I. Is Inflation Persistence Higher in the Euro Area than in the United States?[1]

A. Introduction

1. Inflation rates that remained stubbornly above target long after the burst of the global high-tech bubble prevented the ECB from slashing interest rates quite as aggressively as the U.S. Federal Reserve in response to the deepening economic gloom. While partly explained by a softer downturn in activity, this recent experience has brought to the fore an old question: is inflation in Europe more "persistent" than in the United States in the sense of being less responsive to demand or monetary shocks? If so, such persistence might account for the sometimes perceived tendency of European central bankers to be less 'activist' and less responsive to output developments than their cross-Atlantic counterparts.

2. This chapter provides fresh evidence on the degree of inflation persistence in the euro area relative to the U.S., as well as the sources of that persistence. In particular, the investigation uses real-time inflation forecasts to measure near-term inflation expectations, and tries to discriminate between structural sources of persistence and persistence that arises from the way expectations are formed, including imperfect knowledge of monetary policy objectives. The paper also uses survey evidence of long-run inflation expectations as a measure of agents' perceived long-run inflation anchor, and evaluates the extent to which gradual movements in the perceived long-run inflation objectives of the monetary authorities contributed to observed persistence.

3. Perhaps surprisingly, the chapter concludes that inflation persistence is only moderately higher in the euro area than in the United States, if at all, and there is little firm evidence that structural sources of persistence play a bigger role in the euro area. This is in line with other results from the recent Phillips-curve literature, although somewhat at odds with evidence, e.g. on the response of prices and output to monetary shocks. Consequently, the results in this paper need to be followed up by a better understanding of how the consequences of structural rigidities may already be internalized in the expectations variable. Investigations at the individual country level, rather than the euro-area aggregates used here, could also help shed light on the sources of persistence which are likely to differ among countries.

B. Definition and Sources of Inflation Persistence

4. Persistence in inflation denotes the tendency of inflation to be a slow-moving, inertial variable with autocorrelations fairly close to one. Different sources of inflation persistence can be illustrated in the context of the following Phillips-curve specification which is adapted from Gerlach and Svensson (2002) (Phillips curve specifications based on more rigorous micro foundations are considered below):

---

[1] Prepared by Mads Kieler.

$$(1) \qquad \pi_t = \alpha\pi^* + (1-\alpha)\pi_{t-1} + \beta gap_t + \varepsilon_t$$

In this equation, inflation depends on the central bank's inflation target, π^* (owing to forward-looking expectations) and last period's inflation π_{t-1} (owing to backward-looking expectations, or institutional factors that make inflation dependent on its own history); the output gap(gap_t); and an error term (ε_t) which captures import price and other shocks. In this scheme of things, inflation is more inertial, the smaller is α (i.e., the less firmly inflation expectations are anchored on the central bank's target and the more current inflation is conditioned by past inflation); the more persistent are movements in the output gap; and the smaller is the coefficient β, i.e. the less inflation responds to the output gap.[2]

5. This framework for thinking about persistence illustrates that a given degree of inertia may be caused by quite different underlying factors. For instance, observed inflation persistence in the U.S. could be importantly related to a shifting anchor for inflation, especially during the 1970s and early 1980s, while historical inflation persistence in price stability-oriented Germany might be more closely linked to a weak response of wages and inflation to the output gap. European countries with less firm anchoring of inflation expectations than Germany but equally significant structural rigidities might have experienced high persistence on both counts.

6. A priori, the monetary anchor for inflation expectations (π^*) and/or the degree to which expectations have been linked to this anchor (α) seem likely to have varied significantly over recent decades. An important aim of this paper is to take shifts in the long-run anchor into account in the empirical specifications.

C. A Quick Refresher Course in Phillips Curve Specifications

The traditional Phillips-curve

7. The traditional expectations-augmented Phillips-curve in the spirit of Edmund Phelps and Milton Friedman has the form:

$$(2) \qquad \pi_t = E_{t-1}(\pi_t) + \beta gap_t + \varepsilon_t$$

In empirical work it has often been implemented assuming adaptive or backward-looking expectations, thus giving rise to what is generally termed the 'accelerationist' Phillips curve:

---

[2] Batini and Nelson (2001) define three types of persistence: (1) positive serial correlation in inflation; (2) lags between *systematic* monetary policy actions and their (peak) effect on inflation; and (3) lags between *non-systematic* policy actions and inflation. The two last measures depend also on the transmission of monetary policy actions to *output* (and other variables), making those concepts broader than the considerations adopted here.

$$(3) \qquad \pi_t = \pi_{t-1} + \beta gap_t + \varepsilon_t$$

Although this empirically-motivated Phillips curve is often said to match the data quite well, it is unable to track changes in expectations formation across different regimes. For instance, it fails to explain why persistence appears to have declined in the more stable inflation regime of the 1990s (see below). It also fails to explain the lack of persistence in U.S. inflation during the Gold standard (see Alogoskoufis and Smith (1991)). These failures reflect its lack of micro foundations and is but one example of how models that do not incorporate forward-looking or rational agents can go astray when regimes change, as famously demonstrated by Lucas (1975).

The New Keynesian Phillips curve

8. In line with theoretical advances, the traditional Phillips curve has given way—at least in much theoretical work—to the New Keynesian Phillips curve (NKPC), which can be derived from micro foundations in models of price adjustment with monopolistic competition and costs of adjusting prices. When marginal costs are assumed to be proportional to the output gap the New Keynesian Phillips curve has the following form (for simplicity, the discount factor on next-period inflation has been omitted; derivation usually follows Calvo 1983):

$$(4) \qquad \pi_t = E_t(\pi_{t+1}) + \beta gap_t + \varepsilon_t$$

The equation deviates from the traditional Phillips curve in that it substitutes forward-looking inflation $E_t(\pi_{t+1})$ for backward-looking inflation π_{t-1}. The coefficient on the output gap depends on the frequency of price adjustment, reflecting *nominal* rigidity, and the responsiveness of firms' desired relative prices to economic activity, reflecting *real* rigidities.

9. Although innocent-looking, the substitution of forward-looking inflation for lagged inflation is anything but a minor alteration; it changes the dynamics of the output-inflation relationship fundamentally. Under the new Keynesian Phillips curve, inflation *lacks (inherent or structural) persistence.* Prices are rigid due to menu costs, but their rate of change would not depend on their lagged rate of change.

10. The New Keynesian Phillips curve has been criticized by some for failing to match the observed inflation persistence in the data (e.g., Fuhrer and Moore (1995), and Fuhrer (1997)). By the same token, the model is inconsistent with the generally held view that monetary policy shocks initially affect output and have a delayed and gradual effect on inflation, at least if that proposition is taken to hold everywhere and always. Mankiw puts it most strikingly: "*Although the new Keynesian Phillips curve has many virtues, it also has one striking vice: it is completely at odds with the facts...This harsh conclusion shows up several places in the recent literature, but judging from the continued popularity of this*

model...it's fair to say that its fundamental inconsistency with the facts is not widely appreciated."[3]

The hybrid Phillips curve

11. This state of affairs has led numerous researchers, in the tradition of Chadha, Masson, and Meredith (1992), to use a 'hybrid' formulation which includes both forward-looking and lagged inflation:

$$(5) \qquad \pi_t = \alpha E_t(\pi_{t+1}) + (1-\alpha)\pi_{t-1} + \beta gap_t + \varepsilon_t$$

The lag dynamics may be related to either expectation formation or *structural* features of the economy. Structural persistence can be derived from models of *staggered wage or price setting* in the spirit of Taylor (1980)[4] or *frictions in price adjustment* in the tradition of Rotemberg (1982), possibly around a path determined by trend inflation (see e.g., Kozicki and Tinsley (2002)). Examples of frictions in price adjustment include the deterrent effect of uncertainty about whether competitors will also raise their prices, the unwillingness of firms to upset customers, and lags between cost changes and price adjustments—these three factors have been identified as important explanations of price stickiness in surveys of corporate officers in the United States, see Blinder, Canetti, Lebow, and Rudd (1998). The existence of *formal wage indexation mechanisms*, formerly widespread and still present in the euro area, creates a further reason for including lagged inflation.

12. Alternatively, the addition of lagged inflation is sometimes justified by assuming that a fraction of price-setters have backward-looking expectations or use rule-of-thumb pricing (i.e., it presupposes deviations from full rationality).

13. Models derived from staggered contracts or costly price adjustment typically impose certain restrictions on the coefficients on backward- and forward-looking inflation, while less formalized approaches leave the relative weights to be determined by the data.

---

[3] Others have argued that the observed inflation persistence could be consistent with the NKPC as a result of how monetary policy is conducted (Goodfriend and King, 2001).

[4] The inflation equation derived from Taylor-style contracts will depend explicitly on lagged inflation (and lagged output gaps) if the maximum contract length exceeds two periods. Fuhrer and Moore found, however, that Taylor-based models could not generate enough persistence to match U.S. data and proposed an alternative specification inspired by the relative wage contracting model of Buiter and Jewitt (1981). The Fuhrer-Moore model has been widely criticized for lacking credible micro foundations.

14. Although the hybrid specification might seem to offer a "quick fix" to the problems allegedly besetting the NKPC, it has also been contended that the hybrid equation combines the vices of its two lines of origin: as in the NKPC, inflation may respond immediately to monetary policy shocks (unless *all* agents are backward-looking), but as in the traditional Phillips curve, the hybrid model may fail to explain differences in the degree of persistence across different monetary regimes (Ball, Mankiw, and Reis (2002)).

Shifting monetary policy anchor (inflation objective)

15. A recent strand of the literature takes into account the public's learning about changing monetary policy objectives and/or a shifting monetary anchor over time. Persistence arises in such models from the interaction of inflation expectations with monetary policy formulation, and do not require non-rational behavior.

16. Erceg and Levin (2002) assume that households and firms have limited information about the central bank's objectives and use 'optimal filtering' to disentangle persistent and transitory shifts in the monetary policy rule. They show that inflation persistence can be generated in an optimizing-agent framework where it is *not* an inherent or structural characteristic of the economy. In this framework, the degree of persistence varies with the stability and transparency of the monetary policy regime and the costs of disinflation are strongly diminished if agents quickly realize that a credible shift in the inflation target has taken place.

17. In a similar vein, Kozicki and Tinsley (2002) consider shifts in the long-run anchor of inflation expectations (the perceived inflation target) as a source of lag dynamics. Essentially, they show that standard expressions derived from staggered contracts or frictions in price setting can be formulated (approximately) in terms of the deviation of inflation from its perceived long-run anchor. They find that shifts in the long-run inflation anchor have contributed importantly to observed persistence in U.S. (and Canadian) inflation, but such shifts do not appear to explain all of the historical persistence in inflation, suggesting that less than full policy credibility and inherent inflation stickiness have also been important factors.

Sticky-information

18. Another recently proposed approach is the sticky-information model of price adjustment put forward by Mankiw and Reis (2001) and empirically implemented for the United States, Canada, and the United Kingdom by Khan and Zhu (2002).

19. The essence of Mankiw and Reis' model is that information about macroeconomic conditions diffuses slowly through the population, either because of costs of information acquisition or costs to reoptimization.[5] Although prices are continuously changing in this

[5] Zbaracki et.al. (2000) studied the costs associated with changing prices at a large manufacturing firm. Only a small percentage of these costs were the physical costs of

(continued)

model, price adjustments are not always based on current information. Consequently, the current price level will depend on the expectation of current prices formed quite far in the past. Although expectations are rational and central bank credibility matters, the dynamic response of inflation in the sticky-information model resembles backward-looking Phillips curves. However, the farther in advance a disinflationary policy is announced and the more credible it is, the smaller is the accompanying output contraction.

20. The sticky information Phillips-curve has the following form:

$$(6) \qquad \pi_t = \tfrac{\lambda\alpha}{1-\lambda} gap_t + \lambda \sum_{j=0}^{\infty} (1-\lambda)^j E_{t-1-j}[\pi_t + \alpha \Delta gap_t]$$

Inflation depends on the output gap and past expectations of current inflation as well as the growth rate of output. Note the timing of expectations: what matters is past expectations of current conditions, not current expectations of future conditions as in the NKPC.

D. Empirical Strategy

21. We now have a fairly wide set of potential causes of inflation persistence, including structural features of the economy; backward-looking expectations; imperfect monetary credibility and gradual learning about shifting monetary policy targets; and costly or imperfect information gathering.

22. To compare the degree and sources of inflation persistence in the euro area (EA) and the United States, a four-pronged strategy is followed:

- *Univariate models:* the overall degree of inflation persistence is measured by the sum of coefficients in a regression where inflation is explained by its own lags. Attention is paid to how the degree of persistence may have changed over time, and what role shifting monetary anchors for inflation may have played in inducing persistence. To this end, estimates of long-run inflation anchors are constructed using long-term inflation forecasts from surveys of professional forecasters, and IMF projections.

- *VAR-models:* simple vector autoregressions in inflation and output are used to judge the impact of shocks to output or prices on inflation, and whether these might be different on the two sides of the Atlantic.

- *Phillips-curve specifications:* using survey/forecast measures of expectations, the NKPC is estimated and tested against alternatives such as the traditional accelerationist and expectations-augmented Phillips curves and the hybrid model.

---

printing and distributing price lists. Far more important were the costs of information-gathering, decision-making, negotiation, and communication.

This reveals whether lagged inflation contributes to explain inflation for structural reasons over and above any impact it may have on (survey) expectations. Moreover, the response of inflation to the output gap is compared between the U.S. and the EA.

- *Expectations formation:* the extent to which survey expectations may have backward-looking elements, as opposed to the extent to which they are aligned on the long-run anchor, is investigated in various settings.

E. Main Features of the Data

23. For the euro area as well as the United States, inflation is measured by the GDP deflator and a measure of consumer prices. For the latter, the CPI for the U.S. and the private consumption deflator for the euro area is used in order to achieve the best possible correspondence with those measures of inflation for which survey expectations or historical inflation projections are available.

24. For the United States, survey expectations of inflation from 1 to 8 quarters and over a 10 year horizon are readily available from the Federal Reserve Bank of Philadelphia's surveys of professional forecasters. The long-run inflation expectations (10 year CPI forecasts) are available since the fourth quarter of 1979.

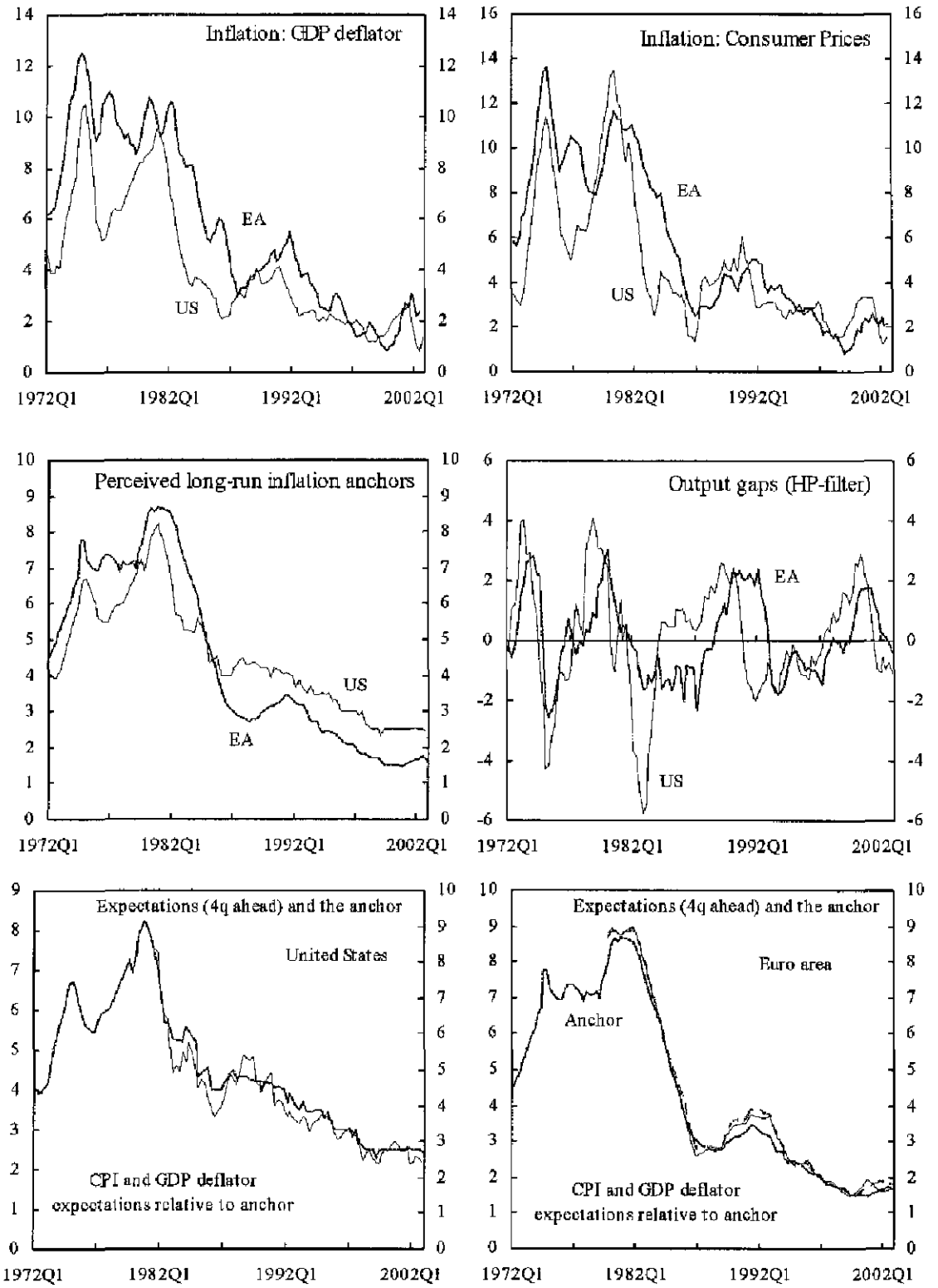
25. For the euro area, the half-yearly IMF forecasts of inflation five years ahead going back to the Summer 1990 WEO were reconstructed (using the same approach for the U.S. yields numbers similar to those in the Philly Fed surveys). Data for the quarters in between the half-yearly observations are interpolated. Since these data are not readily available before 1990, a separate method is used to construct the long-run inflation anchor prior to 1990, as described in Appendix I.

26. Short-run inflation expectations for the euro area are based on OECD forecasts which go back to 1980 (kindly provided by Marita Paloviita of the Bank of Finland, and described in Paloviita (2002)). Data for the quarters in between the annual observations are interpolated. Imperfections in the measures used for survey expectations in the euro area, compared to those readily available for the United States, warrant some degree of caution in evaluating the results of the various Phillips curve regressions presented below.

27. Inflation measured by the GDP deflator tended to be higher in the euro area than in the United States until the mid-1990s (Figure 1). Inflation came down less rapidly in the euro area following the first as well as the second oil crises, and again in the latest economic downturn, suggesting a priori that inflation is inherently more sluggish or that output gaps have been smaller in the euro area. These characteristics are broadly confirmed for consumer price inflation.

28. Inflation in the U.S. tends to be higher on the CPI measure than for the GDP deflator (by an average of 0.7 percent since 1980, but slightly less in recent years). The long-run inflation anchor for the U.S. has come down to 2.5 percent for CPI inflation, which thus

Figure 1. Euro Area and United States: Inflation, Survey Expectations, and Output Gaps, 1972-2002



corresponds to 1.8 percent (or slightly more) for the GDP deflator. The long-run expectation for the euro area currently stands at around 1.8 percent for both the GDP and the private consumption deflators.

29. The HP-filtered output gap in the United States showed much larger swings than in the euro area in the 1970s and 1980s; amplitudes were of comparable magnitudes in the early 1990s; while the recent downturn set in earlier and was more pronounced in the U.S. (IMF output projections to 2007 were used to mitigate the end-point problem of the HP filter).

30. In both the euro area and the U.S., expected inflation four quarters ahead has remained close to the estimated long-run anchors throughout the sample period.

F. Results

How inflation relates to its own lags (univariate methods)

31. Following Kozicki and Tinsley (2003) and others, inflation persistence is measured as the sum of coefficients from an estimated AR(4) model of inflation.

32. The results are summarized in Table 1 (for a fuller version including unit root tests for inflation, see Table 2):

Table 1. Univariate Inflation Persistence

Estimation sample	Inflation		Inflation Deviations	
	EA	U.S.	EA	U.S.
GDP deflator				
Full sample (1971-2002)	0.97	0.94	0.82	0.85
High inflation (1971-85)	0.86	0.87	0.76	0.84
Low inflation (1986-2002)	0.82	0.85	0.60	0.52
Recent (1995-2002)	0.55	0.54	0.45	0.45
Priv Cons deflator				
Full sample (1971-2002)	0.96	0.89	0.83	0.76
High inflation (1971-86)	0.87	0.83	0.74	0.77
Low inflation (1986-2002)	0.85	0.59	0.63	0.41
Recent (1995-2002)	0.51	0.44	0.59	0.45

Persistence is defined as the sum of the coefficients in an AR(4) model of inflation.

- In the full sample, inflation is highly persistent for both the euro area and the U.S., and slightly more so for the euro area (sum of coefficients of 0.96-0.97) than the U.S. (0.89 and 0.94 for the CPI and the GDP deflator, respectively). For this sample, standard tests cannot reject the hypothesis that inflation has a unit root.

- However, much of the observed persistence owes to low-frequency movements in the long-run inflation anchor. When inflation is measured in deviations from the perceived long-run inflation anchor standard tests reject the random walk hypothesis (Table 2), and the measure of persistence declines to 0.82-0.83 for the euro area and 0.76-0.85 for the U.S.

- In both the euro area and the United States, persistence has fallen sharply since the mid-1990s to 0.51-0.55 for the euro area and 0.44-0.54 for the United States. The results using inflation deviations suggest that the lower recent persistence reflect not only a more stable anchor, but also a closer centering of actual inflation on the monetary objective than before.

Table 2. Autoregression: Inflation Explained by Constant and Four Lags of Itself
(inflation is qoq; persistence is measured by the sum of autoregressive coefficients).

Euro Area	*Inflation*							*Deviations from long-run anchor*						
	Avg infl.	S.E.	Sum of Coeff.	R-sq	st dev	DW	Unit root?	Avg. infl.	S.E.	Sum of Coeff.	R-sq	st dev	DW	Unit root?
GDP deflator														
Full sample (1971-2002)	5.8	3.5	0.97	0.88	1.25	1.82	n.r	1.3	1.6	0.82	0.51	1.14	1.96	**
High inflation (1971-85)	8.9	2.2	0.86	0.58	1.50	1.65	n.r.	2.2	1.7	0.76	0.44	1.35	1.92	**
Low inflation (1986-2002)	3.0	1.5	0.82	0.60	0.95	1.98	*	0.6	1.0	0.60	0.25	0.89	1.97	**
Semi-EMU (1995-2002)	1.9	1.0	0.55	0.20	0.91	1.99	**	0.1	0.9	0.45	0.14	0.89	1.99	**
Priv Cons deflator														
Full sample (1971-2002)	5.7	3.6	0.96	0.90	1.14	2.00	n.r	1.3	1.6	0.83	0.60	1.06	1.93	**
High inflation (1971-86)	8.9	2.5	0.87	0.72	1.36	1.97	n.r.	2.2	1.8	0.74	0.54	1.26	1.89	*
Low inflation (1986-2002)	2.9	1.2	0.85	0.59	0.81	2.02	*	0.5	0.9	0.63	0.28	0.78	2.02	**
Semi-EMU (1995-2002)	2.0	0.8	0.51	0.42	0.66	1.95	**	0.2	0.8	0.59	0.32	0.67	1.98	**
United States	*Inflation*							*Deviations from long-run anchor*						
	Avg. infl.	S.E.	Sum of Coeff.	R-sq	st dev	DW	Unit root?	Avg. infl.	S.E.	Sum of Coeff.	R-sq	st dev	DW	Unit root?
GDP deflator														
Full sample (1971-2002)	4.1	2.6	0.94	0.83	1.10	1.97	n.r	-0.4	1.5	0.85	0.57	1.00	1.88	**
High inflation (1971-85)	6.2	2.4	0.87	0.70	1.37	2.00	n.r.	0.4	1.8	0.84	0.55	1.25	1.85	n.r.
Low inflation (1986-2002)	2.4	1.0	0.85	0.47	0.78	1.90	**	-1.0	0.8	0.52	0.14	0.74	1.91	**
1995-2002	1.7	0.8	0.54	0.14	0.77	1.75	**	-1.0	0.8	0.45	0.13	0.78	1.78	**
CPI														
Full sample (1971-2002)	4.8	3.2	0.89	0.77	1.58	1.98	*	0.3	2.2	0.76	0.56	1.52	1.99	**
High inflation (1971-85)	6.8	3.5	0.83	0.75	1.79	2.01	n.r.	1.0	2.8	0.77	0.63	1.77	2.00	*
Low inflation (1986-2002)	3.0	1.5	0.59	0.33	1.27	1.89	**	-0.4	1.3	0.41	0.21	1.21	1.93	**
1995-2002	2.4	1.0	0.44	0.36	0.88	1.88	**	-0.3	1.0	0.45	0.37	0.87	1.86	*

Unit root tests: * (**) means the hypothesis of a unit root can be rejected at the 5 percent (1 percent) level. "n.r." means not rejected.

Inflation and output in bivariate VARs

33. The second step in the empirical strategy consists in estimating unrestricted VARs in output growth and inflation.[6] Figures 2 and 3 show the associated impulse responses of inflation (and cumulated inflation) to shocks to, respectively, output growth and inflation itself. The main findings are:

- In the full sample going back to 1971, the response of prices to *output shocks* is about twice as large in the euro area than in the United States. Plausibly, this could reflect less pronounced monetary stabilization of inflation and stronger wage and price responses to unforeseen output movements than in the United States for the earlier part of the sample period (the simple VAR does not allow for possible asymmetries in the response to positive and negative output shocks, respectively).

- The euro area exhibits a somewhat larger response of inflation to *price shocks* than in the United States. Plausibly, that could be related to a larger degree of monetary accommodation of price shocks and/or more pronounced real wage rigidities and formal wage indexation whereby price shocks had second-round effects and led to price-wage spirals.

- In the shorter and more recent sample (1987-2002; lower half of the page), the estimated impulse responses are essentially identical in the euro area and the United States. This might suggest that monetary policy responses for the euro-area aggregate had become more akin to the United States as the ERM commitment hardened among Germany's partners, and as wage indexation systems were reined in while structural reforms alleviated real rigidities.

The results, therefore, do not point to any clear conclusions that inflation responds less to output movements or that price shocks tend to become more ingrained in inflation in the euro area than in the United States, at least not in the sample since the mid- to late 1980s.[7]

---

[6] The key results reported here were confirmed in alternative VAR-specifications in the output gap and inflation, or with inflation deviations instead of actual inflation.

[7] If the underlying mix of supply and demand shocks is different between the United States and the euro area (as suggested by some of the results in Chapter II of this paper), then the simple shocks to output and prices in an unrestricted VAR considered here may not be comparable between the euro area and the United States.

Figure 2: Impulse Responses Compared: Euro Area and United States, 1971-2002

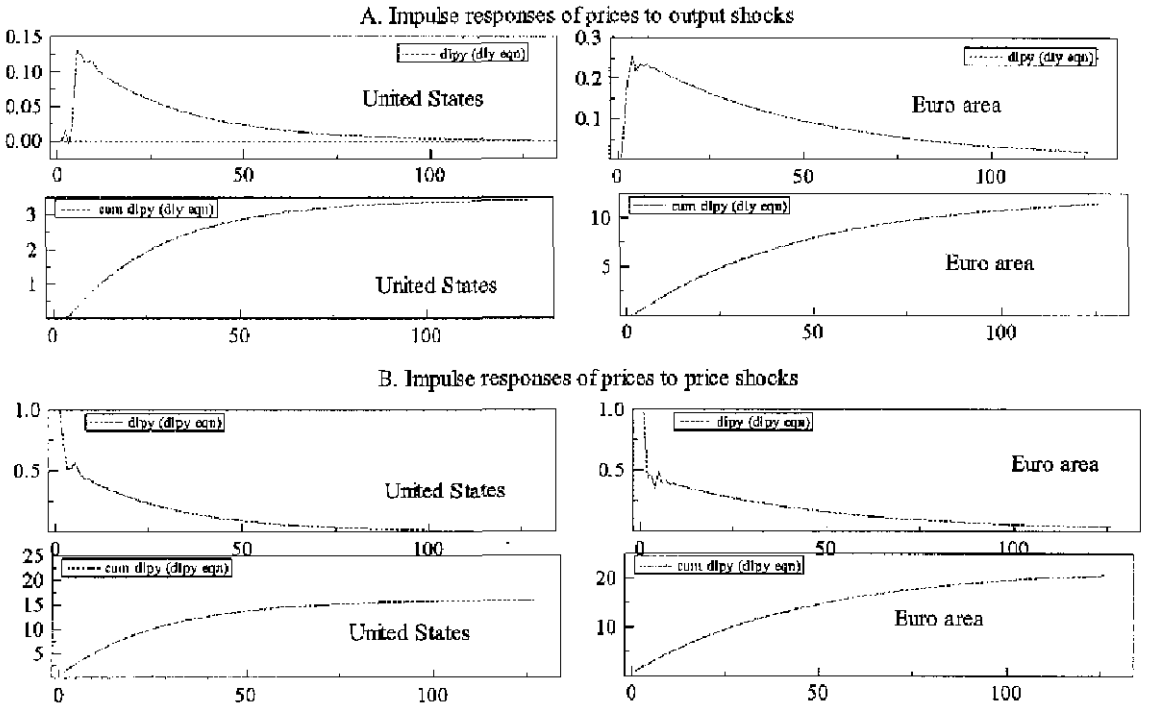
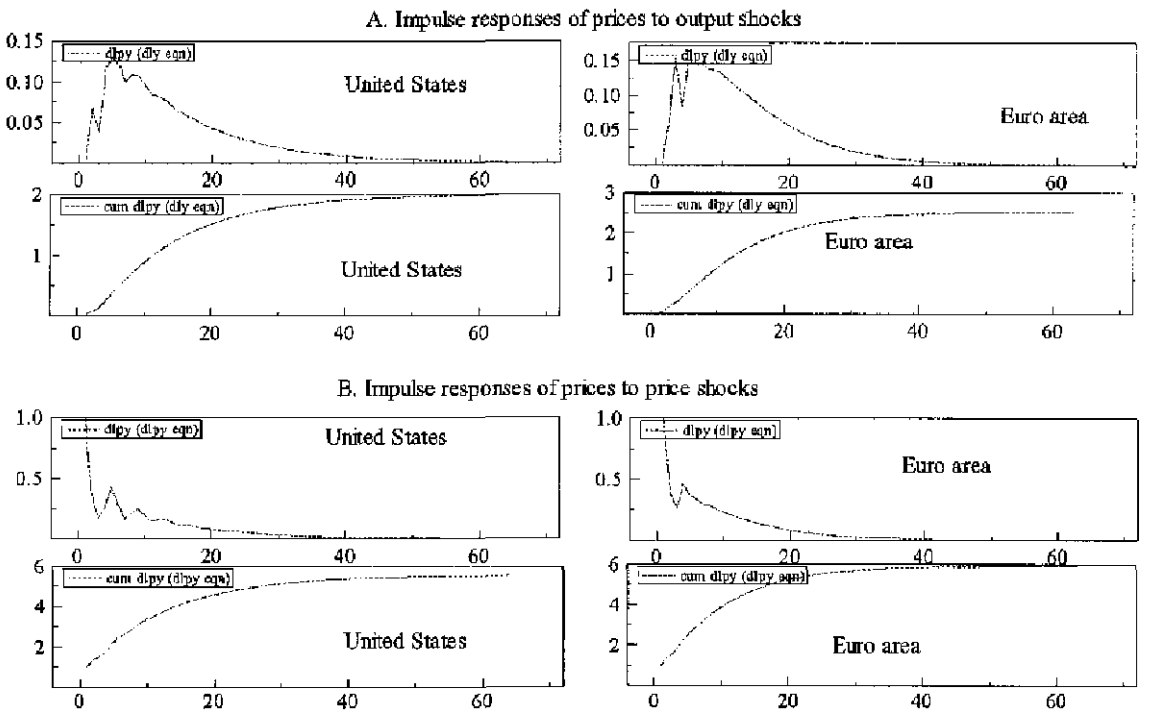


Figure 3: Impulse Responses Compared: Euro Area and United States, 1987-2002



Phillips-curve models: the role of lagged inflation and the coefficient on the output gap

34. The third element in the empirical strategy consists of comparing Phillips curve specifications for the euro area with the United States.

35. The literature on the New Keynesian Phillips curve has generally found that, when using rational expectations assumptions for inflation, the addition of lagged inflation was necessary to match observed persistence in the U.S. and euro area data (e.g., Fuhrer and Moore (1995), Fuhrer (1997), Coenen and Wieland (2002)).[8] However, as shown by Roberts (1998) for U.S. data, when real time survey expectations of inflation are used as a measure of expectations, the need for lagged inflation is obviated. In Roberts' view, this has the interpretation that the observed persistence in inflation is related to expectations formation rather than inherent features. (Although one might surmise that expectations will take account of structural features, such as whether inflation responds quickly to the output gap or not).

Phillips-curve estimates

36. The New Keynesian Phillips Curve as well as the hybrid specification was estimated to see if lagged inflation adds any explanatory power. Also reported are estimates of a more traditional expectations-augmented Phillips curve and the simple accelerationist Phillips curve to compare their (in sample) performance relative to the NKPC.

37. To check for robustness, two measures of the inflation rate were used, namely the GDP deflator and consumer prices. Moreover, estimates were derived for two measures of the output gap, namely an HP-filter gap (using a smoothing coefficient of 6400) and a series generated from the IMF country desks' output gap estimates for euro area countries. Expectations and lagged inflation are measured alternatively over 1 quarter, as in many empirical implementations for the U.S., or over four quarters, since the concept of year-on-year inflation is more prominent in European price and wage setters' information set, and it is closer to the one-year ahead horizon for which inflation projections are available (Fuhrer (1997) uses average inflation over three quarters for the United States). The regressions have been run for a long and a short (low inflation) sample. The import price deflator was used to control for import price (oil and exchange rate) shocks.[9]

---

[8] When using unit labor costs as the proxy for marginal costs instead of the output gap, Gali, Gertler, and Lopez-Salido (2002) find a better fit for the pure NKPC, although even here some degree of persistence appears to improve the fit.

[9] In selecting lags of the output gap and import price variables, I follow the general-to-specific modeling approach advocated by David Hendry and others (see e.g., Hendry (1995)) and implemented through automated model selection procedures in PCGETS. This procedure selects the 'best' model on a range of objective criteria, thereby eliminating the temptation for the researcher to succumb to extensive data mining.

38. The results, summarized in Tables 3 (long sample) and 4 (shorter sample), imply that:

- The role of lagged inflation does not appear to be different between the euro area and the United States. In six out of eight cases, the hybrid specification reduces to the New Keynesian Phillips curve when the PCGETS automated model selection procedures are applied; only in two instances does lagged inflation appear to be a useful and significant addition to the equation. That applies to both the U.S. and the euro area. Thus, the results suggest that the role of lagged inflation is not materially different in the euro area when expectations are measured through survey expectations (the redundancy of lagged inflation when survey measures are used for expectations confirms Roberts' results for the U.S. (1997, 1998)).

- The coefficients on the output gaps do not appear significantly different in the euro area relative to the United States, but the impact is faster (one quarter earlier) in the United States. For the euro area, the coefficients on the output gap in the New Keynesian specifications range from 0.14-0.20, and for the United States from 0.10-0.24 (with only few specifications indicating more than one significant lag of the output gap in such a way that inflation depends not only on the level but also the change in the gap).[10]

- The New Keynesian Phillips curve fit the data better than the accelerationist or expectations-augmented specifications in all specifications, and (as stated above) only four out of sixteen have the hybrid model adding useful information to the NKPC.

Expectations formation

39. The conclusion that projected inflation performs better than lagged inflation in the Phillips curve estimations does not preclude that the inflation projections already incorporate a higher degree of inertia in inflation in the euro area than in the United States.

40. Two simple tests were conducted to look for signs that this might be the case. (These exercises should be taken with a grain of salt, since the degree of multicollinearity between lagged inflation, expected inflation, and the long-run anchor is high, and may affect the robustness of the coefficient estimates.)

---

[10] The finding of similar persistence-related parameters between the U.S. and the euro area is not unusual in the more recent Phillips curve literature. Coenen and Wieland (2002) find that, among three popular contracting specifications, euro-area inflation dynamics are best explained by Taylor-style contracts, while the more inertial Fuhrer-Moore contracts fit U.S. data better, and the coefficient on the output gap is generally higher in the euro area than in the U.S. estimates. Gali, Gertler and López-Salido (2000) find that a purely forward-looking NKPC specification fits euro-area inflation remarkably well, possibly superior to U.S. data, and infer that inflation in the euro area may be less inertial than in the U.S.

Table 3. Phillips Curve Estimates; Euro Area and United States, 1979-2002

Euro Area 1/

	Coefficients						Regr. Stats		Hybrid
	infl (-1)	dlpm	dlpm (-t)	gap (-1)	gap (-2)	infl (+1)	S.E.	R-sq	redux to NKPC? 2/
Private consumption deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.88	0.09	-0.05				0.91	0.91	
Expectations-augmented		0.08		0.25		0.87	0.71	0.94	
New Keynesian		0.07		0.18		0.95	0.71	0.95	
Hybrid	-0.21	0.07		0.20		1.17	0.71	0.95	yes
Private consumption deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.83	0.08		0.19			0.74	0.94	
Expectations-augmented		0.07		0.26		1.07	0.67	0.95	
New Keynesian		0.06		0.19		1.10	0.65	0.95	
Hybrid	0.02	0.06		0.19		1.07	0.66	0.95	yes
GDP deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.85	-0.06	0.09				0.98	0.88	
Expectations-augmented		-0.06	0.07	0.27		0.96	0.89	0.90	
New Keynesian		-0.07	0.08	0.20		0.99	0.85	0.91	
Hybrid	0.18	-0.07	0.08	0.17		0.80	0.85	0.91	yes
GDP deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.91	-0.07	0.10	0.20			0.89	0.90	
Expectations-augmented		-0.08	0.04	0.26		1.14	0.82	0.92	
New Keynesian		-0.08	0.03	0.19		1.18	0.79	0.92	
Hybrid	-0.10	-0.08	0.03	0.18		1.31	0.80	0.92	yes

United States

	infl (-1)	dlpm	dlpm (-t)	gap	gap (-1)	infl (+1)	S.E.	R-sq	Hybrid redux to NKPC? 2/
Consumer price index; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.68	0.11		0.55	-0.52		1.47	0.74	
Expectations-augmented		0.12				0.89	1.13	0.49	
New Keynesian		0.06		0.19		1.18	1.09	0.64	
Hybrid	0.03	0.06		0.19		1.14	1.09	0.64	yes
Consumer price index; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.76	0.12		0.47	-0.32		1.26	0.81	
Expectations-augmented		0.12				0.86	1.15	0.47	
New Keynesian		0.08	0.02	0.26	-0.06	1.08	1.17	0.59	
Hybrid	0.37	0.10	0.02	0.45	-0.28	0.65	1.15	0.61	no
GDP deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.82		0.05				0.85	0.85	
Expectations-augmented		0.03	0.03			0.86	0.79	0.86	
New Keynesian			0.02	0.10		1.01	0.71	0.89	
Hybrid	0.10		0.02	0.09		0.90	0.71	0.89	yes
GDP deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.82	0.03	0.03	0.11			0.74	0.88	
Expectations-augmented		0.03	0.04			0.83	0.79	0.86	
New Keynesian			0.03	0.11		1.00	0.73	0.89	
Hybrid	0.37	0.03	0.03			0.51	0.71	0.89	no

1/ Since the expectations series is not available before, the sample is 1980-2002.

2/ Denotes cases in which lagged inflation is insignificant and automated model selection in PCGETS would reduce the model to the New Keynesian specification.

All coefficients are significant at the 5 percent level, except lagged inflation terms in the hybrid models in those cases where it reduces to the NKPC (where it says "yes" in the last column).

Table 4. Phillips Curve Estimates; Euro Area and United States, 1987-2002

Euro Area

	Coefficients						Regr. Stats		Hybrid
	infl (-1)	dlpm	dlpm (-t)	gap (-1)	gap (-2)	infl (+1)	S.E.	R-sq	redux to NKPC? 2/
Private consumption deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.73	0.12	-0.09	-0.40	0.55		0.74	0.69	
Expectations-augmented		0.12			0.20	0.96	0.63	0.76	
New Keynesian		0.12	-0.04	0.14		0.99	0.62	0.77	
Hybrid	-0.08	0.12	-0.04	0.14		1.08	0.63	0.77	yes
Private consumption deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.92	0.11		0.14			0.66	0.74	
Expectations-augmented		0.09		0.17		1.34	0.62	0.77	
New Keynesian		0.08		0.16		1.12	0.65	0.75	
Hybrid	0.41	0.10		0.17		0.62	0.62	0.77	no
GDP deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.71	-0.08	0.07	0.17			0.88	0.62	
Expectations-augmented			0.08	0.27		0.95	0.77	0.70	
New Keynesian			0.06	0.19		0.98	0.76	0.71	
Hybrid	-0.12		0.07	0.20		1.10	0.76	0.71	yes
GDP deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.91		0.08	0.20			0.78	0.69	
Expectations-augmented		-0.05	0.05	0.23		1.13	0.76	0.71	
New Keynesian		-0.06	0.04	0.18		1.15	0.73	0.73	
Hybrid	0.26	-0.05	0.05	0.18		0.84	0.73	0.73	no

United States

	infl (-1)	dlpm	dlpm (-t)	gap	gap (-1)	infl (+1)	S.E.	R-sq	Hybrid redux to NKPC? 2/
Consumer price index; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.46	0.11			0.16		0.87	0.63	
Expectations-augmented		0.10			0.22	0.93	0.82	0.66	
New Keynesian		0.07			0.22	0.95	0.75	0.72	
Hybrid	0.14	0.08			0.18	0.81	0.75	0.72	yes
Consumer price index; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.56	0.12	0.03		0.18		0.84	0.67	
Expectations-augmented		0.09			0.25	0.91	0.82	0.67	
New Keynesian		0.08			0.24	0.93	0.77	0.71	
Hybrid	0.17	0.08			0.20	0.76	0.76	0.71	yes
GDP deflator; expectations and lagged inflation measured over 1 quarter									
Accelerationist	0.61	0.06					0.71	0.57	
Expectations-augmented			0.03		0.18	0.82	0.62	0.67	
New Keynesian		-0.04	0.04		0.17	0.84	0.61	0.69	
Hybrid	0.15	-0.03	0.04		0.15	0.70	0.61	0.69	yes
GDP deflator; expectations and lagged inflation measured over 4 quarters									
Accelerationist	0.93		0.05		0.16		0.65	0.64	
Expectations-augmented		-0.03	0.04		0.19	0.82	0.63	0.66	
New Keynesian		-0.04	0.04		0.17	0.83	0.58	0.72	
Hybrid	0.13	-0.03	0.04		0.15	0.72	0.58	0.72	yes

2/ Denotes cases in which lagged inflation is insignificant and automated model selection in PCGETS would reduce the model to the New Keynesian specification.

All coefficients are significant at the 5 percent level, except lagged inflation terms in the hybrid models in those cases where it reduces to the NKPC (where it says "yes" in the last column).

41. First, the first set of estimates tries to determine the degree to which inflation expectations have been anchored on the perceived long-run objective of the monetary authorities relative to being determined by lagged inflation. The results show that expectations of inflation four quarters ahead have been fairly well aligned on the perceived long-run inflation objective (if not necessarily the stated objectives) of the monetary authorities, with a weight several times as high as that on lagged inflation (Table 5). The results also indicate that expectations have been better aligned on the anchor in the more recent sample since 1990 than for the longer sample since 1981Q3 for which U.S. data are available. Euro-area expectations have been only slightly less well aligned on the anchor with a coefficient on lagged inflation of 0.2-0.25 compared to a U.S. coefficient on lagged inflation in the range of 0.1-0.2.

Table 5. Expectations: Well-Anchored or Backward-Looking?

	Constrained estimates				Unconstrained estimates			
	Anchor	Lagged inflation	Sum	R-sq	Anchor	Lagged inflation	Sum	R-sq
United States, 1981(3)-2002								
CPI	0.73	0.27	1.00	0.82	0.83	0.25	1.08	0.97
GDP deflator	0.85	0.15	1.00	0.93	0.80	0.20	1.00	0.95
United States, 1990-2002								
CPI	0.81	0.19	1.00	0.73	0.77	0.21	0.98	0.90
GDP deflator	0.90	0.10	1.00	0.92	0.88	0.08	0.96	0.91
Euro Area, 1990-2002								
Cons. Deflator	0.75	0.25	1.00	0.95	0.80	0.22	1.02	0.98
GDP deflator	0.81	0.19	1.00	0.92	0.87	0.15	1.02	0.97

42. The second set of estimates uses a small model of inflation expectations explained by its own lags and the output gap to see if the latter moved inflation expectations more or less quickly in the United States than in the euro area. The results suggest that a positive output gap (as measured ex post) tended to raise inflation expectations only moderately in the euro area, while a positive change in the output gap had a considerably larger effect in the United States (Table 6). The interpretation would be that inflation expectations in the United States reacted significantly to (largely unforeseen) movements in the output gap, while more sluggish price adjustment and more pervasive uncertainty about the level and stability of the NAIRU in the euro area implied more moderate revisions to inflation expectations when activity shifted gear.[11]

Table 6. Expectations and the Output Gap

	Coefficient estimates 1/		
	Gap	Dgap	Own lags 2/
United States	0.02	0.11	0.99
Euro area	0.02		0.97

1/ From a regression of inflation expectations on its own lags and lags of the output gap.
2/ Sum of coefficients on the own lags of inflation expectations.

[11] Additional estimates were derived for Phillips curve equations as in equation (1) above with lagged inflation and the long-run anchor standing in for survey expectations. However, due to the high collinearity between the perceived long-run anchor and lagged inflation, the coefficients were not robust to small changes in the sample or specifications, and the regressions were not able to uncover systematic differences in the degree to which expectations had been aligned on the anchor in the euro area relative to the United States.

G. Conclusions

43. This investigation suggests that the inflation process in the euro area is only moderately more persistent or inertial than in the United States, if at all. The main findings are:

- Inflation persistence has been high in the historical data on *both* sides of the Atlantic. Much but not all of the observed persistence has been related to low-frequency shifts in economic agents' perceived long-run anchor of inflation. Persistence appears to have declined very significantly since some time in the mid-1990s, reflecting both a more constant long-run anchor and a closer alignment of actual inflation on the anchor.

- Historically, both price and output shocks appeared to have longer-lasting and more significant impacts on prices in the euro area than in the United States, but following the hardening of most euro area countries' commitment to stable exchange rates in the ERM after the mid to late 1980s, impulse responses look broadly similar between the United States and the euro area.

- Using survey measures of inflation expectations, the New Keynesian Phillips Curve matches the data quite well in both the U.S. and the euro area, suggesting little need to invoke structural characteristics in explaining persistence (although the survey expectations of inflation may already internalize some such features). There is evidence that inflation reacts more promptly to the output gap in the United States than in the euro area, yet the size of the coefficient on the output gap appears to be broadly the same.

- There are few signs that inflation expectations in the United States should have been significantly better aligned on the long-run inflation anchor rather than being influenced by past inflation, compared with the euro area. But inflation expectations in the United States do appear to react somewhat more strongly to changes in the output gap, presumably reflecting more flexible product and labor markets.

44. Taken at face value, the results imply that the faster reduction of inflation in the United States than in the euro area in the current economic downturn—as well as in the downturns of the 1970s and 1980s—is primarily due to output developments. In the recent instance, the output gap turned negative earlier and more sharply in the United States. In addition, a slightly earlier response of prices to the output gap, as well as a more rapid decline in inflation expectations as the economy weakened, likely played a role. Finally, erratic price shocks (food prices, euro changeover) and the pass through of earlier import price hikes hampered the reduction in inflation in the euro area in the 2000-2002 period.

45. The proposition that (structural) inflation persistence is not higher in the euro area than in the United States is in line with other evidence from the recent Phillips curve literature (e.g., Gali, Gertler, and López-Salido (2000) and Coenen and Wieland (2002)) but somewhat at odds with earlier evidence from monetary VAR models that suggested monetary policy actions have similar impacts on output in the euro area and the United States but smaller and more delayed effects on inflation in the euro area. Moreover, an earlier line of evidence pointing to higher (short-run) real wage rigidity in the euro area than in the United States—in the face of shocks to both prices and unemployment—also would suggest that inflation should be more sticky and harder to control in the euro area. A fuller examination of the role of expectations formation might produce insights that could help to reconcile this conflicting evidence.

Methods Used to Construct Long Run Inflation Anchors

For the U.S., survey expectations of inflation are readily available from the Federal Reserve Bank of Philadelphia's website. The long-run inflation expectations (10 year CPI inflation forecasts) are available since the fourth quarter of 1979.

For the euro area, the half-yearly IMF forecasts of inflation five years ahead going back to the Summer 1990 WEO were reconstructed (using the same approach for the U.S. would have yielded numbers similar to those in the Philly Fed surveys). Data for the quarters in between the half-yearly observations were interpolated.

Since these data are not readily available prior to 1990, the paper uses an alternative procedure to construct the long-run inflation anchor before that. In order to do this, I first construct a summary measure of monetary policy credibility following Laxton and Papa N'Diaye (2002) based on the level of the long-run nominal interest rate. With credibility varying between 1 at the point of the lowest long-term interest rate (RL_{min}) and 0 at the time of the highest long-term interest rate (RL_{max}), credibility is proxied by:

$$c = \frac{(RL - RL_{\max})^2}{((RL - RL_{\max})^2 + (RL - RL_{\min})^2)}$$

The observed long-run anchor in the 1990-2002 period is then regressed on actual inflation, HP-filtered inflation, and the said measure of central bank credibility, as well as an interaction term, which produces a reasonably good fit. The estimated equation is then used to retropolate the long-run anchor for the time before 1990. The advantage of using the credibility variable rather than simply using filtered and actual inflation is that the inflation in the 1970s and 1980s does not show up as anticipated or fully reflected in the long-run anchor. Applied to the U.S., the said method is roughly able to match the features of the U.S. survey expectations which are available back to 1979Q4, and for the period before that it lines up well with the long-run anchor estimated using shifting end-point Kalman filter techniques in Kozicki and Tinsley (2003) (a technique which is computationally heavy and requires fairly long time spans of back data).

Confidence that this method may be broadly appropriate is enhanced by the fact that the available short-term inflation expectations line up well with the estimated anchor for the euro area before 1990 and the United States before 1979Q4 in a manner that does not deviate systematically from the periods for which the long-run anchor is directly observed, see the two bottom panels of Figure 1 on page 11.

References

Alogoskoufis, George, and Ron Smith, 1991, "The Phillips Curve, the Persistence of Inflation and the Lucas Critique: Evidence from Exchange Rate Regimes," *American Economic Review*, Vol. 81, No. 5, pp. 1254-1275.

Ball, Laurence, N. Gregory Mankiw, and Ricardo Reis, 2003, "Monetary Policy for Inattentive Economies," NBER Working Paper 9491, February (Cambridge, Massachusetts: National Bureau of Economic Research).

Batini, N., 2002, "Euro Area Inflation Persistence," ECB Working Paper 201, December (Frankfurt: European Central Bank).

Batini, N., and E. Nelson, 2001, "The Lag from Monetary Policy Actions to Inflation: Friedman Revisited," *International Finance*, Vol. 4, No. 3, pp. 381-400.

Blinder, Alan S., and others, 1998, "Asking About Prices: A New Approach to Understanding Price Stickiness," (New York: Russell Sage Foundation).

Buiter, W.H., and I. Jewitt, 1981, "Staggered Wage Setting with Real Wage Relativities: Variations on a Theme of Taylor," *Manchester School of Economic and Social Studies*, Vol. 49, No. 3, pp. 211-28.

Calvo, G.A., 1983, "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics*, Vol. 12, No. 3, pp. 383-98.

Chadha, B., P.R. Masson, and Guy Meredith, 1992, "Models of Inflation and the Costs of Disinflation," *IMF Staff Papers*, No. 39, pp. 395-431 (Washington: International Monetary Fund).

Coenen, Gunter, and Volker Wieland, 2002, "Inflation Dynamics and International Linkages: A Model of the United States, the Euro Area and Japan," *International Finance Discussion Papers No. 745*, July.

Erceg, C.J., and A.T. Levin, 2001, "Imperfect Information and Inflation Persistence," *Finance and Discussion Paper 2001-45*, Federal Reserve Board.

Fuhrer, J.C., and G.R. Moore, 1995, "Inflation Persistence," *Quarterly Journal of Economics*, Vol. 110, pp. 127-59.

Fuhrer, J.C., 1997, "The (Un)Importance of Forward-Looking Behavior in Price Specification," *Journal of Money, Credit and Banking*, Vol. 29, pp. 338-350.

Gali, J., M. Gertler, and J.D. Lopez-Salido, 2000, "European Inflation Dynamics," *European Economic Review*, Vol. 45, No. 7, pp. 1237-70.