on the one hand these episodes of low and temporarily negative inflation, and on the other hand episodes of severe, persistent deflation and debt-deflation spirals, i.e. episodes when deflation interacts with debt. The notion of debt-deflation goes back to Fisher (1933), who highlighted how a fall in prices causes the real debt burden of borrowers to increase, which in turn leads to a reduction in spending and possibly defaults.

**Table 1 Goods and services price deflations from a historical perspective**

	Full sample	Classical gold standard (1870-1913)	Interwar period (1920-38)	Great Depression (1930-33)	Postwar period (1947-2013)
Number of years					
Inflation	3024	368	282	16	2374
Deflation	663	294	240	99	129
All deflations					
Average duration (years)	2.2	2.1	2.9	3.0	1.5
Average rate (%)	-3.9	-3.8	-5.0	-5.4	-1.9
Persistent deflations					
Number	66	33	29	26	4
Average duration (years)	7.4	6.8	8.5	3.3	4.7
Average rate (%)	-3.0	-2.5	-4.0	-5.1	-0.6
Countries in sample	38	20	32	32	38

Source: Borio et al. (2015).

Notes: The sample covers annual data for 38 economies (AR, AU, AT, BE, BR, CA, CL, CN, CO, DK, FI, FR, DE, GR, HK SAR, IE, IT, JP, KR, MY, MX, NL, NZ, NO, PE, PH, PT, SG, SA, ES, SE, CH, TH, TK, UK, US, UR and VE) over the period 1870-2013. Persistent deflations are identified as periods following price peaks associated with a turning point in the five-year moving average and peak levels exceeding price index levels in the preceding and subsequent five years. Troughs are identified as lowest price index readings after the peak.

An important conclusion of the literature is that the historical record confines episodes of severe deflation to the Great Depression in the 1930s. A recent event analysis based on deflation episodes that took place over the past 140 years in 38 economies highlights that the bulk of persistent deflations took place before

WWII (Borio et al., 2015).<sup>8</sup> Only four persistent deflations have happened since – in Japan, China and Hong Kong (Table 1). And in the most important case of persistent deflation in the postwar era – Japan since 1998 – deflation was mild although very persistent, lasting for more than a decade.<sup>9</sup> Moreover, in the transitory deflations that have occurred in the postwar era, the intensity (in terms of the size of the price drop) and the duration were much smaller than in the prewar era.

## 2.2 Changes in inflation persistence

Has the inflation process become more persistent over time, in the sense that the effects of transitory shocks to inflation fade away more slowly? We address this question with an empirical analysis on a sample period spanning the period of the Great Moderation – during which inflation has been found to have become less persistent – as well as the post-GFC years.<sup>10</sup> We follow two types of univariate time-series methods to gauge possible changes in inflation persistence. The first estimates rolling autoregressive (AR) models for inflation, in line with the literature that has provided evidence of some increase in inflation persistence in the euro area (Ciccarelli and Osbat, 2017). This AR-approach decomposes inflation dynamics into two parts. The autoregressive part captures the dependence of inflation on past realizations, and thereby provides a measure of inflation persistence. A highly persistent inflation process, with inflation depending strongly on its own past, implies that the transition process after a shock to inflation will take more time. The other part in the decomposition represents the shocks that affect the inflation rate.

<sup>8</sup> Borio et al. (2015) define a deflation in the prices of goods and services as a self-sustaining fall in the corresponding price index. Persistent deflations are those for which the price level declines cumulatively over at least a five-year period, based on annual consumer price data.

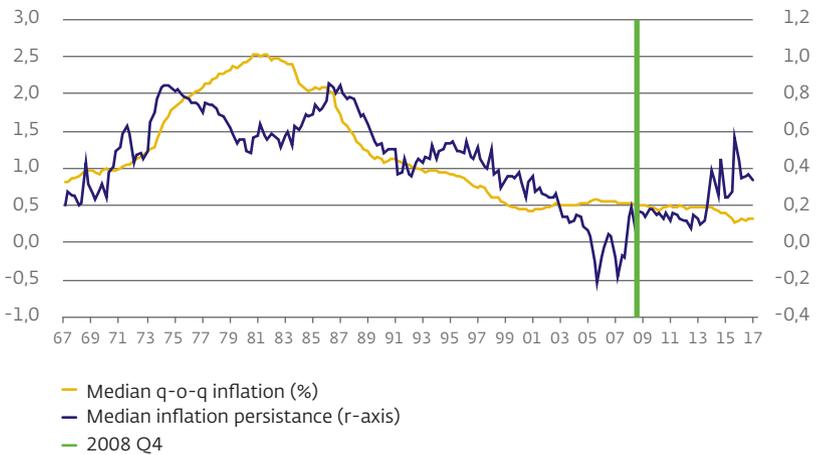
<sup>9</sup> Similar results are presented in Bordo and Filardo (2005), Borio and Filardo (2004) and ECB (2014).

<sup>10</sup> For a discussion of inflation persistence during the Great Moderation, see e.g. Bernanke (2004), Stock and Watson (2003) and Cogley et al. (2010).

We estimate this AR model over a 30-quarter moving window for seasonally adjusted, quarter-on-quarter headline inflation for each of 11 advanced economies over the period 1960 to 2017.<sup>11</sup>

**Figure 2 Euro area HICP inflation and its persistence**

Percent



Notes: Inflation persistence is estimated from a time-varying autoregressive model over a 30-quarter moving window for seasonally adjusted, quarter-on-quarter euro area headline inflation. The graph shows HICP inflation (in percent) together with the inflation persistence parameter. The vertical bar shows the start of the GFC.

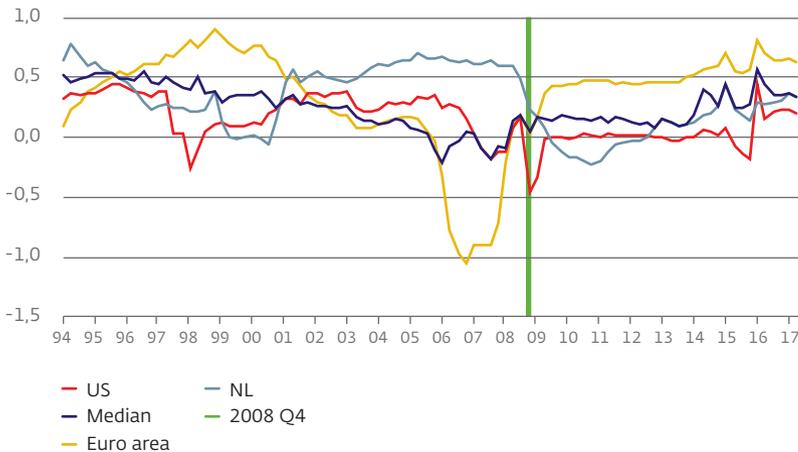
The main result of this analysis is that since the GFC, inflation has been more persistent compared to the final years of the Great Moderation. After having declined gradually between the mid-1980s and the early 2000s, inflation persistence is now back to its long-term average (see Figure 2).

<sup>11</sup> The 11 countries are Austria, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, UK and US.

There is however an important difference between the post-GFC years and the period spanning the 1970s and early 1980s. In the 1970s-80s, high inflation persistence was associated with high levels of inflation. By contrast, in the post-GFC period, inflation persistence has been high at low levels of inflation. This is consistent with recent research showing increasing inflation persistence together with a moderation in inflation levels since the GFC across a set of advanced and emerging market economies (Upper, 2018; Arslan et al., 2018).

### Figure 3 Inflation persistence across countries

Sum of AR-parameters



Notes: Inflation persistence is estimated from a time-varying autoregressive model over a 30-quarter moving window for seasonally adjusted, quarter-on-quarter headline inflation for 11 advanced economies (Austria, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, UK and US) over the period 1960-2017. The graph shows the median of the inflation persistence parameter estimated for all the countries in the data set, together with the inflation persistence parameter estimated for the United States, the euro area and the Netherlands. The vertical bar shows the start of the GFC.

The increase in inflation persistence since the GFC is particularly visible in the euro area (Figure 3). This finding aligns with recent IMF research highlighting the remarkable persistence of inflation in the euro area, which is evident in the sluggish recovery of inflation despite improved labor market conditions (Abdih et al., 2018). The higher inflation persistence in the euro area compared to the United States is noteworthy, since before the crisis, inflation persistence was broadly similar in the two economies (Gadzinski and Orlandi, 2004; Altissimo et al., 2006).

A further important finding of our analysis of AR models of inflation is that the volatility of the shocks to inflation has also increased since the GFC, although it is still lower than its long-term average. This can be interpreted as inflation in the global economy – and in particular in the euro area – benefiting less from “good luck” in the post-GFC period than during the Great Moderation.

Our second approach uses a time series model to estimate the relative importance of temporary and permanent shocks to (core) inflation<sup>12</sup>. This estimate is related to the concept of inflation persistence used in the AR-approach: if permanent shocks are relatively unimportant, past realizations of inflation are not very informative for the future and persistence is low. If, on the other hand, the relative importance of permanent shocks is high, inflation is largely determined by the slow-moving underlying inflation and persistence is high.

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<sup>12</sup> The method is based on a Local Level Model as described in Durbin and Koopman (2012) combined with stochastic volatility in the spirit of Stock and Watson (2007).

When we apply this method to quarterly inflation data for 11 economies over the period 2000 to 2017, we find evidence that inflation dynamics in the euro area have changed since the GFC, albeit in a subtle way. Our estimates reveal an increasing trend in the relative importance of permanent shocks to inflation across the countries in the sample. While the difference is too small to be statistically significant, the direction of the change is consistent with the higher level of inflation persistence which we find by estimating an AR-model.

In sum, time series analysis using two different approaches reveals some increase in inflation persistence since the start of the Global Financial Crisis. The evidence suggests that inflation persistence is now higher compared to the Great Moderation. While this appears to be a global phenomenon, it is more pronounced in the euro area.

### 2.3 The sectoral distribution of price changes

In addition to changes in its time series properties, we also examine how the cross-section of inflation across sectors has evolved in the euro area. In particular, we investigate whether low and temporarily negative inflation has been a broad phenomenon in the sense that it has affected the whole sectoral distribution of price changes. As argued by Bernanke (2002) and Hobijn and Gardiner (2010), broad price declines need to be distinguished from price declines confined to a specific sector. The latter may reflect rising productivity and falling costs or weak demand in that sector compared to the rest of the economy, and hence reflect changes in relative prices. It is therefore important to analyze the dynamics of price indexes at the sectoral level and how they may have changed over time.

Moreover, stylized facts on price changes across disaggregate data may shed light on possible underlying drivers of low inflation, which will be discussed in detail in Section 4. In particular, they allow providing *prima facie* information on sectors with global and domestically driven components, on differences across sectors with more or less contestable markets and different pricing behavior of firms, on sectors likely to be dominated by firms that are more or less vulnerable to financing constraints, and on the impact of administered prices.

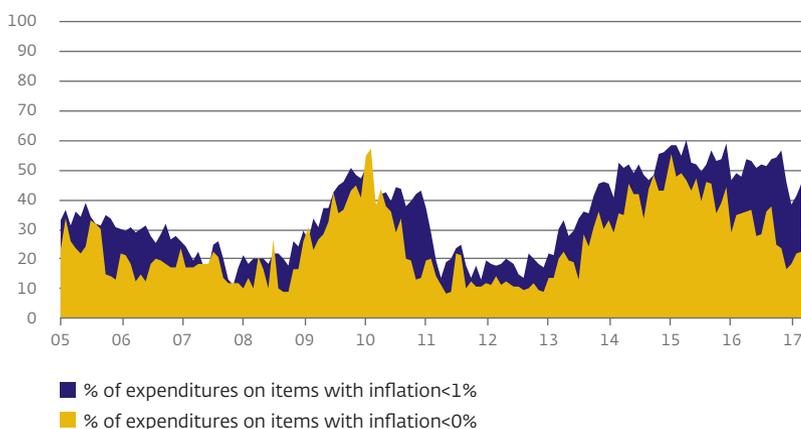
An analysis of sectoral data for the euro area shows that the observed changes in the aggregate inflation process since the GFC do appear to have been broad-based. The decline in average HICP inflation in recent years has been accompanied by a downward shift of the whole distribution of price changes across a wide range of goods and services. This seems to have happened in two waves: during the Great Recession in 2009-2011, and during the period of disinflation in 2014-2017. In both periods, about half of the consumption bundle recorded inflation rates of less than 1% (Figure 4). A similar development has been documented for the United States in the periods 2008-2010 and 2014-2015.<sup>13</sup>

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<sup>13</sup> See Hobijn and Gardiner (2010).

Figure 4 HICP items with low or negative inflation, euro area

Percent of expenditures

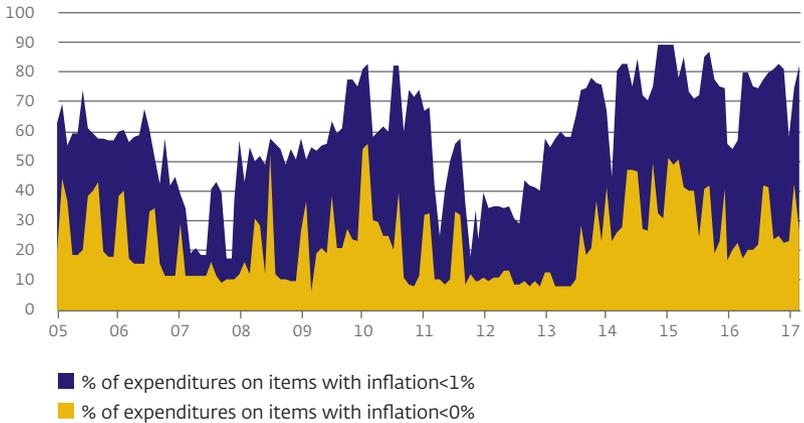


A closer look at sectoral data reveals several other interesting facts. First, looking at broad categories, energy and food contributed to low or negative euro area inflation between 2014 and 2016, as well as to the upturn in inflation recorded in 2017 and 2018. This fact has been documented extensively and has received much attention in the policy debate (see e.g. Ciccarelli and Osbat, 2017).

Second, the low and stable core inflation observed in the euro area in part reflects the declining inflation of many items among non-energy industrial goods (NEIG, Figure 5). This trend started well before the GFC, and in the literature has been associated with technological changes and globalization forces.

## Figure 5 Non-energy industrial goods with low or negative inflation, euro area

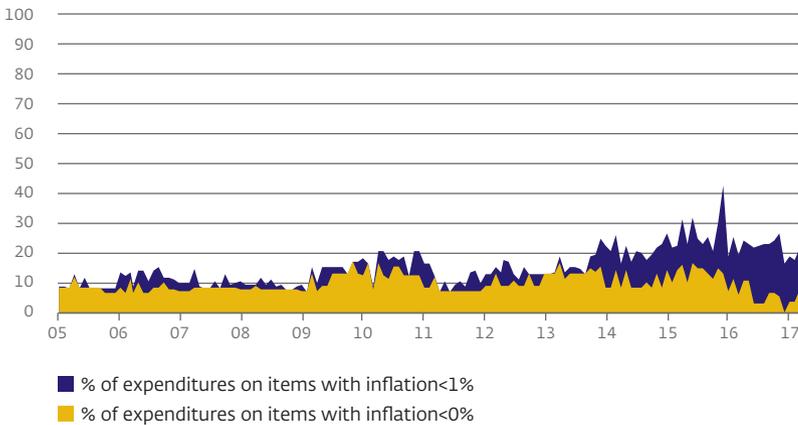
Percent of expenditures on industrial goods



A third stylized fact is that the low and stable core inflation in the euro area not only reflects inflation dynamics in the NEIG sector but also in the service sector. A small but growing share of items from the service sector in the consumption bundle has recorded persistently low inflation over the past decade (Figure 6). This fairly new development has recently started to receive attention (Galesi and Rachedi, 2018; Coeuré, 2019).

## Figure 6 Services with low or negative inflation, euro area

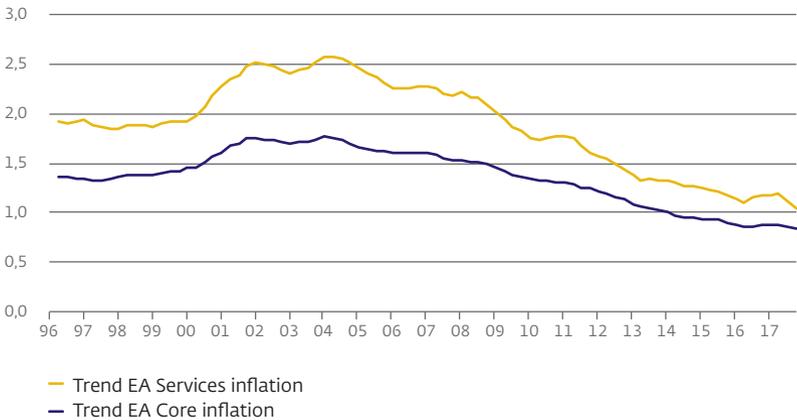
Percent of expenditures on services



We dig deeper into this issue by examining the role of services inflation in explaining the dynamics of core inflation, which in recent years has remained stuck around 1% in the euro area. Services inflation takes the lion share (63%) in the core inflation basket. Using a time series decomposition based on a UCM, we extract trends from annualized quarter-on-quarter core and services inflation for the euro area since the mid-1990s. The estimated trend component of core inflation in the euro area is clearly moving downward over time, from about 1.5% in 1996 to roughly 0.9% in 2017 (Figure 7). Note that this latter trend is accompanied by an increase in the share of services in total consumption expenditure and in the core inflation basket from 51% in 1996 to 63% in 2018. These stylized facts suggest that low core inflation to an important extent reflects the trend and composition effect in services inflation.

Figure 7 Estimated trend in core- and services inflation, euro area

Percent



Notes: The trends are estimated by a UCM of inflation and the unemployment rate for the euro area. For details, see Section 3.5.

The punchline from our analysis of sectoral data is that the disinflation and low headline inflation observed in the years following the GFC have been broad-based. This reflects the well-known downward trend in inflation in the NEIG sector that was visible before the crisis, but more recently also the downward trend in services inflation. The empirical results suggest that core inflation in the euro area may remain subdued in the near future unless the current trend component in services inflation is reversed.

# 3 The Phillips Curve is “alive and well”

This section discusses how the Phillips curve paradigm can help shed light on the two puzzles that have emerged in the wake of the GFC: the “missing disinflation” during the Great Recession and the “missing inflation” since the period when the recovery took hold in 2013. We start by overviewing the different positions in the debate on the validity of the Phillips curve. Next, we review three main problems that affect empirical work on the Phillips curve: measurement issues, the instability of the parameters and problems of model specification. We then show how these three problems can be dealt with by a time-series approach based on a UCM, which explicitly performs a trend-cycle decomposition of the Phillips curve relationship.

## 3.1 Inflation puzzles and the Phillips curve paradigm

Policymakers and researchers have been grappling with the apparent anomaly of the reaction of inflation to changes in economic slack since the GFC. Two puzzles stand out. First, in spite of the strong decline in output and rise in unemployment during the Great Recession of 2008-2010, inflation did not fall sharply during those years, a phenomenon termed “the missing disinflation” (e.g. IMF, 2013). And second, the broad recovery that started around 2013 in a context of still very accommodative monetary policy, was not followed by a marked surge in inflation, a phenomenon known as “the missing inflation”.

Moreover, forecasting inflation based on macroeconomic variables has become more difficult since the turn of the millennium. Professional forecasts of inflation at central banks and in the private sector have been subject to large errors, particularly when commodity prices rallied in the mid-2000s and fell sharply in the mid-2010s, and in the wake of the Global Financial Crisis. The size and persistence of these forecast errors and their clustering across countries have been unusual.

These phenomena underscore how central banks have operated in recent years in an environment characterized by increased uncertainty, which arguably reflects various factors of a macroeconomic, financial and political nature. The increased uncertainty may explain the forecast errors by central banks and in the private sector since the crisis. These phenomena have also led policymakers and researchers to question the validity of the Phillips curve, the analytical framework commonly used in macroeconomics to capture inflation dynamics and to inform monetary policymaking. The Phillips curve relates measures of economic slack – such as the output gap or the unemployment rate – to inflation or wage growth. In the words of Summers (2017), a key question is whether the Phillips curve has been thrown off course temporarily, or the whole Phillips curve framework has broken down and we need a new paradigm.

In the 1970s, the paradigm developed by Friedman (1968) and Phelps (1967) postulated that the Phillips Curve is vertical in the long run at the natural rate of unemployment. Pushing the unemployment rate temporarily below the natural rate would only shift the short-term curve upwards and lead to higher inflation. In the current dominant paradigm that was developed in the 1980s and 1990s, the New Keynesian Phillips Curve (NKPC), inflation is primarily driven by expectations of future macroeconomic activity.<sup>14</sup> The policy implication of both Friedman's and the NKPC paradigm is that central banks have a limited ability to exploit the Phillips trade-off. Hence, successful monetary policy should be based on rules. Moreover, in the NKPC framework, central bank communication has come to play a pivotal role as a tool to manage expectations.<sup>15</sup>

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14 Standard references are Woodford (2003); Galí and Gertler (1999, 2007); and Galí (2009).

15 For a discussion of rules and communication as a tool to manage expectations, see e.g. Bernanke, 2007, 2008.

The literature has shown that the Friedman view has been overturned for some time. There is ample empirical evidence that in the past decades, the slope of the short-term Phillips curve seems to be significantly less than vertical (Gordon, 2018) and prone to change over time, reflecting changes in the macroeconomic, financial and policy environment. And in terms of its forecasting ability, Dotsey et al. (2018) find that, since the mid-1980s, Phillips curve models do not outperform naïve univariate forecasting models. Moreover, there are no conditioning variables that significantly help to improve the forecast of the Phillips curve model relative to a simple univariate time series model.

Faced with the inflation puzzles observed since the GFC, policy views and analytical findings on the Phillips curve have diverged markedly, reflecting the great uncertainty characterizing the current environment.<sup>16</sup> In broad lines, the debate on Summers' question can be divided into three views. One view contends that underlying macroeconomic relationships such as the Phillips curve still hold but important measurement problems affect empirical work that relies on measures of the amount of slack and/or inflation expectations. According to a second view, the model parameters in the Phillips curve have changed in a fundamental way over time, and in particular since the GFC. Yet another view highlights problems with the specification of empirical Phillips curve models. The most radical proponents of this view question the usefulness for policymakers of relationships like the Phillips curve that are based on unobservable variables.

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<sup>16</sup> See e.g. Cunliffe (2017). A detailed overview of the literature and policy debate on the Phillips curve is beyond the scope of this paper. Interested readers are referred to overviews provided by Mavroudis et al. (2014), Abbas et al. (2016), Mankiw and Reis (2018), Gordon (2018), Haldane (2018) and Merler (2018).

## 3.2 Measurement issues

A recent strand of the research literature emphasizes that underlying economic relationships such as the Phillips curve still hold but empirical exercises suffer from important measurement problems. One such problem is that central banks have simply continued to underestimate the amount of slack in the economy (see e.g. Aaronson et al., 2014). This line of research shows that recent changes in the unemployment rate mask different dynamics in hours worked (given inter alia the greater use of part-time work) and in the participation rate. Daly and Hobijn (2017) for example document how the composition of the employed changes over the business cycle in the United States. They relate these composition changes to both the number and the relative wage levels of workers entering and exiting the labor market. Hence, more granular indicators of labor market conditions are needed to capture Phillips curve relationships in the data.

Research that uses these types of measures of slack point to a more nuanced picture of changes in the Phillips curve since the Global Financial Crisis. Bonam et al. (2018) estimate a wage Phillips curve in euro area countries with time-varying parameters using alternative measures for labor market slack, such as the European Commission's labor shortage indicator. They present evidence of a "meaningful" Phillips curve with evidence of some changes in parameter estimates since the GFC. For euro area economies, they find that the wage Phillips curve steepened in Italy, France and Spain, remained stable in the Netherlands, and become flatter in Germany.

Another important measurement issue concerns inflation expectations: conclusions on the validity of the Phillips curve hinge on how inflation expectations are captured. Coibion et al. (2019), for example, show that an expectations-augmented Phillips curve can explain inflation dynamics across a range of countries, once household or firm-level inflation expectations are

used. But inflation expectations cannot be observed directly, and there is no consensus on how to best measure them.

The literature has relied on three main approaches to measuring inflation expectations: surveys of professional forecasters, market-based measures and surveys of consumers or firms. All these approaches have both advantages and shortcomings. Surveys of professional forecasters are closest to a direct measure of expectations but a limitation is that respondents do not have to act on the basis of their responses, i.e. “do not put their money where their mouth is” (Berk, 1999).<sup>17</sup> Another problem is that survey results are sensitive to the wording of the questions (Van der Klaauw et al., 2008). Moreover, different types of survey measures may produce very different results (Mankiw, 2004; Sinclair, 2010).

Market-based measures are typically based on bonds or interest rate swaps linked to inflation, and are generally more volatile than survey-based measures (see e.g. Beechey et al., 2011). These measures are particularly suited to investigating changes in the behavior of expectations that occur at high frequencies in response to particular events, such as macroeconomic news or changes in central bank communication. Moreover, market participants do act on the basis of these measures. At the same time, these measures may be “contaminated” by factors other than expectations, especially during turbulent times in financial markets: inflation risk premia, liquidity premia, and technical factors such as sudden portfolio shifts by leveraged investors unrelated to changing views about future economic fundamentals (Hördahl, 2009).

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<sup>17</sup> Evidence from a natural experiment however suggests that this problem may be less important in practice (Galati et al., 2011). See Berk and Hebbink (2010) for a discussion of the usefulness of consumer surveys for euro area monetary policy.

A recent line of research has examined expectations measured by surveys conducted with households and firms. Researchers still do not have a clear picture about how these expectations are formed (Gorodnichenko et al., 2018). There is some evidence that households and firms generally have biased views on actual inflation (Coibion, 2018), and that media information does not help the general public in understanding inflation (Jansen and Neuenkirch, 2018).<sup>18</sup>

In sum, the apparent failure of empirical Phillips curve models may reflect two main measurement problems. The first concerns economic slack: traditional measures such as the output gap or the unemployment rate may not be accurate. The second concerns inflation expectations, which are notoriously tricky to measure.

### 3.3 Time-varying model parameters

A second view on the Phillips curve is that its parameters can be correctly estimated but are liable to change significantly over time. According to some proponents of this view, the slope of the Phillips curve has substantially declined since the 1980s both in the output-inflation space and in the employment-wage space. Others emphasize the changing relationship between unemployment and inflation around recession periods.

Daly and Hobijn (2014) show – both theoretically and empirically – that the slope and curvature of the Phillips curve depend on the level of inflation and the extent of downward nominal wage rigidities. During recessions, wage rigidities prevent wages from falling and the labor market adjustment

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<sup>18</sup> There is also evidence that household inflation expectations are linked to trust in the central bank (Christelis et al., 2016). One implication of these results is that central banks might need to consider more direct ways of engaging with the general public. For a detailed discussion of research on how central banks can influence expectations, see de Haan and Sturm (2019) and de Haan et al. (2016).

happens primarily through the unemployment margin rather than through wages. Since recessions result in substantial pent-up wage deflation, the recovery period is characterized by a simultaneous deceleration of wage inflation and a decline in the unemployment rate. This “bending” of the Phillips curve is especially pronounced in a low inflation environment.

Another prominent proponent of the view that Phillips curve parameters change over time is Blanchard (Blanchard et al., 2015; 2016). He argues that the inflation process may have changed in a way that inflation tends to be lower and more persistent. Recessions can generate disinflationary pressures which may be more protracted than expected and more difficult for central banks to counter. Blanchard’s work points to the importance of a declining trend component of inflation. He interprets this trend in terms of inflation expectations having become steadily more anchored, leading to a relation between the unemployment rate and the level of inflation rather than the change in inflation.

### 3.4 Model specification

A third view focuses on problems of model specification of the Phillips curve, which particularly affect the NKPC. According to this view, much of the empirical work on the Phillips curve neglects the fact that it should rely on non-linear models, misses important variables, fails to capture the role of trends and structural changes, and lacks robustness.

Nonlinearities in the relationship between inflation and slack can arise if the relationship depends on the size and duration of economic slack, or the degree of anchoring of inflation expectations (Albuquerque and Baumann, 2017; Nawelalik, 2017). Byrne and Zekaite (2018), for instance, capture nonlinearities in the impact of labor market slack measures and show that the Phillips curve is steeper, the tighter are labor market conditions.

Lansing (2019) shows that including a variable that measures how inflation and the output gap interact over time gives stable Phillips curve slope coefficients over time for the United States. Bonam and Mavromatis (2019) show how the observed time variation in the Phillips curve parameters may result from a misspecification of a nonlinear relationship. The authors find for the Netherlands, that inflation dynamics can be described by a standard Phillips curve where the coefficients change across two distinct regimes for inflation – a low- and a high-volatility regime. The relationship between slack and inflation is significant in the low-volatility regime but not significant (i.e. the Phillips curve is flat) in the high-volatility regime. This high-inflation-volatility regime is found to correspond to periods when the Dutch economy experienced large, global cost-push shocks. Insofar as these shocks are correlated with demand shocks, it becomes more difficult to infer a statistically significant relationship between inflation and economic slack. This simultaneity bias would give the impression that the Phillips curve relationship has changed over time, while the actual, nonlinear relationship did not change.

In terms of missing variables, the literature has emphasized global factors (see e.g. de Haan et al., 2016). As shown by Eickmeier and Moll (2009), the Phillips curve may be harder to estimate with NKPC models if the domestic economies increasingly get hit by global shocks transmitted over more complex global value chains. Recent research finds that the NKPC remains a useful framework in a cross-country setting once global factors – exchange rate pass-through, the global output gap and oil prices – are accounted for (Forbes, 2018; Jasova et al., 2018).

In addition, when taken to the data, NKPC models have a hard time incorporating long-term structural changes in the macroeconomy, which can reflect trends in globalization, demographics or technological

innovation. In fact, NKPC models capture the persistence in inflation mainly by introducing frictions into optimizing rational expectations, e.g. through ad hoc backward-looking terms (see e.g., Galí and Gertler, 1999).<sup>19</sup>

In terms of lack of robustness, the NKPC has been shown to be highly sensitive to even minor econometric changes, including the sample period, the data vintage and the empirical specification (Mavroeidis et al., 2014). As an illustration, Mavroeidis et al. (2014) point to an exercise that re-estimates the benchmark NKPC by Galí and Gertler (1999) using the same variables, sample period and estimation method but with a different vintage of data. This reduces the estimated coefficient on economic activity by half and makes it no longer statistically significant (Rudd and Whelan, 2007).

A recent line of research addresses some of these key specification issues of standard DSGE models of the Phillips curve by departing in several respects from standard DSGE models and thereby managing to explain the “missing disinflation” and the “missing inflation” puzzles (Lindé and Trabandt, 2019).<sup>20</sup>

Overall, however, the different reasons for the weak in-sample and forecasting performance of standard NKPC models, particularly since the start of the crisis, have led some policymakers to contend that central banks should disregard models and analytical constructs such as the Phillips curve, the natural rate of unemployment or the output gap that are proven not to work in practice (Tarullo, 2017; Borio, 2018; Summers, 2017).

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<sup>19</sup> This point is discussed in detail by Fuhrer (2011). In the same vein, Ascari and Sbordone (2014) argue that the empirical performance of the NKPC would improve if Phillips curves are formulated in terms of the trend-based inflation gap, rather than the mean-based gap.

<sup>20</sup> Technically, there are three main elements in this approach. First, relying on the Kimball (1995) aggregator instead of the standard Dixit-Stiglitz (1977) aggregator produces a lower sensitivity of prices and wages to slack. Second, real rigidities and strategic complementarities are incorporated in price- and wage setting behavior. And third, instead of linearizing all equilibrium equations around the steady state, non-linear model solutions are used. This allows examining deviations from the steady state in response to large shocks, such as those that bring an economy to the zero lower bound.

### 3.5 The Phillips Curve is alive and well: new evidence from a UCM

A recent paper by Hindrayanto et al. (2019) provides a positive perspective on the Phillips curve debate by addressing all three issues of measurement, time variation and model specification. The authors estimate the Phillips curve based on UCMs that estimate directly both the trend and the cycle in inflation dynamics.<sup>21</sup> Following Beveridge and Nelson (1981), the trend is equal to the long-run forecast of inflation given the available data up to the current period. In a looser sense, the trend can be interpreted as capturing medium- to long-term inflation expectations. The cyclical component consists of a slack variable, i.e. the output or unemployment gap, which is assumed to be stationary by construction. The relation between detrended inflation and the slack variable is what Hindrayanto et al. (2019) call the unobserved components (UC) Phillips curve.

This approach has several important advantages. One is that it allows extracting trends in inflation directly, and trends have been found to play an important and under-appreciated aspect of inflation. Another advantage is that as a measure of inflation expectations, trend inflation implicitly reflects expectations held in the overall economy, rather than those held in a specific sector (such as professional forecasters or traders in inflation-linked financial assets). Furthermore, since the model is only based on inflation and unemployment, it allows extending the analysis further into the past (as long as data on these two variables are available) instead of depending

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<sup>21</sup> In technical terms, the empirical specification uses a simple modification of the backward-looking Phillips curve proposed by Harvey (2011) to decompose inflation into a permanent (trend) and a transitory (cyclical) component. The trend of inflation is modelled as a driftless random walk and captures the underlying level of inflation.

on the more limited availability of survey data or market-based measures of inflation expectations.<sup>22</sup>

One main finding of this work is that the Phillips curve in the output-inflation space is “alive and well” in the United States, in line with earlier work by Harvey (2011), as well as in the euro area. This finding is consistent with the conclusion of an influential paper by Ciccarelli and Osbat (2017) on causes and consequences of low inflation in the euro area. Similar results are obtained when the Phillips curve is estimated in the unemployment-inflation space for the euro area and its five largest economies. This exercise is performed for two sample periods: 1985-2017 and 2008-2017. For the euro area as a whole and four of its largest countries, there is evidence of a negative and significant relationship between the cyclical components of inflation and unemployment. Based on the results of the whole sample period for the euro area, an unemployment rate of 1% below trend is associated with an annualized monthly inflation that is roughly 0.5% above its trend. Furthermore, with the exception of Spain, this relationship has not changed substantially since the start of the Global Financial Crisis. Importantly, these results are based on using a “standard” measure of slack such as the unemployment rate.

Another important finding is a downward trend in inflation over the past decades. This result is consistent with work based on different approaches that have found that trend inflation and inflation expectations may currently be lower than before the crisis, thereby dampening inflation (see e.g. Ciccarelli and Osbat, 2017). A seminal paper by Stock and Watson (2007)

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<sup>22</sup> In addition, the model accounts for the possibility of inflation being non-stationary. Most empirical work on the Phillips curve for example assumes stationarity in the inflation process by including a lagged dependent variable in the model, which may introduce a bias in the estimates (see e.g., Cogley and Sbordone, 2008).

presents evidence that underlying trend inflation in the United States has been moving down already before the crisis, by some 0.5 percentage point over the previous decade. Cecchetti et al. (2017) estimate that this trend decline has continued since 2007.

If this trend is not modelled explicitly, an empirical analysis of inflation dynamics could attribute the current low inflation to an increased inflation persistence, while in fact it reflects a declining trend. Note that empirical work based on UC models method does not allow conclusions about whether leads and lags in the relationship between slack and inflation have changed over time.

Hindrayanto et al. (2019) also show that there are differences in the relationship between slack and inflation across euro area economies. The estimated slope coefficient is statistically significant around -0.5 for the euro area and Germany, -0.6 for the Netherlands and -0.7 for France. The coefficient for Spain is somewhat lower in magnitude (-0.4), and not statistically significant, while for Italy, the coefficient turned out to be economically relatively small and statistically not significant. These cross-country differences suggest that structural factors may play a role in determining the exact shape of the Phillips curve. In Section 4, we review the main conclusions of the literature on such structural factors.

Finally, to dig deeper into the role of service inflation in driving total headline inflation, the Phillips curve is estimated separately for goods and services. Estimating these sectoral Phillips curves is not trivial. The main problem lies in finding a reasonable measure of economic slack, for which timely and reliable data exist, at the sectoral level that can be suitably matched with sectoral inflation. Previous studies have dealt with this issue by using either an aggregate slack variable (total output or the unemployment gap

(Luengo-Prado et al., 2018), or a sectoral slack variable proxied by a measure of sectoral productivity or sectoral costs (Imbs et al., 2011).

Phillips curves have been estimated with an UC model as in Hindrayanto et al. (2019) for the NEIG and services sectors in the euro area and the Netherlands. The NEIG sector includes all non-energy industrial consumer goods (e.g. clothing, cars), while the services sector includes all sub-categories of consumer services (e.g. housing, transportation). Following the literature, economic slack is measured by an aggregate output gap and unemployment gap.<sup>23</sup> The relationship between economic slack and NEIG inflation is significant both in the euro area and the Netherlands, suggesting that prices are responsive to the business cycle in the NEIG sector. The slope of the Phillips curve for the services sector is somewhat smaller in magnitude compared to the NEIG sector for the Netherlands, while for the euro area, the sectoral Phillips curve slopes for services and NEIG are comparable.

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<sup>23</sup> A sectoral slack variable is tricky to estimate for the euro area and the Netherlands since it is difficult to disentangle NEIG from total goods in sectoral statistics.

# 4 Structural factors and inflation trends

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A key issue in the interpretation of the downward trend that is given in the UC framework is that it reflects a decline in inflation expectations. But this does not preclude that other, structural factors contribute to a dampening of inflation in the longer-run. These factors could in principle also help explain the findings of higher inflation persistence since the GFC and the possibly longer lag before a change in economic slack is translated into a change in inflation.

The policy debate and research literature have emphasized a number of related, deeper drivers of inflation. These include the ongoing globalization trend, the declining bargaining power of labor, demographic changes, technological progress and the rise of e-commerce, and financial factors (see e.g. Ha et al., 2019b). The complex nature of these forces and their interaction underscores the uncertainty that characterizes the current macroeconomic environment, and future research is needed to analyze to what extent these forces are likely to persist.

The increasing globalization has attracted much attention in the policy debate (see e.g. Villeroy de Galhau, 2017; Carney, 2015, 2017; Forbes, 2018). The impact of global factors operates to an important extent through the direct effect of global commodity and food prices on domestic inflation (Weale, 2015). There is empirical evidence that through their direct effect on inflation, global factors can significantly explain the “missing disinflation” and “missing inflation” puzzles in the euro area (Peersman, 2018). Without disruptions in global food markets, inflation in the euro area would have been 0.2 to 0.8% lower in the period 2009-2012 and 0.5%-1.0% higher in 2014-2015.

The literature has also documented several indirect channels through which global factors matter for domestic inflation.<sup>24</sup> These include stronger trade linkages (Bianchi and Civelli, 2015), rapidly expanding global supply chains (Auer et al., 2017), changes in the contestability of markets which affect the pricing behavior of firms (Sbordone, 2009) and greater international competition (Kabukçuoğlu and Martínez-García 2018), financial linkages (Neely and Rapach, 2011) and technological changes (Carney, 2017). The idea is that over the past years many goods, and increasingly also services, have become more tradeable and are being priced in more contestable markets. Therefore, not only domestic but also global supply and demand conditions are relevant for price developments.

The empirical evidence on the role of global factors through these indirect channels is mixed. On the one hand, research conducted at the BIS and the OECD, based on cross-country studies, finds evidence of a prominent role of global factors in recent inflation dynamics (Borio and Filardo, 2007; Auer et al., 2017; Andrews et al, 2018). Moreover, in a set of 20 OECD countries, a substantial share of inflation volatility has been found to be accounted by a global factor that also drives the levels and persistence of inflation (Carriero et al., 2019). On the other hand, Ihrig et al. (2010) conclude that global slack does not appear to exert an appreciable direct effect on domestic inflation in the United States and most other advanced economies. The authors also stress that that empirical results on the role of global factors depend on the measure used to capture of global resource utilization. In a similar vein, Mikolajun and Lodge (2016) and ECB (2017) conclude that global factors cannot explain the flattening of the Phillips Curve in the euro area since the Global Financial Crisis.

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24 A detailed discussion of the literature on these channels is provided in Ha et al. (2019).

One way to reconcile these different findings is to look at data on prices and economic slack disaggregated by sectors. Gilchrist and Zakrajsek (2019) follow this approach by analyzing both aggregate data on measures of inflation and economic slack in the United States, and a rich panel data set containing producer prices, wages, output, and employment at a narrowly defined industry level. Their analysis shows that the rising exposure of the US economy to international trade can indeed help explain a significant fraction of the overall decline in responsiveness of aggregate inflation to fluctuations in economic activity, i.e. a flattening of the Phillips Curve. In particular, the authors find that the inflation-output tradeoff is about three times larger for low trade-intensity industries compared with their high trade-intensity counterparts in the United States.

A second structural factor that can arguably explain the downward trend in inflation is the ongoing trend towards a declining pricing power of labor. This weaker pricing power can be explained by the huge expansion of the global labor force since the 1990s and a further economic integration that has boosted international competition in labor markets (BIS, 2017; IMF, 2017).

The impact of demographic factors on labor markets and inflation has come under increasing scrutiny in recent years. A huge positive shock to global supply occurred in the 1980s and 1990s on the back of demographic trends and the inclusion of China and Eastern Europe into the World Trade Organization (Goodhart and Pradhan, 2017). During this period, the shift in manufacturing to Asia and in particular China was accompanied by a global stagnation in real wages and a collapse in the power of private sector trade unions. This led to disinflationary pressures and falling interest rates. Goodhart and Pradhan (2017) argue that this shock is now reversing: as the world ages, real interest rates will rise and inflation and wage growth will rise.

There is now empirical support for the long-run link between demographic factors and inflation. A recent paper by Bobeica et al. (2017) provides evidence for the United States and the euro area of a positive long-run relationship between inflation and the growth rate of the working-age population as a share of total population. The authors argue that the strength of the link between ageing and inflation depends importantly on the extent to which monetary authorities react to demographic forces. Juselius and Takats (2018) present empirical evidence that a higher dependency ratio is correlated with higher inflation, while a larger share of working age cohorts is correlated with lower inflation. They find that these results are robust to using different country samples, time periods, control variables and estimation techniques.

Another possible driver of the downward inflation trend is technological progress, and in particular the ongoing progress of automation. A new and quickly growing literature has started to explore the impact of robotic technologies and Artificial Intelligence on labor in industrial production (Acemoglu and Restrepo, 2018). But the impact of these technological advances is being felt also in the global service sector. In turn, this may be reflected in the observed downward trend in service inflation during the recent recovery. One channel through which this may happen is the steady growth in e-commerce (Cavallo and Rigobon, 2016; Gorodnichenko et al., 2018). Recent research by Bolt and Butler (2017) provides evidence based on survey data for the Netherlands that e-commerce has risen at double-digit rates in recent years, albeit from very low levels. The authors argue that this development may have a small, temporary negative effect on inflation, around 10-20 bps in any given year. This effect, which is in line with estimates in the literature (e.g. Brown and Goolsbee, 2002; Cavallo, 2017), is likely to become more important in the future.

Finally, a nascent literature strand emphasizes the role of financial factors and how the financial system has evolved over time. Research by Gilchrist et al. (2015, 2017) suggests that market structure and financial factors influence the way that firms price their goods (and services). Inflation might be stickier if financing constraints are more relevant, and if market power is greater. Using a detailed dataset of producer prices, Gilchrist et al. (2017) find that firms that were financially constrained increased their prices in 2008, whereas unconstrained firms cut their prices when demand fell. They develop a model in which firms have an incentive to invest in their customer base by lowering their price. With a larger customer base, expected future profits are larger. Firms that face financial constraints, however, value the future profits less and will therefore not lower their price or even increase prices. This behavior implies that inflation, due to financial constraints, moves less in response to changes in the output gap.

Results consistent with the work by Gilchrist et al. (2015, 2017) are found in a recent paper by Bodnar et al (2018), which links sluggish wage growth to credit difficulties. Based on a questionnaire conducted among 19000 firms in 24 EU countries, the paper finds that firms facing credit difficulties during the 2010-2013 period were not only more likely to reduce labor input, but also significantly more likely to reduce wages. The causal relationship between credit difficulties and wage reductions is confirmed by an analysis based on matched firm-bank data for Italy and France.

There are important avenues for future work emerging. Our results from UCM Phillips Curves points to investigating the nature and role of trends in inflation as a very important issue for future research (Ascari and Sbordone, 2014).

Another promising line of research relies on detailed micro data to study price dynamics and their determinants.<sup>25</sup> An example of this type of research is a new paper by Gilchrist and Zakrajsek (2019), which relies on data on prices, wages, output, and employment at a narrowly defined industry level to pinpoint more precisely the effects of globalization and the channels through which it may affect inflation.

A further important avenue for future research is to improve our understanding of expectations formation (Mankiw and Reis, 2002; 2018). In this line of research, focusing on expectations of firms and households is especially promising in light of the recent empirical work (Coibion and Gorodnichenko, 2015; Coibion et al., 2017). Empirical work will benefit also from new data sources, field experiments on how news spreads in networks of people and laboratory data on the formation of perceptions (Mankiw and Reis, 2018).

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<sup>25</sup> See e.g. the review by Nakamura and Steinsson (2013) and the theoretical analysis in Adam and Weber (2019).

# 5 Policy implications

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From a policy perspective, the positive analysis presented in this study raises two key questions. Have the subdued inflation dynamics since the GFC and the uncertain nature of their drivers threatened the monetary authorities' credibility? And what are their implications for the monetary strategy, i.e. the framework within which decisions on the appropriate monetary policy actions are taken, to ensure the successful conduct of monetary policy?

## 5.1 Are inflation expectations still well-anchored?

Inflation expectations have been identified in the policy debate and the research literature as a key driver of the observed low inflation (see e.g. Bernanke, 2010; Draghi, 2014). Short-term inflation expectations naturally reflect views on current and prospective near-term macroeconomic developments. By contrast, long-term inflation expectations reflect the credibility of the central bank in pursuing its goal of price stability: if they are firmly anchored to the central bank's inflation target, the central bank can be considered as fully credible. Since the GFC, a key question for monetary authorities has been whether long-term inflation expectations have remained firmly anchored.

In recent years, inflation falling short of the central banks' inflation targets despite sharp improvements in resource utilization have led some observers to question whether inflation expectations are still well-anchored. Brainard (2017) for example contrasts the shortfall in US inflation in recent years with the visibly higher inflation levels in the last period when the US economy was close to full employment, namely, just before the financial crisis. Both during 2004-2007 and 2014-2017, unemployment averaged around 5 percent, but in the former period, core inflation averaged 2.2%, notably higher than the 1.5% observed in the latter period. Brainard concludes that inflation expectations might now be anchored at too low a level.

To answer this question, it is necessary to examine whether changes are visible in the patterns of long-term inflation expectations (measured by alternative indicators) since the GFC, and how these changes can be interpreted. Based on data up to September 2018, Hartmann and Smets (2018) conclude that the behavior of the mean or median of long-term inflation expectations shows that expectations have remained broadly anchored in the euro area. At the same time, they also point to the higher uncertainty and negative skew of inflation expectations since the GFC, indicating that market participants view the risk of low inflation as having increased. The latter fact is supported by studies that focus on the information content of higher moments of the probability distribution of expectations, extracted from either survey measures of inflation expectations (e.g. Dovern and Kenny, 2017) or on measures derived from derivatives prices (Speck, 2017; Scharnagl and Stapf, 2015; Natoli and Sigalotti, 2017; Galati et al., 2018). These studies find that anchoring properties of euro area inflation expectations may have weakened, albeit in a subtle way. Moreover, the conclusion in Hartmann and Smets (2018) is based on data until September 2018. Since then, market-based measures of inflation expectations have decreased substantially, prompting concerns that the anchoring of expectations has weakened.

A different perspective on the anchoring issue comes from the behavior of inflation expectations at the height of the European debt crisis. According to the Fiscal Theory of the Price Level, the price level may be determined by fiscal policy actions, rather than monetary policy (Sims, 1994; Woodford, 1998, 2001). According to this theory, a sustainable path for real government debt can be ensured if the central bank abandons its inflation target and lets the price level jump to whatever level is necessary to stabilize government debt. In this case, fiscal policy shocks that lead to higher levels of government debt – such as those that occurred during the European debt

crisis – should also lead to an increase in inflation and inflation expectations. In the same vein, the fiscal consolidation efforts to reduce government debt in the aftermath of the crisis should have pulled down inflation expectations. Bonam et al. (2019) find that in neither of these episodes did fiscal policy have a significant effect on long-term inflation expectations, suggesting that it is unlikely that the price level in the euro area is driven significantly by fiscal policy.<sup>26</sup>

Overall, research suggests that the anchoring of long-term inflation expectations to central banks' inflation targets (or, in the case of the ECB, to its inflation aim) has at most weakened subtly since the GFC. At the same time, this research calls for closely monitoring the anchoring properties of inflation expectations should low inflation persist. And it highlights that their measurement, dynamics and drivers need to be better understood.

## 5.2 Implications for the monetary strategy

The analysis presented in this study has potential implications for the monetary strategy in the post-crisis new normal. The central bank may have less control over inflation in an environment of increased uncertainty about the inflation process and on the shape of the Phillips Curve – a key element of the monetary transmission mechanism. And if, despite very accommodative monetary policy, inflation remains persistently below the central bank's objective, this may undermine monetary authorities' credibility and the effectiveness of their policies. This risk is a good reason to take a closer look at the ECB's strategy (Hartmann and Smets, 2018).

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<sup>26</sup> These results are consistent with empirical research suggest that since 1999, fiscal policy has been Ricardian, in the sense that price stability has been guaranteed by the central bank (Bonam, 2017; Panjer et al., 2019).

The current implementation of the ECB's strategy has faced several challenges. As discussed in Sections 3 and 4, since the GFC, inflation in the euro area may to an important extent be affected by structural factors outside the central bank's sphere of influence. In particular, the ongoing globalization trend, the declining bargaining power of labor, demographic changes, technological progress and the rise of e-commerce, and financial factors can contribute to a dampening of inflation. These factors can also be a reason why since the GFC, euro area inflation has become more persistent (as documented in Section 2), and the speed of the transmission between economic slack and inflation has slowed. Moreover, the complex and interdependent nature of these factors can explain the high uncertainty around the current macroeconomic environment. Forecasting models used by central banks do not incorporate these factors and therefore decision-makers face increasing challenges in capturing inflation risks.

In the policy debate and the research literature, alternative proposals have been put forward for adapting the monetary strategy. Most of the proposals center on the role of inflation expectations, and emphasize the importance of a communication that is clear and consistent over time to ensure a "rock-solid" anchoring of inflation expectations (Williams, 2017). While much of this discussion has focused on the Federal Reserve, some lessons may apply more generally. One proposal that would leave the current monetary framework in place but change one key parameter is to raise the inflation target, specifically to 4 rather than 2% (e.g. Ball, 2014; Blanchard et al., 2010; Williams, 2016). The proponents of this view argue that a higher inflation target would ease the constraints on monetary policy arising from the zero bound on interest rates – which would more likely be reached in an environment of low inflation – with the result that economic downturns would be less severe.

An alternative approach consists in targeting average inflation (e.g. Svensson, 1999; Nissan and Vestin, 2005). This strategy implies that the central bank aims at an above-target inflation rate in “good” times (i.e. when the lower bound is not a constraint) to offset the inflation undershooting during “bad” times (i.e. when the lower bound is binding). If carried out effectively, this strategy would allow the longer-run average inflation rate and inflation expectations to align with the central bank’s target.

Yet another strategy consist in targeting the price level. With this strategy, monetary authorities aim at keeping the level of prices on a steady growth path. They hence try to keep the average inflation rate over the very long run stable, say at 2%. Compared to the conventional inflation targeting, price-level targeting therefore introduces an element of history dependence in monetary policy, meaning that that monetary policy responds to past economic conditions, in addition to current and expected future conditions (Woodford, 2003). In the former strategy, monetary authorities can ignore a temporary deviation of inflation from target as long as inflation returns to target after time. In the latter strategy, by contrast, the central bank commits to reversing temporary deviations of inflation from target: a period of inflation below target would be followed by a period of above-target inflation, and an episode of low inflation would be followed by a period of inflation above target.

Variants of this approach are nominal GDP targeting (McCallum, 2011; Woodford, 2012), whereby the central bank targets the future level of economic activity in nominal terms and temporary price-level targeting, whereby a price level target is introduced only in periods around episodes in which the lower bound has been binding (Bernanke, 2017, 2019).

A very different proposal for changing the current monetary strategy consists in putting less weight on inflation and more weight on the longer-term real effects of monetary policy through its impact on financial stability (Borio, 2018).<sup>27</sup> Proponents of this view regard disinflationary pressures resulting from forces such as globalization or technology as benign, as they would reflect favorable supply side developments rather than damaging demand weakness. Hence, the monetary strategy should be made more flexible by lengthening the horizon over which it would be desirable to bring inflation back towards target. Alternatively, the policy-relevant horizon could not be seen as a fixed time horizon but as a variable horizon that depends on the size and duration of shocks affecting the economy. Under specific circumstances in which structural factors outside the central bank's influence affect headline inflation, the policy-relevant horizon may cover a longer horizon than usually assumed. This greater flexibility would also provide additional room for maneuver to address the potential negative macroeconomic effects of boom-bust cycles in the financial system.

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<sup>27</sup> See also Kashyap and Siegert (2019) for a recent discussion of this view.

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