Breaks in the mean of inflation:
How they happen and what to do with them

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Abstract: In most OECD countries, we cannot reject up to three breaks in the mean of inflation: one break towards a higher mean in the late 1960's or the early 1970's, one break towards a lower mean in the early to mid 1980's and another break that again lowers the mean of inflation in the early 1990's. We outline three major features of these breaks.

First, we show that these breaks tend to be associated more often to breaks in the mean of nominal variables than to breaks in the mean of real variables, which confirms that they are in general monetary phenomena. Second, we show that ignoring breaks in the mean of inflation clearly lead to overrate inflation persistence in standard bi-variate models of inflation. The response of inflation to shocks in these models is markedly faster with breaks than without breaks. The acceleration of the inflation response is however smaller for real shocks because the persistence of these shocks is less affected by the breaks to the mean of inflation than the one of nominal shocks. Third, controlling for breaks in the mean of inflation weakens the effects on inflation of M3 growth and of the real unit labour cost towards insignificance while the effects of the output gaps on inflation are more robust.

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1. Introduction

OECD countries have experienced long swings in the level of inflation. Inflation has progressively risen in the 1960's and 1970's before it declined in the 1980's. Inflation has further declined in the early 1990's and has since then remained low and stable. Because these swings have been very persistent, the common view is that inflation is a persistent process. Standard measures of persistence, either based on autoregressive models or on indicators of mean reversion, confirm that, for samples covering the last three or four decades, inflation is a persistent process. For instance, autoregressive models typically admit roots close to unity in most OECD countries. As a result, many macroeconomists[1] take the high degree of inflation persistence as one of the key stylised facts that micro-founded models ought to replicate.

However, inflation appears much less persistent within shorter periods. Focusing on the last decade, for instance because one considers that the ongoing transformation of the economy discards the relevance of older data, inflation is not so persistent. At least unit roots are far in the tails of the distribution of the estimated roots of autoregressive models. Actually, this low persistence of inflation can be found for earlier decades as well.

The contrast between the persistence of inflation taken for a long sample period and the one obtained for specific sub-samples can be illustrated by eyeball evaluation of the mean reversion of inflation series. The full line in Figure 1 is the CPI inflation time series for the euro area and the US between 1970 and 2003. Inflation relentlessly remains for long periods on one side of its full sample mean (of the order of five percent for both monetary unions). On the contrary, there are several periods when inflation fluctuates around a *local* mean: from 1970 to 1972, from 1973 to 1984 (1982 in the US) and from 1985 (1983 in the US) to 2003. For each period taken in isolation, the roots of autoregressive models of inflation are actually far below unity.

This discrepancy between short and long samples-based measures of inflation persistence has been described with formal econometric models by a number of recent studies that cover various countries and periods.[2] The degree of estimated inflation persistence considerably decreases either allowing for breaks in the mean of inflation or posing the estimation on short samples. This fairly intuitive result is supported by statistical tests that cannot reject that the mean of inflation

[1] E.g. Fuhrer and Moore (1995), Mankiw (2000), Christiano, Eichenbaum and Evans (2001), Benassy (2004).
[2] Levin and Piger (2004), Benati (2003, 2004), Benati and Wood (2004), Altissimo (2003), Gadzinski and Orlandi (2004) and Goodhart and Hofmann (2003), Cecchetti and Debelle (2004), Robalo Marques (2004) and Dias and Robalo Marques (2004).

has been subject to breaks. It comes across the board for various sample periods in most OECD countries.

Surprisingly, all these studies focused their investigations on univariate models of inflation. This is an important limitation because inflation is usually considered as an endogenous variable, which adjust to monetary and real developments. In particular, the limitations of univariate models of inflation are worrisome in two respects[3].

First, the breaks in the mean of inflation may not be the exogenous phenomena we assume them to be in univariate break tests. In case they are not exogenous, we need to clarify what brings them along. Second, given that breaks are a feature of the data, their impact on the models we use to analyse inflation need to be measured.

The objective of the paper is therefore twofold: to clarify the origin of breaks in the mean of inflation and measure their effects on the response of inflation to standard macroeconomic shocks.

Can breaks in the mean of inflation be exogenous phenomena, and if not, what triggers them? Some argue that breaks reflect changes in the monetary policy regime[4]. This is quite clear for the 1990's, a period when 16 OECD countries either converged to the low inflation standard of the Bundesbank before adopting the euro or embraced "inflation targeting". However the case for changes in monetary policy regimes is not as massive for the breaks in the mean of inflation that occurred in the 1970's and the 1980's.

Prominent studies of the US case clearly point to the different aspects of the Federal Reserve monetary policy to explain the drift of inflation in the 1970's and its return to lower levels in the 1980's (e.g. Cogley and Sargent, 2001; Clarida, Gali and Gertler, 2000; Orphanides, 2003). Unfortunately, the analytical apparatus mobilised by these studies is neither feasible nor desirable

[3] See also Stock (2001), Pivetta and Reis (2002) and O'Reilly and Whelan (2004) who question the size of the break tests used Levin and Piger (2004) and show that inflation may actually have a unit root. By definition, any change in a unit rooted inflation is permanent, which implies a highly persistent inflation. We deliberately do not enter this discussion because we doubt there can be a consensus on the performance of break tests in terms of the power/size trade off. We take the view that breaks signal large persistent adjustments of time series and that whether or not they match everybody's standard of what a structural break should be is irrelevant as long as there may be a difference between times of large persistent adjustments and "normal times". One aim of the paper is precisely to find out whether or not controlling for breaks, i.e. focusing on "normal times", changes the properties of the inflation process and its response to standard macroeconomic shocks. Indications that models estimated in "normal times" are indeed different than models estimated for all times point to risks of mis-specification that cannot be ignored.

[4] See references in footnote 1 and Ahmed et al (2002) who review the literature that has debated which share of output and inflation stabilisation is deserved by policy makers.

for other OECD countries where the institutional environment and the implementation of monetary policy went through profound changes in the last 40 years.

We therefore propose simpler tests of whether breaks in the mean of inflation can be associated with changes in the monetary policy regime. We check whether breaks, which are long-term changes, tend to be "neutral". In particular, changes in monetary policy regime / breaks in the mean of inflation should tend to coincide more with breaks in the mean of nominal variables than with breaks in the mean of real variables. To conduct this investigation, we first follow closely the approach proposed by Rapach and Wohar (2002): we simply compared the breaks dates as estimated by the Altissimo and Corradi (2003) multiple breaks test procedure, first for inflation series and then for "Guinea pigs" groups of nominal and real variables. Second, we test whether the dates when inflation admits a break in its mean correspond to a significant (in the statistical sense) shift in the mean of these "Guinea pigs" variables.

The other major limitation of univariate models of inflation is that they do not give a full account of the economically relevant aspects of persistence, i.e. the speed at which inflation adjusts to monetary and business cycle developments (see the typology of persistence proposed by Batini, 2002 and Batini and Nelson, 2002). In particular, policy makers should worry about whether breaks in the mean of inflation alter the response of inflation to standard shocks, be they monetary or real.

The paper addresses this issue by estimating 10 reduced form bi-variate models of inflation. Each model makes inflation depend on its own lags and on lags of another macroeconomic variable. The latter is either an indicator of monetary conditions, a real variable that typically appears in Philips curves and an indicator of Foreign or sectoral (i.e. non core) inflation shocks. Comparing the estimates of these models with and without breaks shows whether and how the breaks influence the adjustment of inflation.

Before announcing the plan of the paper, we would like to stress a non trivial aspect of our approach. One major challenge of the study of structural breaks is that they are, by definition, rare events. It is for this reason that our study covers the period from 1960 to 2003 for 22 OECD countries and the euro area. Eventually our pool of breaks in the mean of inflation is large enough to attempt inference thanks to the comprehensiveness of our sample.

Section 2 of the paper reports the estimates of breaks in the mean of inflation. Section 3 estimates the breaks in the mean of five real and five nominal variables before its checks how the break dates coincide, across the 23 countries, with the one found for inflation. Section 4 tackles the effects of breaks in the mean of inflation on its response to standard shocks. Section 5 summarises the main contributions of the paper.

2. The breaks in the mean of inflation: When and where?

The initial step of our empirical investigation is to identify when the breaks in the mean of inflation may have taken place. We focus on these *breaks in the mean* for three reasons. First, the mean of inflation is a major characteristic of a monetary policy regime. Economic agents are better of when the level of inflation is low. And while inflation cannot be controlled at all time, moderate fluctuations around a low level, which translate into a low mean of inflation, are preferable to small or large fluctuations of inflation around a high mean of inflation. Second, the mean of inflation is closely linked to the inflation objective of the central bank. Typically, this objective is to maintain low inflation. Eventually, the mean of inflation is a good summary indicator of the success of central banks in delivering their objective. Third, given that we analyse the robustness of breaks in the mean of inflation and the "Conditional on break low persistence of inflation" (CBL thereafter) in a multivariate context, the methodology of the univariate analyses of the inflation process is a natural benchmark.

We test for breaks in two measures of inflation: the CPI/HICP inflation and the GDP deflator inflation. Both are defined as annualised quarter-to-quarter growth rates. The source and the availability of the data are described in the Annex Table A1. The CPI time series are available back to 1960 for most countries while the GDP deflator first observation spans from 1970 to the late 1980's.

We implement the break test developed by Altissimo and Corradi (2003) because it allows for multiple breaks and it performs better than the more widely used Bai and Perron multiple break test both in terms of size and power. In addition, test for multiple breaks in the mean of inflation using the Bai and Perron test is already available in Benati (2003) for most of the countries we cover. Our results usefully complement the breaks tests results already available in the literature.[5]

[5] Break tests have altogether been criticised because they are subject to type II error for highly auto-correlated processes and potentially integrated processes (e.g., O'Reilly and Whelan, 2004). While these critics may have a point, we would like to stress that we use break tests to spot potential discontinuity in the adjustment of inflation between normal times and large adjustments time (see footnote 3). More specifically on unit roots, ex-post assessment shows that inflation has been a stationary process. Its fluctuations and its variance have been bounded and, although some estimates may not strictly reject the null of a unit root, we can neither reject roots strictly inferior to one for the inflation of any of the countries in our sample. While unit rooted inflation could make economic sense for countries that may be subject to hyper inflation, we believe it is irrelevant in the case of OECD countries.

We identify 57 breaks altogether, i.e. a bit less than three on average per country. The dates of the breaks (Table 1) largely coincide across countries. We observe a first *wave* of breaks, from the late 1960's to the early 1970's, affecting 21 countries[6]. The second wave took place in the first half of the 1980's when 19 of the 23 countries experience a break. The third wave, in the early nineties, broke the mean of inflation in 14 countries[7].

These dates of the break are largely consistent (see the Annex Table A1) with the ones obtained with alternative test procedures by Benati (2003, 2004), Rapach and Wohar (2002) who implement alternative multi-break tests, as well as with the results of Levin and Piger (2004) and Gadzinski and Orlandi (2004) who test the presence of one break in the mean of inflation after 1984.

However, we should also note that the break dates are not estimated with a high degree of precision (the confidence intervals reported by Benati 2003, 2004; and Rapach and Wohar, 2002) often last a few years). We therefore consider that while the presence of breaks is a robust feature of the data, it seems vain to try to date exactly when the date is taking place. This is why, in the following of the paper, we will analyse all the break dates listed in Table 1, identified on either the CPI inflation series or the GDP deflator inflation. These break dates of a country are just times when something large happened to inflation for that country.

3. Why did the mean of inflation break?

The debate on the origin of changes in the mean of inflation has largely focused on the US experience. Most contributions to this debate point to the role of the monetary policy. For instance, Cogley and Sargent (2001) show that the US low frequency swings in inflation are consistent with the Federal Reserve gradually upgrading its view on the (im)possibility of exploiting an output-inflation trade off. Clarida, Gali and Gertler (2000) show that the major change in US inflation, i.e. the Volker disinflation, coincide with a change in the central bank's reaction function from setting pro-cyclical real interest rates to counter-cyclical ones. Orphanides (2003) argues that the Fed overestimated the decline in trend productivity in the 1970's. Finally, Mojon (2004) shows that monetary policy shocks, as identified with standard VARs, have contributed to the breaks in the mean of inflation.

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[6] The four countries that admit a break both in the late 1960s and the early 1970's are counted only once.
[7] These figures do not add up to 57 because some countries admit more than one break in some of the waves.

In the case of the UK, Benati and Wood (2004) show that over the last one hundred years, the inflation has been notably more persistent and with a noticeably higher mean between 1972 and 1992, a period when the Bank of England did not stress any particular nominal anchor.

Levin and Piger (2004) take an international perspective. They notice that the breaks in the early 1990's coincide with the spreading of inflation targeting. Likewise, nearly half of the OECD countries, that eventually adopted the euro, have pursued lower level of inflation in the nominal convergence process foreseen in the Maastrich treaty[8].

What then for the breaks of the 1970's and 1980's? Replicating the above mentioned US studies for other OECD countries is neither feasible nor desirable. The main reason is that many of these economies have been subject to profound changes in the institutional environment and the implementation of monetary policy. Imposing a constant behavioural framework on the monetary policy decision making process, such as a Taylor rule, would be meaningless. Another approach would consist of keeping track of the monetary policy institutional changes and investigating their effect on inflation. We know that the early and mid-1980's have marked significant changes in the monetary policy regime of several countries in our sample. In addition to the US and the UK, above mentioned, the monetary policy changed in France (Attali, 1996 and Bilke, 2004), in Italy (Gressani et al. 1988) and for Spain and Portugal who joined the CEE (which since then became EU) and pegged to the Deutsche Mark. While, the repetition of historical investigations for each of the 23 countries would be beyond the ambitions of this paper, we have a strong presumption that changes in the mean of inflation reflect some kind of shift in the monetary policy regime. We therefore propose, in the next section, to recourse to an informal analysis of the breaks in the mean of OECD inflation rates that can check this presumption.

[8] This may explain why Ball and Sheridan (2003) do not find much difference between inflation targeters and other OECD countries, many of which tied their monetary policy destiny together.

3.1 Methodology

Basically, we check whether the breaks in the mean of inflation coincide with the breaks in the mean of other economic variables. A first version of this “test” has recently been implemented by Rapach and Wohar (2002) to analyse the effects of changes in monetary regimes on the real interest rate. In essence, Rapach and Wohar compare the dates of breaks in the mean of the real interest rate with dates of breaks in the mean of inflation. Breaks are identified with the Bai and Perron multiple break test separately for each variable, in turn for 13 OECD countries. They find that the breaks in the real interest rate reflect a monetary phenomenon because they largely coincide with the breaks in the mean of inflation. They also stress that breaks when the inflation increases (decreases) to a higher mean correspond to breaks when the mean of the real interest rate decreases (increases). They conclude that the Fisher hypothesis, whereby the equilibrium real interest rate is independent of the level of inflation, is sharply rejected by the data.

To start with, we follow the approach of Rapach and Wohar to test more generally for the long term neutrality of monetary policy regimes. If breaks correspond to shifts in the monetary policy regime, we would expect the mean of all nominal variables to break when the mean of inflation does. Second, if changes in the monetary regime are neutral for real developments, we should see no relation between breaks in the mean of inflation and breaks in the mean of real variables. We also report the timing of the breaks because they may point to some leading indicators of inflation breaks, an information potentially extremely useful for central banks.

This test is however quite demanding because it ignores the information we have on the dates when inflation breaks. Structural changes and specific shocks, i.e. on the velocity of money, can blur the signal that we try to extract by testing for breaks at unknown dates with the procedure of Altissimo-Corradi. We therefore complement our investigation by testing whether the dates of breaks in the mean of inflation mark a significant change in the mean of the other economic variables. This test consists of a Student T of the change in the intercept of an auto-regressive model of the variable of interest.

3.2 Variables of interest

Altogether we test for breaks in the mean of ten variables, five nominal and five real. The nominal variables are the growth rate of M3, the short-term interest rate, the long-term interest rate, the import price inflation and the nominal earnings inflation. Money and the short-term interest rate are associated to monetary policy, either as instruments or operating targets[9]. The long-term interest rate is particularly interesting given that it reflects long run inflation expectations. The test would therefore show whether financial market participants have been able to predict breaks (by definition major shifts) to the mean of inflation.

The import price inflation should encompass shocks to the exchange rate as well as shocks to the commodity prices. Finally, nominal wage inflation is a central link in propagating inflation shocks into persistent changes.

We then choose five real variables among standard "drivers" of Old and New Philips curves and indicators of the monetary policy stance. The Philips curve, be it old or new, remains one of the most popular models of inflation. Stock and Watson (1999) have shown that simple "old fashion" Philips curves perform very well for short horizon forecasts of inflation. All estimated SDGE models rely on a "Philips Curve" transmission mechanism where the gap between supply and demand affects prices (e.g. Smets and Wouters, 2003; and many others).

Philips curve "drivers" include the unemployment rate, the real wage and the real unit labour costs. We do not consider output gaps because these are proxies of deviations for equilibrium. Their mean should be zero, or if not exactly zero, breaks in their mean are meaningless.

3.3 Results

The break dates for the ten variables listed above have been estimated by first implementing the Altissimo-Corradi (2003) multiple breaks test. We summarise the results in Table 2.[10] There, for each wave of inflation breaks, we report the number of countries where the variables of interest admitted a break in their mean, the cross-country averages for the date of break and the magnitude of the break[11]. For instance, in the case of nominal wages in the early 1980's, we observe breaks in 16 of the 17 countries where data are available. The average date of this break in the mean of wage inflation is 1981[12] and its average size is -6.8 %. On the last column we also report the total number of breaks in all three waves and the average lead with respect to when the inflation break took place. Breaks in nominal wages led inflation breaks by one year while the one in the short-term interest rate lag by one year.

[9] To some extent, this approach may be criticised for the first half of our sample (i.e. before 1980) for the countries which financial system was largely administered. For example, Mojon (1999) argues that one cannot consider that the Banque de France used the interbank interest rate as the main device to control market liquidity before the mid-eighties.

[10] The full set of results is available upon request to the authors.

[11] There is hardly any case when a variable admits a break in its mean and inflation either measured with the CPI or the GDP deflator, does not.

Second, we estimated the coefficient associated to a break in the intercept of an AR(4) model at the date when the inflation of the country of interest admits a break. The results of this second test, that we will refer to as the Student T test thereafter, are reported in Table 3.

We stress two general results. First, the coincidence of breaks is usually higher for nominal variables than for real variables according to the Student T test but not with the more demanding “unknown break test” à la Altissimo-Corradi. This confirms that breaks in the mean of inflation are monetary phenomena. Indeed the frequency of significant breaks in the intercepts (Student T above 1.96) at the date when inflation admits a break in its mean is altogether clearly higher for the nominal variables (from 0.42 to 0.72) than for the real variables (from 0.25 to 0.38).

Second, the “unknown date” test (Table 2) shows the break in the mean of inflation is preceded by a break elsewhere only in a few cases. Four variables admit a break in their mean either during the same year as or before inflation does for a majority of countries for one or two of the three waves: import price inflation in 1982, nominal wage inflation in 1969 and in 1981, the growth rate of M3 in 1984 and the real interest rate in 1981. But none leads the break of inflation for the three waves. Also, in the cases of the two variables with the highest coincidence of breaks with the breaks of inflation (the real unit labour cost and the long-term interest rate) we notice an average delay of four years. So again, breaks in the mean of these variables cannot be used to predict breaks in the mean of inflation. In particular, we find interesting that the long-term nominal interest rates do not anticipate major changes in the level of inflation.

Finally, it is also worthwhile noticing the direction of the breaks affecting the real interest rate in the two waves of disinflation[13]. In the 1980’s, the real interest rate increases while in the 1990’s it declines. First, this invalidates the prediction of Rapach and Wohar (2002) that inflation breaks correspond to breaks of opposite sign in the real interest rate[14]. Second, this result highlights the difference in the timing of the break in the real interest rate and inflation for the 1980’s and the 1990’s. While in the 1980’s a sharp increase in the real interest rate may have led to disinflation, in the 1990’s it is the disinflation that eventually resulted in lower real interest rates. This latter disinflation has therefore been credible much faster than the previous one.

Taken together, these results indicate that the breaks in the mean of inflation that we have estimated are “purely monetary phenomena” in the sense that they more often affect the mean of

[12] We report years given the degree of uncertainty on the precise quarter when the break takes place.
[13] The real interest rate is defined as the interest rate minus the current year-on-year inflation in the CPI.
[14] Our sample extends theirs by four years, which may explain why we find more often breaks in the 1990’s than they do.

nominal than the mean of real variables (Table 3). However, breaks in the mean of inflation cannot be systematically associated to any leading "break indicator" (Table 2).

This failure of the unknown date test à la Altissimo-Corradi to identify a common pattern across all breaks with one monetary policy indicator that "almost always breaks with inflation" may be due to the diversity of the monetary policy regimes covered in our sample. It remains that the clustering of breaks to the mean of inflation across countries should be related to some common driving force[15] that affects inflation and not necessarily other nominal variables.

The results above lead us to reject some of the usual suspects such as commodity price shocks or common demand shocks. On the side of commodity prices, we notice that the three waves of breaks in the mean of inflation have been anterior to the well-known oil shocks (up in 1973, 1979 and down in 1986). In addition, we reject that import price inflation (most countries in the sample import most of their commodities) break together with CPI inflation. Common demand shocks (or their international transmission) should be reflected in the inflation of traded products. And again, we should have picked up this phenomenon in import prices.

In any case, we leave the identification of common factors to breaks in the mean of inflation for future research.

4. What do breaks in the mean of inflation do to its persistence in multivariate models?

After having made the case that breaks in the mean of inflation is a feature of the data, we ought to assess whether and how the breaks affect the inflation process. The object of this section is therefore to analyse what these breaks do to standard reduced form models of inflation.

In contrast with most studies of the persistence of inflation, we carry out this analysis in multi-variate models. We take this route because inflation should adjust to monetary and business cycle

[15] Another possibility would be that inflation is contagious.
Contagion may work through trade, if the exchange rate would not adjust inflation differentials between trade partners. This may actually be most relevant for the first wave of breaks which took place mainly before the collapse of the Breton Wood system, and within Europe Monetary System for the second and the third waves. But for other places, given the size of the inflation breaks involved, of the order of 5 %, it would imply large and persistent deviations from relative PPP.
A second channel of contagion would be the credibility of the monetary policy authorities to fight inflation. The latter may have eroded through out the OECD in the 1970's, with the notable exception of Germany. In the early 1980's the Volker-Thatcher disinflation and in the early 1990's the frequent adoption of inflation targeting may have spurred the credibility of low inflation regimes. However, as long as credibility and expectation formation are unobservable, this hypothesis cannot be tested.

developments. In this respect, a clarification of whether and how breaks in the mean of inflation affect the response of inflation to these developments is warranted.

4.1 Variables of interest

We analyse the effect on inflation persistence of a selection of macroeconomic variables that are either indicators of the monetary policy stance and real variables that usually enter "Philips curves"[16]. The former are particularly interesting because persistence has a bearing on the time it takes for monetary policy to affect inflation. Actually, in the typology of three definitions of inflation persistence proposed by Batini (2002) and Batini and Nelson (2002), two reflect the speed of transmission from "monetary policy" to inflation. Here we estimate the effects of the two monetary policy "instruments" and the two monetary policy stance indicators that we introduced in section 3: the short-term interest rate and M3 growth rate both in nominal and in real terms.

We also estimate reduced form Philips curves because, as we argued in section 3.2, these are widely used either as forecasting tools or within more structural models. We cover a wide range of real indicators. We use two measures of the output gap defined as deviations of log output from a linear or from a quadratic trend. We chose these measures of the tensions between demand and the output potential because of their simplicity. We also use the unemployment rate as an indicator of labour market tensions on prices. Then, we estimate models inspired by the recent emergence of "New Philips curves" models. In particular, Galì and Gertler (1999) and Sbordone (2003) derive micro-founded models where inflation is a function of the marginal cost of firms. Empirical estimates of these "New Philips curves" have used either the real unit labour costs or the labour share as proxies of the marginal costs. We will therefore report whether the effect of these variables on inflation is sensitive to breaks in the mean of inflation.

Finally we estimate a model where inflation depends on import price inflation. This model can capture whether and by how much shocks that affect relative prices are transmitted to the price of the full consumption basket. Import prices are particularly relevant because, in practice, such shocks typically originate on in commodity markets or following exchange rate fluctuations.

4.2 New stylised facts for calibration

[16] Appendix Table A1 gives the source and availability of our data.

To get a first sense of the effects of breaks of bi-variate models of inflation, this section reports correlations[17] between the inflation series and leads and lags of the inflation drivers[18]. These cross-correlations are often used to calibrate the parameters of stylised models. Given that the fluctuations studied in these models are derivatives around the steady state of the economy, it seems natural to calibrate them once controlling for breaks in the mean which, arguably, represent shifts in the steady state itself.

This first rough description of the data signals that allowing for breaks in the mean of inflation not only "reduces the persistence/autocorrelation" of inflation but it also strikingly affects its correlation to some of its determinants.

Figure 3 gives, for the US and the euro area, the correlation of inflation with its own leads and lags as well as with the leads and lags of the variables listed above. Each cell chart compares the cross-correlation between the raw inflation and raw series (solid line) to the cross-correlation between demeaned inflation and the raw series (dotted line) and to the cross-correlation where both series are demeaned[19] (broken line). The middle of the cell chart gives the contemporaneous correlation between the two variables. For instance, the correlation of inflation with itself, showed in the top-left corner cell, equals one.

The right end within the cell chart gives the correlation between today's inflation and the other variable 10 quarters ago, i.e. positive numbers on the right of the cell chart indicates that increases in the variable lead increases in inflation. Given that we usually have between 60 and 130 observations, correlation coefficients above about 0.25 in absolute value are statistically significant.

First, the correlations between inflation and several of its determinants drop from significant levels to non-significant ones. The most striking such drops are observed for nominal M3 growth, the nominal and real interest rates, the real unit labour cost, import prices and, in the case of the

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[17] Arguably these correlations could be spurious if inflation and the other variable have unit roots and different stochastic trends. We however dismiss the argument that inflation has an economically meaningful unit root (see footnote 3). Moreover, we relate inflation to variables that we chose because economic theory predicts that they should have a relation to inflation so that a significant correlation in the data should not be a spurious phenomenon.

[18] See Stock and Watson (1999) for a similar approach to describe stylised facts in the U.S. business cycle and Agresti and Mojon (2003) for a comparison of the U.S. and the euro area business cycles. Both papers document the high auto-correlation of inflation at business cycle frequencies and that inflation lags GDP by two to three quarters. However, an important difference of our approach with these papers is that we do not filter the data to focus on business cycles frequencies only.

[19] We implememt the Altissimo-Corradi test to check whether the time series of the inflation determinants are characterised by breaks in their mean. See section 3. Through out the text we refer to a demeaned variable as the difference between the raw variable and its "breaking" mean.

euro area, the unemployment rate. Hence, these variables contain little information on inflation outside the "break of inflation" itself.

Second, the output gap, and to a lesser extent the import price consistently lead inflation by two to four quarters whether or not the inflation process has been demeaned. This correlation is robust to shifts in the mean of inflation, i.e. to what several economists describe as changes in the monetary policy regime. In this sense, the output gaps lead of inflation by two to four quarters is a "structural"[20] feature of the data that is very useful to build robust short horizon forecasts of inflation.

These results are not limited to the U.S. and the euro area taken as an aggregate. Table 4 summarises[21] similar correlation that we computed for all the 23 countries focusing on the most relevant horizons (e.g. the correlation between current inflation and 8 quarters-lagged M3 or 2 quarters-lagged output gaps). The bottom of each column reports the average difference between the correlation and the number of countries for which we observe a drop superior to 0.2 of the correlation coefficient.

There is hardly any country where the correlation between the current output gaps and two quarters lead of inflation drops. On the contrary, the correlation between current nominal M3 growth and two years-ahead inflation drops significantly in 18 of the 23 countries considered. Also, in 9 out of 14 countries, there is a significant drop between the real unit labour cost and inflation.

A striking aspect of the results is the difference between the way the output gaps and the real unit labour costs affect/lead inflation. While the output gaps lead both headline and demeaned inflation, the lead correlation of the real unit labour cost with inflation holds only for the raw inflation series. Hence the information content of the real unit labour cost on inflation is more similar to the one born out in M3 than in the output gap. One possible explanation would be that the real unit labour cost may be a better approximation of the low frequency changes in the marginal cost than of its high frequency changes. As suggested by Mc Adam and Willman (2003), such changes may reflect long run shift in sectoral composition rather than cyclical tensions.

4.3 Low persistence in univariate models

[20] See the discussion of Estrella and Fuhrer (2003) on the alternative use of structural to qualify economic relations between variables.

[21] The full set of results is available upon request.

Before plunging into the multivariate analyses, we recall what a growing consensus establishes as the key stylised fact of inflation dynamics: conditional on breaks in its mean, inflation is not a persistent process. As argued in the introduction, it is rather intuitive that allowing for breaks in the mean of a process reduces its measured persistence. The more the mean of a time series changes, the more frequent will this process mean revert. In the case of two simple AR models of inflation (1) with a constant intercept and (1'), where we allow for breaks in the intercept, we should obtain a lower estimate of *ρ'*, the sum of its autoregressive coefficients, a standard measure of persistence[22], than estimating *ρ* in (1).

(1) $$\Delta p_t = \mu + \rho \Delta p_{t-1} + \sum_{i=1}^{K-1} \gamma_i \Delta^2 p_{t-1} + \varepsilon_t$$

(1') $$\Delta p_t = \mu_0 + \sum_{bk=1}^{Nbk} \mu_{bk} + \rho' \Delta p_{t-1} + \sum_{i=1}^{K-1} \gamma'_i \, \Delta^2 p_{t-i} + \varepsilon'_t$$

with Δp_t the inflation rate, $\Delta^2 p_t$ first difference of inflation*, Nbk* the number of breaks in the intercept/mean of inflation over the sample period, *K* the order of the autoregressive process, and ε_t a residual.

This result is quite general as showed by several recent multi-country studies on univariate models of inflation (e.g. Levin and Piger, 2004; Gadzinski and Orlandi, 2004; Cecchetti and Debelle, 2004; and Benati, 2003, 2004). And we largely confirm this finding.

On average across countries, *ρ* is about 0.90[23] with a constant intercept and about 0.57 with an intercept that breaks at the dates identified with the Altissimo-Corradi test. Figure 2 (obtained under the simplifying assumption that inflation can be characterised by a first order autoregressive process) illustrates the width of the gap in the response of the two processes to shocks. In the "0.57 persistence" case a shock to inflation dies out within a year, while in the "0.9 case", 60% of the initial shock still affects inflation after four quarters.

[22] This particular measure of persistence has the advantage the model we use to estimate it is a nested in multivariate AR models of the inflation process.
[23] These estimates are based on plain OLS. They do not vary whether estimating (1) and (1') over the full sample of 170 observations (1960-2003), the post 1970, the post 1980 or the post 1985 samples. Given that most of the paper analyses large cross-section of estimates (across countries, sample period, variables,…), we stick to OLS estimations. We have checked that the cross-section of OLS estimates of persistence parameters are perfectly correlated with the more sophisticated Hansen's grid bootstrap estimates of persistence.

Second, we also confirm that, in the vast majority of cases (51 out of 57, see Table 5), the equation (1') is stable: conditional on allowing for the breaks in the mean of inflation process, the persistence of inflation is low and stable. Hence, the persistence of inflation in the OECD countries has not been changing over time. Equivalently, if one focuses on short enough sample periods, say for a monetary policy regime that is homogenous with respect to the mean of inflation, inflation is usually not persistent.

4.4 Low persistence in multivariate models

Let's now consider that inflation depends on other economic variables y_t. Inflation adjusts with some lags to an inflation target, and depends on an exogenous inflation driver y_t, as in

$$\Delta p_t = \tau + \alpha(L)\Delta p_t + \gamma(L) y_t$$

with L the lag operator and $\alpha()$ and $\gamma()$ some polynomials.

A particular version of this model, using again the Wald decomposition to recover the sum of the coefficients on the lags of each explanatory variable, is given by

(2) $$\Delta p_t = \tau + \alpha \Delta p_{t-1} + \sum_{i=1}^{K-1} \alpha_i \Delta^2 p_{t-1} + \gamma y_t + \sum_{i=0}^{K'-1} \gamma_i \Delta^2 y_{t-1} + \vartheta_t \,.$$

4.4.1 Robustness of the breaks

The first series of tests we conduct is to check whether the breaks in the mean of inflation that have been identified using univariate models such as (1') can be rejected for standard bi-variate models of inflation such as (2). This basically amounts to estimate (2') and check whether τ_{bk} are significantly different from zero.

(2') $$\Delta p_t = \tau_0 + \sum_{bk=1}^{Nbk} \tau_{bk} + \alpha' \Delta p_{t-1} + \sum_{i=1}^{K-1} \alpha'_i \Delta^2 p_{t-1} + \gamma' y_t + \sum_{i=0}^{K'-1} \gamma'_i \Delta^2 y_{t-1} + \vartheta'_t$$

For this estimation, we add to the equation as many dummy variables as break dates, allowing the intercept to take different values between break dates (as in Figure 1).

Table 6 reports the cross-country average of the Student T associated to the coefficients τ_{bk} that pick up potential changes in the intercept of the equation. The average Student T for changes in the intercept of inflation is well above two on average for all the bi-variate models of inflation.

Moreover, this high average reflects significance of the change in the mean for more than three breaks out of four.

These results confirm that breaks in the mean of inflation that have been identified on the basis of univariate tests are not artefacts due to omitting some variables that determine inflation.

4.4.2 Robustness of the low persistence of inflation

We then investigate the effects of breaks on the persistence of the response of inflation to economic shocks. For this we first assume that the driver variable follows an autoregressive model:

(3) $$y_t = \omega + \theta y_{t-1} + \sum_{i=1}^{K} \delta_i \Delta y_{t-i} + \eta_t$$

In case the driver variable would have admitted breaks in its mean, this model can be re-written as

(3’) $$y_t = \omega_0 + \sum_{bk=1}^{Nbk} \omega_{bk} + \theta' y_{t-1} + \sum_{i=1}^{K} \theta'_i \Delta y_{t-i} + \eta'_t \ .$$

The two equations systems (2)-(3) and (2’)-(3’) admit two types of shocks. Shocks to the inflation equation itself and shocks to the equation of the other variable. Given our simplifying assumption that inflation does not affect the other variables, we can characterise the response of inflation to these two shocks as follow. In the case of a shock to the inflation equation (ϑ_t), the response of inflation depends only on *α(L)*, i.e. the own persistence of the inflation process. The case of a shock to the equation of the driver, the response of inflation is more complex as it depends also on γ*(L)* and on the persistence of the driver itself*,* θ in equation (3).

The univariate models-based measures of persistence (ρ) that we (and many others) have analysed by estimating (1) and (1’) depends on three factors *α(L),* γ*(L)* and θ .[24] We can therefore disentangle whether the persistence of inflation is driven by the “own” persistence of the inflation (α), the persistence of the driver (θ) or the effects of the driver on inflation (γ).

We proceed in three steps. First, we estimate the time series models of inflation and its driver without breaks, i.e. we estimate (1), (2) and (3). This provides us with estimates of α, γ, θ and ρ for each of our 23 countries. Second, we estimate the same set of parameters in a world with

[24] See also Hamilton (1994) chapter 3 and Whelan (2004) for a more thorough discussion of the sources of persistence.

exogenous breaks, using the 57 break dates reported in Table 1. We obtain τ_{bk}, α', γ', ω_{bk}, θ' and ρ' from estimating equations (1'), (2') and (3')[25].

Table 7 reports the cross-country averages of sum of the four autoregressive coefficients of inflation α, the sum of the coefficients of four lags of the driving variables γ, and the sum of the autoregressive coefficients in the AR model of the driving variable θ. We also report the cross-country mean of these parameters when we admit breaks in the intercept of the equation, the difference between the means of two estimates (α'- α), (γ' – γ) and (θ'- θ), the number of countries where this difference is larger than twice the standard error of the parameter estimates and the correlation between (ρ'- ρ) and (α'- α), (γ' – γ) and (θ'- θ).

We find first that, across the board, admitting breaks in the intercept leads to a sharp decline of the own persistence of inflation in a large majority of countries. This is actually the case in 171 out of 199 equations (2 and 2') that we estimate. In contrast, (γ' – γ) is significant only in a minority of countries and (θ'- θ) drops in about one half of the countries, depending on the variable considered.

The drop in the own persistence of inflation implies that the effects of shocks to the inflation equations return to baseline much faster in the world with breaks (see Figure 2). The response of inflation to shocks affecting the driver variables is also faster. However, this acceleration depends also on the persistence of the driver variable itself. For instance, the acceleration of inflation response to M3 shocks because we control for breaks in the mean of inflation is larger than the response to output gap shocks. This is because the M3 growth is less persistent than the output gap and the persistence of M3 also drops. However, even in a model where inflation depends on the output gap, the half-life of the impulse response of inflation decreases due to the drop in the own persistence of inflation.

Second, we notice that for some of the driver variables, γ becomes insignificant in the model with breaks. To start with, γ is usually not significant. The cross-country average of the student T of the sum of the four lags of the driver variables is usually greater than two only for the nominal and real M3 and for the real wage. For the most inflation determinants, we find no consistent evidence that they have a significant impact on inflation. This somewhat negative result is however consistent with the forecasting literature that stresses the "impossibility" of finding a universally accurate leading indicator of inflation. It remains that the significance drops for M3

[25] All the parameters are estimated for the longest period of availability of the driver variable, using breaks at the dates reported in Table 1. All estimates of (2), (2'), (3) and (3') include four lags of the variables

and the real wage as well as for the real unit labour cost in a majority of the countries where it is found significant in the model without breaks. In contrast, we note that the significance of the effects of the output gap on inflation improves. These results nicely recoup the correlation analysis of section 4.2.

Third, the persistence of most real variables is hardly affected by allowing for breaks in their mean at the time when inflation itself admitted breaks. In addition, the correlation between (θ'- θ) and (ρ'- ρ) is very low for most variables[26]. Hence, breaks in the mean of inflation have a larger effect on the response of inflation to nominal shocks than to real ones.

5. Conclusion

This paper has analysed the inflation process between 1960 and 2003 in 22 countries and the euro area. The first part of the paper identified breaks in the mean of inflation and a selection of nominal and real variables with a bearing on inflation. The second part estimated the effects of breaks in the mean of inflation on the persistence of inflation, including in terms of the speed of its response to monetary conditions and the business cycle.

We stressed six original results and point out one important challenge for future research.

First, inflation of any OECD country has been subject to two, three or four breaks in its mean since 1960. These breaks are robust in both univariate and (a set of) multivariate models of inflation. Second, the breaks are often neutral monetary phenomenon. They are more frequently (across countries) accompanied by breaks in the mean of nominal variables than by breaks in the mean of real variables. Third, none of the inflation determinants we analysed break systematically before inflation does. Hence no variable alone appear as a potentially leading indicator of breaks in the mean of inflation. Fourth, the conditional on break low persistence of inflation is also robust in multivariate models of inflation. The response of inflation to shocks to the output gaps or to the growth rate of money is actually faster in the model with breaks. While the change in the response is more substantial for monetary policy indicators than for business cycle ones, the response of inflation to every single variable is faster once we control for breaks in its mean. This result implies that models that ignore breaks in the mean of inflation may overrate the time it takes for inflation to adjust to shocks.

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involved.

Fifth, we show that the breaks have dramatic effects for some determinants / leading indicators of inflation. The correlation between inflation and either M3 growth or the real unit labour cost is weakened once we allow for breaks in the mean of inflation. In contrast, the correlation with the output gap is robust to the inclusion of breaks in the mean of inflation. This correlation may therefore be seen as a structural feature of the data in the sense that it does not depend on changes in the monetary policy regime.

Last but not least, the breaks have clustered in three waves, around 1970, around 1982 and around 1991. This last result suggests that either a common shock has driven the long swings of inflation that we observed in the last forty years or that inflation and dis-inflation are "contagious". The research that will identify this common shock or formalise the contagion of inflation across countries will be useful and, almost certainly, successful.

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[26] The two exceptions are the real interest rate and the real unit labour cost. The persistence of both variables declines markedly and, in the case of the latter, we also note a fairly high cross-country correlation between (θ'- θ) and (ρ'- ρ).

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List of abbreviations

Countries		Variables	
EA	Euro area	dcpi	CPI inflation
		dp_gdp	GDP deflator inflation
AT	Austria		
BE	Belgium	nominal	
DE	Germany	dw	Growth rate of nominal earnings
ES	Spain	dmp	Import price inflation
FI	Finland	dm3	Growth rate of M3
FR	France	IRS	Short-term interest rate
GR	Greece	IRL	Long-term interest rate
IE	Ireland		
IT	Italy		
LU	Luxembourg		
NL	Netherlands	real	
PT	Portugal	YGL	Output gap: deviation of Log(GDP) from a linear trend
		YGQ	Output gap: deviation of Log(GDP) from a quadratic trend
DK	Danemark	drw	Growth rate of real earnings
SE	Sweden	rulc	Log real unit labour cost
UK	United Kingdom	drm3	Growth rate of real M3
		RIRS	Real short-term interest rate
US	United States	UNR	Unemployment rate
JP	Japan	dlbs	Labour share
AU	Australia		
CA	Canada		
NZ	New Zealand		
NO	Norway		
CH	Switzerland		

Table 1: Breaks in the mean of CPI/HICP and GDP deflator inflation

	wave 1						wave 2			wave 3			
	late 1960s			early 1970s			mid 1980s			early 1990s			
EA				3.60	72Q2	9.81	9.81	85Q2	3.04	4.69	93Q2*	2.06	
AT				3.42	71Q1	5.82	5.82	84Q3	2.20				
BE				2.98	71Q2	7.03	7.03	85Q1	2.04				
DE							4.76	82Q3*	2.78	2.78	95Q3*	0.82	
ES				6.15	72Q4	15.36	15.36	82Q2	9.60	6.33	92Q3*	3.57	
							9.60	*86Q3*	*4.10*				
FI				4.99	72Q3	10.42	10.42	85Q1	2.64	5.79	90Q3*	1.81	
FR				4.24	73Q1	10.00	10.00	85Q2	2.09				
GR				2.42	72Q4	16.61				16.61	93Q2	5.24	
IE				5.19	72Q2	13.67	13.67	84Q2	3.14				
IT				3.99	72Q2	13.75	13.75	85Q4	3.91				
LU	2.25	69Q3	6.56				6.56	85Q2	2.03				
NL	3.66	68Q1	6.66				6.66	82Q2	2.16				
PT				4.26	70Q4	14.97	20.96	85Q1	10.54	10.54	92Q2	3.64	
				14.97	*76Q2*	*20.96*							
DK				5.67	72Q4	9.48	9.48	85Q1	2.62	4.16	91Q1*	1.85	
SE	3.67	69Q4	8.04							8.04	91Q4	1.58	
UK	3.74	69Q4	8.95	8.95	74Q1	13.22	13.22	81Q4	5.65	5.65	91Q1	2.57	
US	1.75	67Q3	4.61	4.61	73Q1	8.37	8.37	82Q2	3.06				
JP				5.41	72Q3	8.02	8.02	81Q2	0.98	2.30	92Q2*	-0.82	
AU				2.50	70Q3	8.76				8.76	90Q4	2.36	
CA				2.82	72Q2	9.21	9.21	82Q3	4.47	4.47	91Q2	1.83	
NZ	3.34	69Q4	8.40	8.40	74Q1	13.91	13.91	82Q3	8.82	8.82	90Q2	1.87	
NO	3.54	69Q1	8.07				8.07	88Q3	2.51				
CH										3.74	93Q2	0.86	
Number of breaks													Total
		7			17			19			14		57
Average inflation before and after the break													
	3.1		7.3	5.3		11.6	10.2		3.9	6.6		2.1	

Note: Authors calculation (see the main text). * break in the mean of the GDP deflator inflation

Table 2: Breaks in the mean of selected inflation drivers / leading indicators

Inflation series		wave 1 1960-1970	wave 2 1980	wave 3 1990	All
dcpi	Data availability	23	23	23	69
	# breaks	**21**	**18**	8	47
	average year	**69**	**84**	92	
	average break	5.2	-6.6	-5.8	
Nominal variables					
dMP	Data availability	16	21	21	58
	# breaks	0	**10**	1	11
	average year or lead	-	**82**	92	1
	size of break (%)	-	**-11**	-9	
dw	Data availability	16	17	21	54
	# breaks	**9**	**16**	7	**32**
	average year or lead	**69**	**81**	93	1
	size of break (%)	**6.1**	**-6.8**	-9.2	
IRS	Data availability	12	23	21	56
	# breaks	2	3	**18**	23
	average year or lead	74	83	**94**	-2
	size of break	6.1	-1.6	**-6.7**	
dm3	Data availability	19	20	23	62
	# breaks	0	**15**	**11**	26
	average year or lead	-	**84**	**93**	-1
	size of break (%)	-	**-5.0**	**-4.2**	
IRL	Data availability	21	21	23	65
	# breaks	**18**	8	**20**	**46**
	average year or lead	**75**	86	**96**	-4
	size of break (%)	**3.9**	-1.6	**-4.0**	

		wave 1 1960-1970	wave 2 1980	wave 3 1990	All
dp_gdp	Data availability	9	18	21	48
	# breaks	1	**12**	9	22
	average year	78	**85**	92	
	size of break	5.2	-5.0	-4.2	
Real variables					
UNR	Data availability	6	20	21	47
	# breaks	2	3	6	11
	average year or lead	76	86	95	-4
	size of break (%)	2.9	2.5	-0.8*	
drw	Data availability	16	19	19	54
	# breaks	12	none	none	12
	average year or lead	76	-	-	
	size of break (%)	75.7	-	-	
RIRS	Data availability	18	23	23	64
	# breaks	5	**18**	**16**	**39**
	average year or lead	72	**81**	**95**	0
	size of break (%)	-5.0	**5.0**	**-3.7**	
drm3	Data availability	19	23	23	65
	# breaks	1	2	3	6
	average year or lead	79	81	91	0
	size of break (%)	-4.5	0.4*	-0.3*	
rulc	Data availability	3	16	14	33
	# breaks	**3**	6	**8**	**17**
	average year or lead	76	87	**96**	-4
	size of break (%)	2.4	-9.2	**-7.5**	

Note: for each "wave" number of countries where the data is available, number of countries where we cannot reject at least a break in the mean for that period and average year of occurence of the break. For "All" averages lead with respect to the break of inflation in years.

bold characters signal variables for which we cannot reject a break in more than half of the countries

[green shading] indicates anteriority or coincidence with the average year when inflation breaks

* indicates breaks of opposite signs accross countries

Table 3: Breaks in the mean of selected inflation drivers / leading indicators

		wave 1 1960-1970	wave 2 1980	wave 3 1990	All			wave 1 1960-1970	wave 2 1980	wave 3 1990	All
Nominal variables						Real variables					
dMP	Data availability	16	20	21	57	UNR	Data availability	6	20	22	48
	# breaks	-	15	13	28		# breaks	-	5	11	16
	average Student T	-	-2.47	-0.47	-1.47		average Student T	-	0.08	0.07	0.08
	t>1.96	-	11	3	14		t>1.96	-	2	2	4
	frequency	-	0.73	0.23	0.48		frequency	-	0.40	0.18	0.29
dw	Data availability	16	17	21	54	drw	Data availability	16	17	21	54
	# breaks	12	17	13	42		# breaks	12	17	13	42
	average Student T	1.70	-2.90	-3.35	-1.52		average Student T	-1.98	-0.10	0.12	-0.65
	t>1.96	6	11	13	30		t>1.96	7	4	4	15
	frequency	0.50	0.65	1.00	0.72		frequency	0.58	0.24	0.31	0.38
IRS	Data availability	20	23	23	66	RIRS	Data availability	20	23	23	66
	# breaks	8	19	14	41		# breaks	8	19	14	41
	average Student T	1.54	-1.39	-2.53	-0.79		average Student T	-0.15	0.98	-1.63	-0.27
	t>1.96	1	5	12	18		t>1.96	1	5	5	11
	frequency	0.13	0.26	0.86	0.42		frequency	0.13	0.26	0.36	0.25
dm3	Data availability	22	22	23	67	drm3	Data availability	22	22	23	67
	# breaks	18	18	13	49		# breaks	18	18	13	49
	average Student T	1.17	-2.06	-2.55	-1.15		average Student T	-2.05	0.87	-0.67	-0.61
	t>1.96	6	9	8	23		t>1.96	8	5	4	17
	frequency	0.33	0.50	0.62	0.48		frequency	0.44	0.28	0.31	0.34
IRL	Data availability	20	21	23	64	rulc	Data availability	3	16	14	33
	# breaks	15	17	13	45		# breaks	-	7	9	16
	average Student T	1.77	-1.80	-2.46	-0.83		average Student T	-	-1.25	-1.36	-1.30
	t>1.96	5	10	11	26		t>1.96	-	3	3	6
	frequency	0.33	0.59	0.85	0.59		frequency	-	0.43	0.33	0.38

Note: for each "wave" number of countries where the data is available, number of breaks, average Student T on the breaks in the intercept of equation (2'), number of Student T when t>1.96 and their frequency.

Table 4: Cross-correlations CPI / inflation drivers: cross-country averages

Autocorrelations

	lags	dcpi	dcpi'	*c(dcpi',dcpi') - c(dcpi,dcpi)*	$\#\lvert\Delta corr\rvert>0.2$
dcpi	2	0.83	0.52	-0.32	18

Cross-correlations CPI / inflation drivers

	lags	dcpi	dcpi'	*c(dcpi',driver) - c(dcpi,driver)*	$\#\lvert\Delta corr\rvert>0.2$		dcpi'	*c(dcpi',driver') - c(dcpi,driver)*	$\#\lvert\Delta corr\rvert>0.2$
Indicators of monetary policy stance									
IRS	8	0.15	0.01	-0.13	0	IRS'	-0.06	-0.21	0
RIRS	8	-0.22	0.01	0.24	10	RIRS'	0.00	0.23	10
dm3	8	0.49	0.14	-0.35	18	dm3'	0.08	-0.41	15
drm3	8	0.10	0.14	0.04	1	drm3'	0.13	0.03	2
Reduced form Philips curves									
YGL	2	0.21	0.19	-0.02	4				
YGQ	2	0.21	0.21	0.00	2				
UNR	2	-0.23	-0.15	0.08	8	UNR'	-0.10	0.13	8
drw	2	0.05	-0.01	-0.06	3	drw'	-0.06	-0.11	5
rulc	2	0.38	0.09	-0.28	9	rulc'	0.06	-0.32	8
dlbs	2	0.10	0.14	0.04	0	dlbs'	0.14	0.04	0
dMP	2	0.37	0.18	-0.19	13	dMP'	0.19	-0.19	13
average		0.15	0.09	-0.06	6		0.04	-0.09	7

Note: Primes indicate that the correlation is computed with the demeaned series. The second column reports averages of the correlations between CPI and inflation drivers, the third column gives the correlation between the demeaned CPI and inflation drivers, and the fourth column their difference. The fifth column gives the number of countries where the difference is larger than 0.2. The sixth column gives averages of the correlation between the demeaned CPI and its demeaned inflation driver, the seventh column the difference between the first column and the eight column, and the last column reports the number of countries where this difference is larger than 0.2.

Table 5: Stability of inflation persistence parameters

	wave 1		wave 2	wave 3
	late 1960s	early 1970s	mid 1980s	early 1990s
EA		0.01	0.02	0.21
AT		0.00	0.44	
BE		0.06	0.39	
DE			0.25	0.58
ES		0.01	0.07	0.22
			0.17	
FI		0.00	0.26	0.32
FR		0.25	0.51	
GR		0.45		0.46
IE		0.99	0.49	
IT		0.91	0.01	
LU	0.31		0.65	
NL	0.02		0.72	
PT		0.66	0.22	0.81
		0.15		
DK		0.16	0.33	0.72
SE	0.76			0.68
UK	0.44	0.69	0.66	1.00
US	0.77	0.71	0.01	
JP		0.00	0.75	0.54
AU		0.67		0.41
CA		0.10	0.71	0.63
NZ	0.99	0.63	0.84	0.90
NO	0.05		0.95	
CH				0.30

Note: results of the Chow test on the stability of the parameters of equation (1'). The "total" sample covers the two samples around the break date reported in Table 1.

indicates rejection of stability

Table 6: Robustness of the breaks in the mean of inflation in bi-variate models

	# breaks	average Student T	*t>1.96* #	frequency
Indicators of monetary policy stance				
IRS	36	3.13	28	0.78
RIRS	36	2.88	29	0.81
dm3	43	2.99	30	0.70
drm3	43	3.42	35	0.81
Reduced form Philips curves				
YGL	28	2.72	19	0.68
YGQ	28	2.78	22	0.79
UNR	26	3.27	22	0.85
drw	40	3.10	33	0.83
rulc	20	2.35	13	0.65
dlbs	21	2.73	15	0.71
dMP	30	2.47	19	0.63
average	32	2.89	24	0.75

Note: Average Student T on the breaks in the intercept of equation (2'). The number of breaks vary due to change in the availability of the data.

Table 7: Bi-variate regressions CPI / inflation drivers: cross-country averages of inflation "own persistence", driver effect and driver persistence

	ρ	ρ'	$\rho' - \rho$	# >2σ
dcpi	0.84	0.61	-0.23	18

	Own inflation persistence					Effect of the "driver" on inflation							Persistence of the driver				
	α	α'	$\alpha' - \alpha$	# >2σ	$c(\alpha' - \alpha, \rho' - \rho)$	γ	γ'	$\gamma' - \gamma$	# >2σ	$c(\gamma' - \gamma, \rho' - \rho)$	$\gamma(1-\alpha)^{-1}$	$\gamma'(1-\alpha')^{-1}$	θ	θ'	$\theta' - \theta$	# >2σ	$c(\theta' - \theta, \rho' - \rho)$
Indicators of monetary policy stance																	
IRS	**0.83**	**0.61**	-0.22	14	0.52	0.04	-0.01	-0.05	9	-0.01	0.24	-0.03	**0.95**	**0.74**	-0.21	18	0.09
RIRS	**0.86**	**0.65**	-0.21	16	0.40	0.01	0.06	0.06	8	0.14	0.04	0.18	**0.89**	**0.71**	-0.18	15	-0.04
dm3	**0.79**	**0.60**	-0.19	17	0.29	**0.12**	0.05	-0.06	8	-0.33	0.55	0.13	**0.89**	**0.72**	-0.17	19	0.20
drm3	**0.90**	**0.62**	-0.28	21	0.16	**0.08**	0.04	-0.04	6	0.02	0.84	0.11	**0.79**	**0.76**	-0.03	4	0.23
Reduced form Philips curves																	
YGL	**0.79**	**0.53**	-0.27	17	0.37	0.08	**0.11**	0.03	4	0.01	0.41	0.23	**0.92**	**0.92**	0.00	0	0.16
YGQ	**0.83**	**0.55**	-0.27	17	0.37	0.07	**0.12**	0.05	3	-0.11	0.38	0.26	**0.87**	**0.87**	0.00	0	0.16
UNR	**0.77**	**0.55**	-0.22	13	0.00	-0.17	-0.13	0.04	4	0.16	-0.74	-0.29	**0.97**	**0.93**	-0.04	7	-0.08
drw	**0.89**	**0.57**	-0.32	18	0.64	**0.16**	0.09	-0.07	2	0.22	1.42	0.20	**0.50**	**0.32**	-0.18	10	0.16
rulc	**0.77**	**0.58**	-0.19	8	0.33	0.05	0.05	0.00	3	-0.02	0.21	0.11	**0.96**	**0.81**	-0.14	8	0.57
dlbs	**0.88**	**0.62**	-0.26	12	0.39	0.07	0.12	0.05	1	-0.18	0.55	0.31	**0.60**	**0.60**	0.00	0	-0.29
dMP	**0.88**	**0.64**	-0.24	16	0.53	0.02	0.02	0.00	2	-0.09	0.16	0.05	**0.55**	**0.42**	-0.13	5	0.38
average *	0.83	0.59	-0.24	15	0.36	0.09	0.08	0.00	5	-0.02	0.58	0.19	0.81	0.71	-0.10	8	0.14

Note: The first two columns of each panel report cross-country averages the estimated parameters of equations (2), (2'), (3) and (3') presented in the text, and the third column their difference. Primes indicate that breaks in the intercepts at the dates reported in Table 1 are allowed for. The fourth column of each panel gives the number of countries where the difference is larger than two standard deviations of the parameter estimates. The last column of each panel gives the cross-country correlation between the break inclusion induced change in the parameter and the change in the univariate measure of persistence.

* for γ and $\gamma(1-\alpha)^{-1}$, the average is based on all variables except the interest rates for which the coefficient has the wrong sign and the opposite of the unemployment coefficients

Bold characters indicate significance of cross-country averages of t-stat (with t-stat>1.55)

All estimations are standard OLS on the longest sample of availability of the data. They all include 4 lags of the variables involved. The detailed results are available upon request.

Annex Table A1: Data availability

code	CPI	YER	YED	MPD	EAR	ULCi	LBS	UNR	M3	IRS	IRL
label	Consumer Price Index	Real GDP	GDP Deflator	Import Prices Deflator	Hourly Earnings	Unit Labour Costs Index	Labour share	Unemployment Rate	Monetary Aggregate M3	Short-term Interest Rate (3 month)	Long-term Interest Rate (10 years)
frequency	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
unit	1995=100				1995=100	2000=100		%		%	%
source	OECD (MEI)	Eurostat (ESA) /OECD	Eurostat (ESA) /OECD	Eurostat (ESA) /IMF (IFS)	OECD (MEI)	Eurostat (ESA) /OECD (MEI)	Eurostat (ESA) /OECD (QNA)	Eurostat (ESA) /OECD (MEI)	ECB /IMF /OECD (MEI)	REUTERS /OECD (OEO)	REUTERS /OECD (MEI)
adjustment	NSA	SA	SA	SA /NSA	NSA	SA	SA	SA	NSA		
EA	60	70	70	70	70 SA	70	70	70	70	70	70
AT	60	88	88	88	60	88	88	93	60	67	65
BE	60	80	80	80	80	81	80	82	60	60	60
DE	60	91	91	91	60	91	91	92	65	60	60
R1		70	70	70				82			
ES	60	80	80	80	81	80	80	83	62	77	66
FI	60	75	75	75	60	75	75	88	63	70	61
FR	60	78	78	78	60	78	78	82	60	70	60
GR	60	70	70	70				98	60	60	97
IE	60	97 NSA	97 NSA	57	60			82	60	75	85
IT	60	70	70	80	60	70	70	82	63	71	60
LU	60				80			82	70	60	94
NL	60	77	77	77	70	87	77	82	60	60	60
PT	60	95	95	95				83	67	66	66
DK	60	77	77	77	71	77	77	82	89	79	60
SE	60	93NSA	93NSA	93	71			83	60	82	60
UK	60	70	70	70	63	80	70	82	63 SA	69	60
US	60	70	70	57	60	60	70	60	60 SA	60	60
JP	60	80	80	57	60	60	80	60	60 SA	69	66
AU	60	70	70	57	83		70	70	60 SA	68	69
CA	60	81	81	57	60	70	70	70	60 SA	60	60
NZ	60	87	87	57	89			85	60	74	70
NO	60	78	78	57	60			72	60	79	62
CH	60	80	80	64				91	60	74	60

(grey shading) confidential data

Annex Table A2:

Consistency of our break dates for the mean of inflation with the ones found by Benati (2003,2004), Rapach and Wohar (2002), Orlandi and Gadzinski (2004) and Levin and Piger (2004)

	late 1960s					**early 1970s**					**mid 1980s**					**early 1990s**						
	C&M	Benati 1	Benati 2	Benati 3	R&W	C&M	Benati 1	Benati 2	Benati 3	R&W	C&M	Benati 1	Benati 2	Benati 3	R&W	C&M	Benati 1	Benati 2	Benati 3	R&W	G&O	L&P
U2	n.a.	n.a.	n.a.	n.a.	n.a.	72Q2				n.a.	85Q2	82-85	83-85		n.a.	93Q2*	91-93	90-94		n.a.	93Q2 (93Q2*)	n.a.
AT			62-73		n.a.	71Q1				n.a.	84Q3		84-91		n.a.					n.a.	95Q3*	n.a.
BE		63-64		61-66		71Q2	73-76	69-73		71-73 75-79	85Q1		83-87		84-85						94Q3*	n.a.
DE		68-72	65-69	n.a.	n.a.					n.a.	82Q3*	81-85			n.a.	95Q3*		87-96		n.a.	94Q4*	95Q2*
ES			65-70		n.a.	72Q4	69-73	72-83		n.a.	82Q2, 86Q3	83-84	81-86		n.a.	92Q3*	94-97			n.a.	92Q2*	n.a.
FI					n.a.	72Q3	71-73	68-85		n.a.	85Q1	80-82	68-85		n.a.	90Q3*		89-92		n.a.	91Q2 (90Q4*)	n.a.
FR					67-69	73Q1	71-75£	72-75		73-73	85Q2	82-84£	82-85£	82-84	84-84		88-92£	91-95		91-93	92Q2	93Q2*
GR		n.a.	n.a.	n.a.	n.a.	72Q4	71-73	72-73	n.a.	n.a.					n.a.	93Q2	92-93	90-95	n.a.	n.a.	93Q2 (93Q3*)	n.a.
IE						72Q2	68-72	71-73		71-74	84Q2	81-82	82-85		84-84							n.a.
IT		65-68	60-66	47-65		72Q2	72-75	72-72	70-79	72-73	85Q4	82-83	81-84		84-84					91-94	95Q3 (91Q2*)	95Q2 (91Q3*)
LU	69Q3	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	85Q2	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.		n.a.
NL	68Q1	70-70	68-71	67-73	69-73					75-79	82Q2			83-89	81-83			88-91			88Q4 (99Q2*)	88Q1 (90Q4)
PT						70Q4&76Q2	70-70 76-80	73-74	69-84		85Q1	84-85	83-86	69-84		92Q2	91-93	91-93			92Q2	n.a.
DK						72Q4	74-77	72-74		71-74	85Q1	82-83	81-84		82-83	91Q1*	89-90	88-93		89-91	90Q1 (90Q2*)	n.a.
SE	69Q4		67-72		n.a.					n.a.					n.a.	91Q4		90-95	86-97	n.a.	93Q2 (93Q2*)	93Q1 (90Q3*)
UK	69Q4			67-69	66-68	74Q1	70-77		71-79	70-73	81Q4	79-82			80-83	91Q1	90-91	88-93		90-93	90Q4 (92Q1*)	90Q4 (92Q2*)
US	67Q3	59-63	56-60		66-68	73Q1		72-73		71-73	82Q2	76-82	79-84£	77-84	80-82			85-96			91Q1 (91Q2*)	91Q1 (91Q3*)
JP				61-67	n.a.	72Q3			70-77	n.a.	81Q2				n.a.	92Q2*				n.a.	n.a.	94Q2 (92Q1*)
AU						70Q3				69-71					81-89	90Q4				89-91	n.a.	91Q1 (89Q3*)
CA			52-67	63-70	65-66	72Q2				72-73	82Q3				82-83	91Q2			90-91	91-92	n.a.	90Q4
NZ	69Q4	68-74	69-70		64-67	74Q1				71-74	82Q3	86-88		84-89	86-88	90Q2		88-92			n.a.	90Q2 (89Q4*)
NO	69Q1	63-70	65-75		68-69						88Q3	87-88	86-90		81-90						n.a.	n.a.
CH							70-79	66-81	74-75	67-70					74-77	93Q2		91-95		91-93	n.a.	93Q1 (93Q2*)

Notes: *indicates that the break date falls out of the Benati's confidence intervals.*

C&M. Altissimo and Corradi test (authors' calculation)

G&O: Gadzinski and Orlandi (2004). Single break test.

L& P: Levin and Piger (2004): Single break test; bayesian approach.

R&W: Rapach and Rohar (2002): Bai and Perron multiple break tests

Benati 1: Bai-Perron; Benati 2: Bai-Andrews-Ploberger both in Benati (2003); Benati 3: Bai-Andrews-Ploberger with a different strategy of lag selection in Benati (2004)

£ confidence interval is the union of the confidence interval found for the test on a break in the mean conducted on CPI inflation and GDP inflation

* break in the mean of the GDP deflator inflation rate

Figure 1. CPI a_qoq inflation, mean (dotted) and demeaned (dashed)

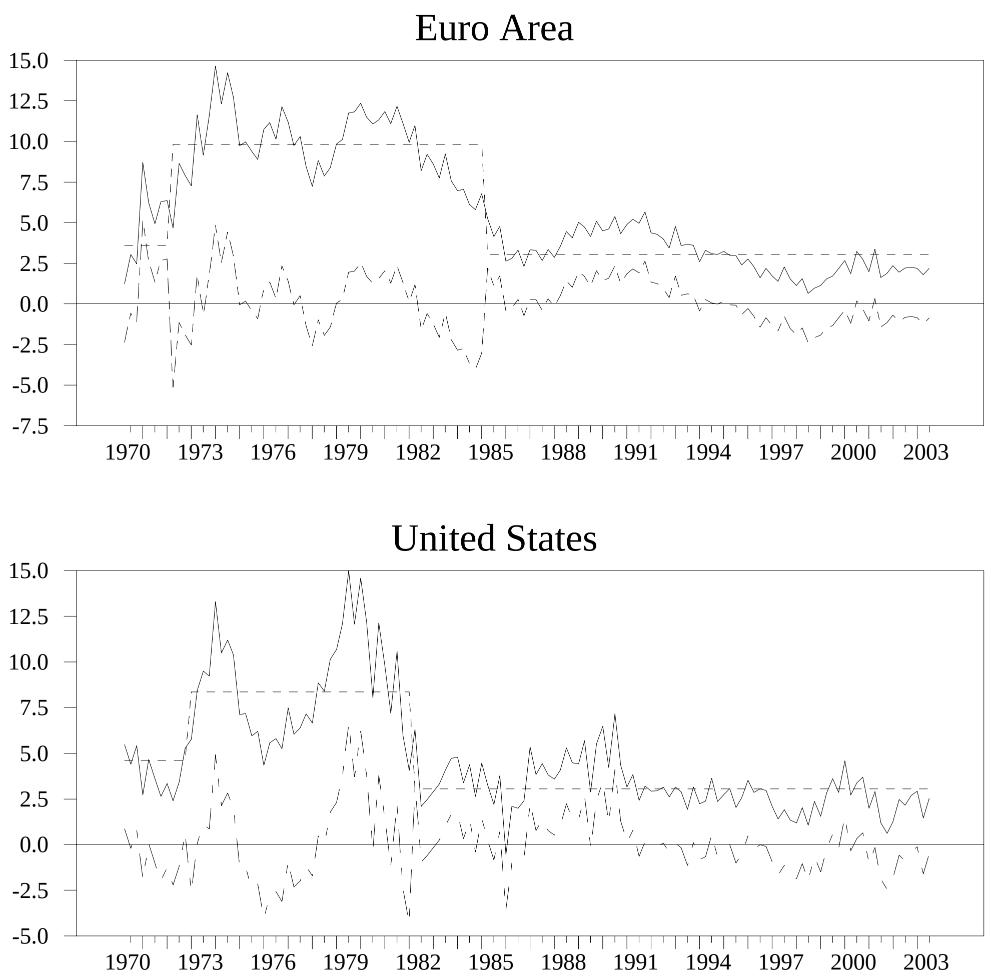
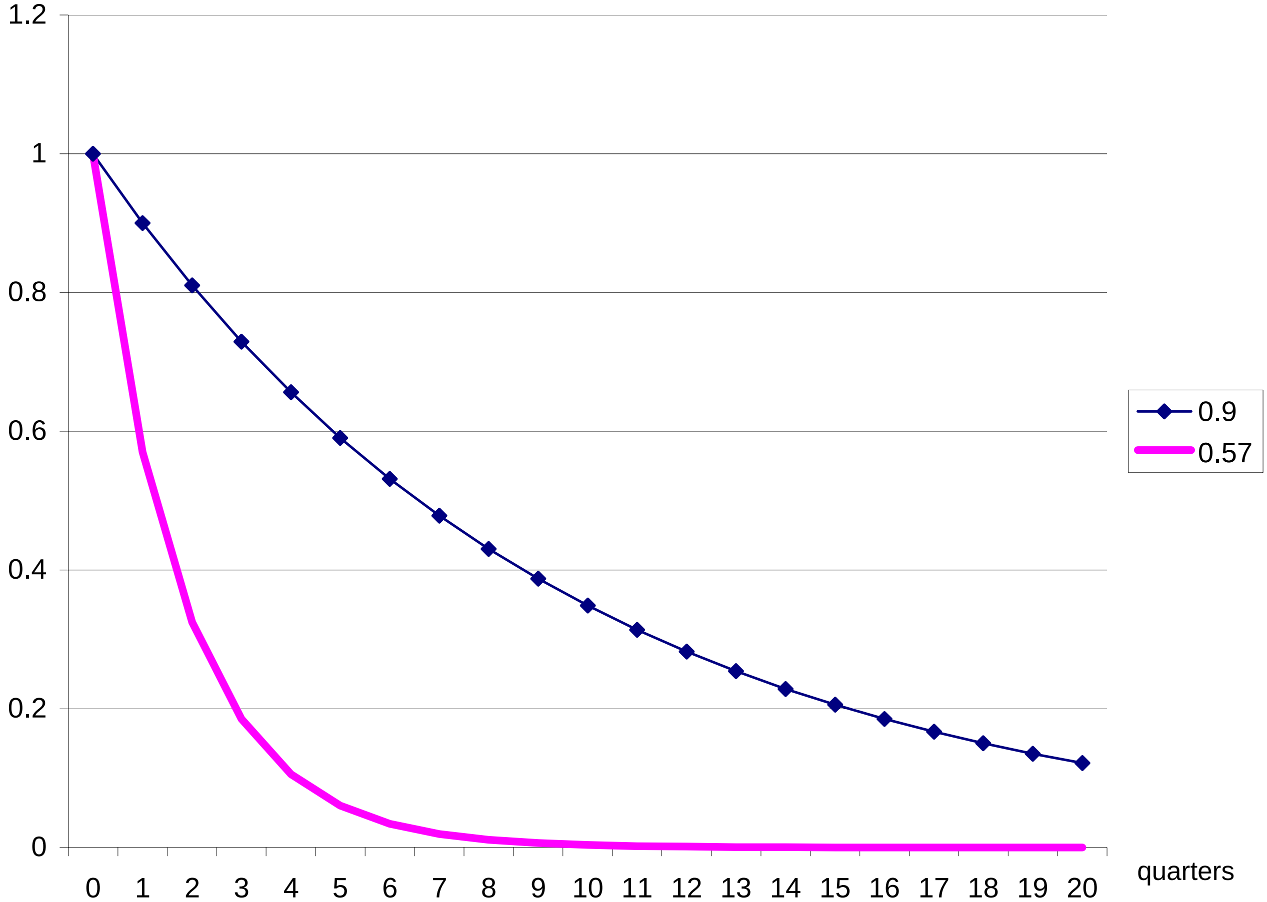


Figure 2. Impulse responses of inflation for two values of its persistence



Note: The above simulation would characterise the response of inflation under the assumption that it follows a first order autoregressive process.

Figure 3a. Breaks & CPI / inflation drivers cross-correlations
+/-10 q; cpi demeaned (dotted); both demeaned (dashed)
Euro Area

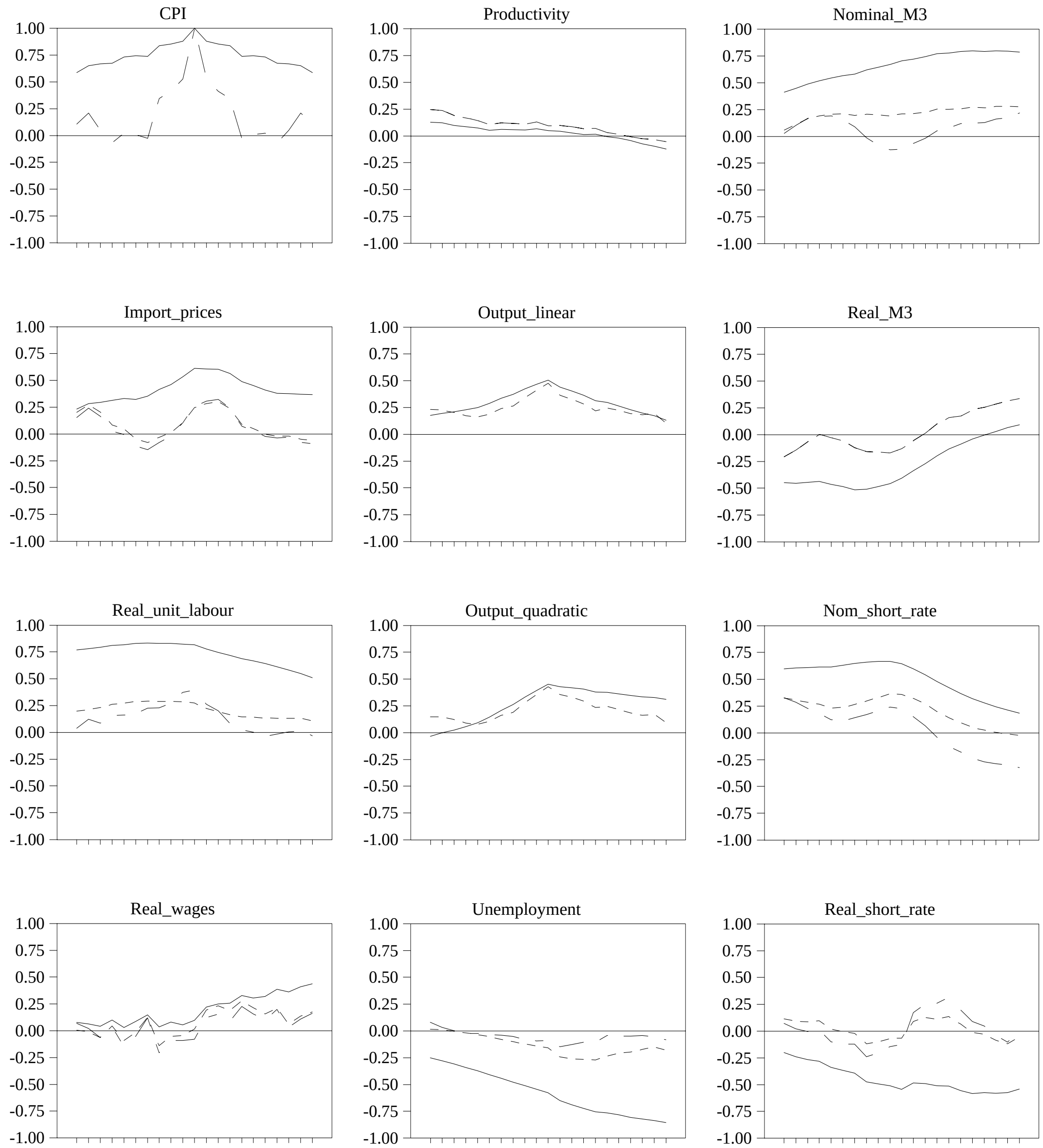


Figure 3b (continued). Breaks & CPI / inflation drivers cross-correlations

+/-10 q; cpi demeaned (dotted); both demeaned (dashed)

United States