The pillars of the ECB

SUMMARY

I interpret the European Central Bank's two-pillar strategy by proposing an empirical model for inflation that distinguishes between the short- and long-run components of inflation. The latter component depends on an exponentially weighted moving average of past monetary growth and the former on the output gap. Estimates for the 1971–2003 period suggest that money can be combined with other indicators to form the 'broadly based assessment of the outlook for future price developments' that constitutes the ECB's second pillar. However, the analysis does not suggest that money should be treated differently from other indicators. While money is a useful policy indicator, all relevant indicators should be assessed in an integrated manner, and a separate pillar focused on monetary aggregates does not appear necessary.

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The two pillars of the European Central Bank

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1. INTRODUCTION

> 'Pillar. 1. A detached vertical structure of . . . solid material, . . . used either as a vertical support of some superstructure, as a stable point of attachment of something heavy and oscillatory, or standing alone as a conspicuous monument or ornament; . . .' (*The Compact Edition of the Oxford English Dictionary*, Vol. II, 1984, p. 2175).

As the above quotation illustrates, the term 'pillar' has several meanings (in fact, the *OED* gives another eleven definitions of 'pillar'). It is perhaps therefore not surprising that after more than five years of operation, the monetary policy strategy of the European Central Bank (ECB) remains highly controversial. Initially announced in October

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1998, the hallmark of the strategy is the use of 'two pillars' in formulating and setting monetary policy.[1] The first pillar, which is defined as a:

> 'prominent role for money, as signalled by the announcement of a reference value for the growth of a broad monetary aggregate',

has remained the object of a lively debate and has been subject to intense criticism.[2] For instance, Begg *et al.* (2002, p. xiv), writing in the CEPR *Monitoring the European Central Bank* series, state that:

> 'the first pillar of the monetary strategy is now flawed beyond repair – both as a matter of theory and empirically'.

By contrast, the second pillar, defined by the ECB as a:

> 'broadly based assessment of the outlook for future price developments and the risks to price stability in the euro area as a whole',

has been accepted by the public and the economics profession as a natural part of any active monetary policy strategy. Of course, all central banks that gear monetary policy to achieving and maintaining price stability presumably rely on such an assessment in setting interest rates. So why has the monetary pillar become so exceedingly controversial?

1.1. The issues

One reason for the controversy as regards the ECB's monetary pillar is that observers have failed to detect any relationship between the growth rate of M3 and interest rate decisions taken by the Governing Council of the Eurosystem. With the exception of Gerdesmeier and Roffia (2003), econometric estimates of reaction functions for the euro area typically fail to find that money growth plays a role in the ECB's interest rate decisions. Furthermore, in commenting on the reasons for its policy decisions, the Governing Council has repeatedly stated that episodes of rapid money growth were due to special factors and/or shifts in the demand for money arising from changes in portfolio preferences or in the opportunity cost of holding money. For this reason, it interpreted the observed money growth as not signalling '*risks to price stability*' and therefore chose to disregard it. Galí *et al.* (2004) review the statements

[1] The ECB's policy framework is reviewed in 'The stability-oriented monetary policy strategy of the Eurosystem', ECB *Monthly Bulletin*, January 1999, pp. 39–50. For a non-technical review, see ECB (2004). The role of money in the strategy is discussed in 'Euro area monetary aggregates and their role in the Eurosystem's monetary policy strategy', ECB *Monthly Bulletin*, February 1999, pp. 29–46. Svensson (1999) contains an early but still highly relevant critique of the ECB's monetary policy strategy. See also Svensson (2002).

[2] Reviewing the critique of the two-pillar framework goes beyond the scope of this study. In Box 1, I instead summarize the analysis in the last report in the CEPR series on *Monitoring the ECB 5* (Galí *et al.* 2004), which provides a critical review of a number of arguments in support of the first pillar.

about economic conditions in the Editorials in the ECB's *Monthly Bulletin* and conclude that the Governing Council typically interpreted money growth as not worrying even when it exceeded the 4.5% reference value (see also Gerlach, 2004). Strikingly, despite the fact that money growth was above the reference value between July 2001 and September 2003, the Governing Council never took the view that rapid money growth warranted a tightening of monetary policy.[3]

An arguably more important reason for the controversy surrounding the framework is that the ECB has not spelled out in detail its view of the exact role of money in the inflation process and in the setting of interest rates. Indeed, the ECB has never provided a formal explanation for why it believes that money growth and prices are linked over time and, in particular, why it interprets this relationship as reflecting causation, rather than merely correlation. Indeed, as noted by Galí (2003), a direct relationship between money growth and inflation arises from the existence of a stable money demand function irrespectively of the monetary policy strategy followed by the central bank. Furthermore, in discussing the role of money in its strategy and conduct of policy the ECB has tended to use imprecise terminology. For instance, it has emphasized the 'medium-term' orientation of the framework and has repeatedly used the notion of a 'monetary overhang' but has never given these concepts unambiguous definitions. It has also asserted that money growth has been disturbed by 'special factors' without necessarily being too clear about whether they were of a once-off nature or could be expected to return. Many observers have arguably interpreted this, rightly or wrongly, as the ECB having given the monetary pillar an extra degree of freedom by its choice of terminology.

For the ECB to overcome the scepticism that surrounds the monetary pillar, it needs to provide a clearer explanation of the role of money in the inflation process than it has to date. This necessarily requires a formal, estimable model of the inflation process and the role of money in it. The existence of such a model would naturally shift the debate from the general level that characterizes the exchange between the ECB and its critics today, to the concrete level at which economics is typically debated in the literature. Instead of arguing about whether the framework is 'sensible', the debate would move to technical questions such as whether the model could be derived from first principles, how it should be estimated, whether the resulting estimates are stable over time, whether the empirical results provide support for the two-pillar model, and so on. It is precisely for this reason that central banks, in particular those with inflation targets, tend to make public the models they use to forecast inflation. Formalization is helpful in that it makes

[3] In presenting the framework, however, the ECB did emphasize that it would not change interest rates automatically in response to changes in money growth: 'the concept of a reference value does not entail a commitment on the part of the Eurosystem to correct deviations of monetary growth from the reference value of the short term. Interest rates will not be changed "mechanistically" in response to such deviations in an attempt to return monetary growth to the reference value.' (ECB *Monthly Bulletin*, January 1999, p. 49).

it possible to pin down the exact nature of the disagreement(s) and the areas of agreement.

In light of this, one would have expected the ECB to put forth a formal model of its framework. Rather than doing so, however, when discussing its two-pillar strategy (ECB *Monthly Bulletin*, November 2000, pp. 37–48) it has stated that:

> 'it has proven extremely difficult to integrate an active role for money in conventional real economy models . . . despite the general consensus that inflation is ultimately a monetary phenomenon' (p. 45).

In discussing the two pillars, it has gone on to assert that:

> 'it is not practically feasible to combine these two forms of analysis in a transparent manner in a single analytical approach' (p. 46).

While seemingly innocuous, these statements are thought provoking. Why, one may wonder, did the ECB adopt a monetary policy framework that it has found difficult to rationalize using standard macroeconomic analysis? Isn't the mere fact that it is difficult to formalize the two pillars in a clear and transparent fashion a good reason to worry about, or even doubt, the usefulness of such a policy framework?

Given the need for a model of the ECB's two-pillar framework, seeking to formalize it should be high on the research agenda. This paper provides an attempt to do so by proposing a simple ad hoc empirical model of inflation in the euro area.[4] The model, which incorporates money growth in a Phillips curve, interprets the two pillars as separate approaches to forecasting inflation at different time horizons. The first pillar – *the monetary analysis* – is seen as a way to forecast inflation at long time horizons and to account for changes in the steady-state rate of inflation (or in the average rate of inflation over a few years). Empirically, I associate the first pillar with an exponentially declining moving average of M3 growth.[5] The second pillar – *the economic analysis* – is understood as the ECB's way to predict short-run movements in inflation around that steady-state level. The model identifies the output gap with the second pillar; a more elaborate version would need to consider also other determinants of temporary swings in inflation, including import and energy prices, changes in value added taxes and so on.

[4] There are several other studies on the role of money in the euro area, but, with the exception of Neumann (2003), these do not focus on interpreting the two-pillar framework as I do here. Andrés *et al.* (2003), following Ireland (2002), study the role of money by estimating a small-scale dynamic general equilibrium model in which real balances may affect the marginal utility of consumption, but find no evidence for such an effect. Coenen *et al.* (2001) estimate a model in which money contains information about output, which is measured with error. Andrés *et al.* (2004), Kajanoja (2003) and Lippi and Neri (2003) estimate forward-looking money-demand models that imply that money may contain useful information about the state of economy that is not embedded in currently observed variables.

[5] Of course, the ECB's monetary analysis extends beyond simply understanding the nature of M3 growth.

1.2. Outline and main results

The paper makes two contributions. The first of these is to demonstrate, as others have done before, that money growth does contain information about future inflation in the euro area and that money therefore can serve as an information variable. I argue, however, that the analysis does not support the notion that money should be treated any differently from other information variables and, in this sense, does not point to a need for a separate monetary pillar. Indeed, the second contribution of the paper is to show how money growth can be integrated with other information variables to forecast inflation and to form the 'broadly based assessment of the outlook for future price developments and the risks to price stability' that constitutes the *second* pillar of the ECB's framework.

Section 2 characterizes briefly the joint behaviour of inflation and money growth in the euro area. I show that these variables are closely correlated. Section 3 presents some evidence to the effect that (a measure of) money growth contained information for future inflation in the 1970–2003 period, even after accounting for the information in past inflation and the output gap. Estimates for subperiods show that while money was informative for future inflation in the 1970–86 period, the information content declined after 1987. Section 4 argues that the two-pillar framework must ultimately rely on a two-pillar view of inflation. It goes on to propose an empirical model of inflation – a 'two-pillar Phillips curve' – that integrates money with a standard, although forward-looking, Phillips curve and provides a composite forecasting model for inflation. Section 5 proceeds to estimate the model using data for the 1971–2003 period. Without going through the results in detail here, I argue that the model fits the data well. Section 6 provides estimates for two subsamples. The first of these spans the high inflation period 1971–91, and the second the low inflation period 1992–2003. Perhaps surprisingly, I find that the model fits well also in the latter sample period. Four boxes and two appendixes complement the analysis in the main part of the paper. Box 1 summarizes the analysis in the last report in the CEPR series on *Monitoring the ECB* (Galí *et al.*, 2004), which provides a critical review of a number of arguments in support of the first pillar. Box 2 surveys research published by the ECB on the information content of money growth for inflation. Box 3 reviews how the role of money growth in the ECB's policy strategy was changed as a consequence of the review of the framework that was completed in May 2003. Box 4 provides a formal statement of the empirical model and the resulting inflation equation that I estimate. Appendix 1 provides some new results on the usefulness of money in forecasting inflation in the euro area and Appendix 2 derives the inflation equation that I estimate.

In Section 7 I conclude by turning to the central question whether the model and the broader literature on money growth and inflation provide support for a monetary pillar. I claim that money growth is about as useful for predicting future inflation in the euro area as the output gap, and that it consequently makes good sense for the

ECB to monitor monetary developments in the same way as it assesses other indicators of price pressures. Next I turn to the question of the monetary pillar. I argue that while money is a useful policy indicator, all such indicators should be assessed in an integrated manner. Thus, I do not believe that the analysis implies that a separate monetary pillar is necessary.

Box 1. Monitoring the ECB 5

Reviewing in detail the large literature criticizing the two-pillar strategy would go far beyond the scope of the present paper. This box instead summarizes the analysis of a number of claims in favour of a monetary pillar in the most recent of the annual reports by the CEPR on 'Monitoring the ECB', entitled, *The Monetary Policy Strategy of the ECB Reconsidered* (Galí *et al.*, 2004; needless to say, my interpretation of these arguments may or may not coincide with those of my co-authors).

One argument in support of the first pillar is that *money may be a proxy for variables that are observed with a lag or not at all.* For instance, output gaps, which play an important role in most central banks' analysis of inflation, are unobserved and measures thereof must be constructed using data that are published with a lag and may undergo repeated revisions. Since money growth data are rapidly available and money may be correlated with income, it could potentially be used to improve assessments of the current output gap. However, the report argues that other, non-monetary variables are likely to be more informative than money for this purpose. Furthermore, even if money did contain useful information, there is no reason to give it a separate pillar. Rather, the information in money should be used together with other indicators in forming a broader view of economic conditions.

A further alleged reason for why it may be helpful to monitor money growth is that *money may play an important role in the transmission mechanism of monetary policy.* The report analyses this argument but concludes that while it may well be correct, it would suggest looking at more direct measures of the financial conditions of firms and households than the growth rate of the broad money stock. Moreover, also in this case would it be natural to undertake this work as a part of the economic analysis underlying the second pillar.

Another claim for why money growth needs to be monitored is that high inflation is always associated with rapid money growth, which in turn suggests that *monetary control is essential for ensuring long-run price stability*. While the report does not dispute that growth rates of money and prices are frequently closely related (in the sense that money and prices may be cointegrated), it argues that this is not sufficient to justify a monetary pillar. A finding of cointegration does not imply that prices adjust to money. In a multivariate setting in which money and prices are cointegrated with, say, income and interest rates, the adjustment to equilibrium may be carried out by movements in the latter variables rather than money or prices. Thus, money being high relative to prices might well lead to lower money growth in the future. Moreover, to the extent that prices adjust, they need not do so rapidly. Overall, cointegration between money and prices does not impose much restriction, if any, on the short-run behaviour of inflation. Optimizing inflation control therefore requires policy-makers to focus on other, short-run factors that are presumably captured in the economic analysis of the second pillar.

It is sometimes asserted that *while the economic analysis of the second pillar may serve to ensure price stability in the short term, this is not sufficient to safeguard price stability in the long run*. Here the report takes the view that maintaining price stability month-by-month presumably must imply maintaining it over the long run as well. Moreover, while the report is open to the notion that there could indeed be potential medium-term risks to price stability, it argues that the ECB's strategy does not at all spell out what policy reactions these should elicit as long as that threat remains merely potential. The usefulness of indicators of medium to long-term risks to price stability is therefore unclear.

It has been argued that *conducting monetary policy with an eye on money growth may be useful for avoiding the trap of discretionary policy-making with a resultant increase in inflation*. While avoiding an inflation bias due to discretionary policy is desirable, the report concludes that this problem is better solved by the ECB committing itself to following an appropriately designed policy rule rather than adopting a two-pillar strategy.

Yet another argument in favour of monitoring money is that *the two-pillar strategy leads to more robust decision-making by cross-checking the implications for interest rates of alternative models of inflation*. While the report recognizes the need for such cross-checking, this could presumably be done in the context of the economic analysis in the second pillar, which should take into account all information regarding inflation pressures including information about the role of money growth in the inflation process. The report also notes that the ECB has never spelled out in detail what the role of money is in the alternative models of the inflation process it has in mind, and that the ECB appears to view monetary analysis as providing an escape clause for policy. Thus, the ECB seems to argue that although that analysis does not lead to formal inflation forecasts, it helps guard against inflation gradually rising above the objective. The report is recognizant of the need to guard against this and notes that limiting money growth may be one way in which persistently high inflation can be avoided. However, it goes on to argue that a more natural and better way to achieve this is simply to monitor actual inflation developments.

The final argument considered by the report is the claim that *monitoring monetary aggregates is essential to preventing instability due to self-fulfilling expectations.* The report analyzes this argument, but concludes that many of these problems can be overcome with interest rate rules (see the discussion in Woodford, 2003). The potential exception is the case of self-fulfilling deflationary traps in case of which the report argues that a commitment by the central bank to maintain money balances at a level above that required to keep the interest rate at zero may be desirable (as discussed by Eggertsen and Woodford, 2003). However, this is only necessary in specific circumstances, and does not generally involve cross-checking in the form of a two-pillar policy framework.

My own interpretation of the report is that it takes the view that the ECB would be ill advised to disregard monetary factors, but that taking proper account of these does neither necessarily entail monitoring the growth rate of M3, nor does it require a separate monetary pillar.

2. MONEY GROWTH AND INFLATION: EMPIRICAL REGULARITIES

To motivate the subsequent analysis, it is useful to start by looking at the behaviour of inflation and money in the euro area. Figure 1 shows the evolution of CPI inflation and money growth since 1971.[6] Following the practice of the ECB and most other central banks, both growth rates are computed as the change over four quarters. The figure tells a familiar story: money growth and inflation were both high in the 1970, declined and reached a low around 1986, and then accelerated until 1991. Subsequently both decelerated before increasing somewhat towards the end of the sample.

The ECB views these correlations as reflecting the impact of money growth on future inflation. In the *Monthly Bulletin* of February 1999 (p. 39), it provides a figure of an eight-quarter moving average of four-quarter inflation and money growth, with money growth led six quarters, presumably because this captures the lag between movements in money and prices. Figure 2 provides an updated version of this plot, with the data starting in 1972Q4 and ending in 2003Q1. To facilitate a comparison, the sample period used in the figure in the *Monthly Bulletin* is also indicated.

The figure shows a close relationship between the two series. However, that relationship was somewhat less close in the 1972–83 and the 1999–2003 periods that were not included in the figure in the *Monthly Bulletin.*

[6] Prices are measured by consumer prices, money by M3 and output by real GDP. All variables are seasonally adjusted. The data set and information about its construction are available at http://www.economic-policy.org.

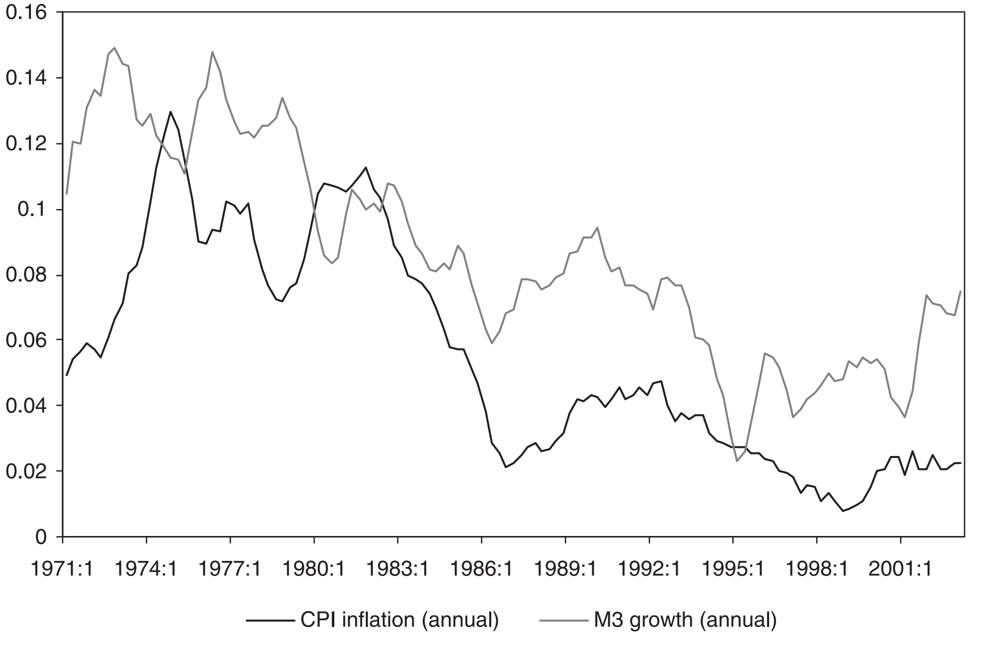

Figure 1. CPI inflation and M3 growth

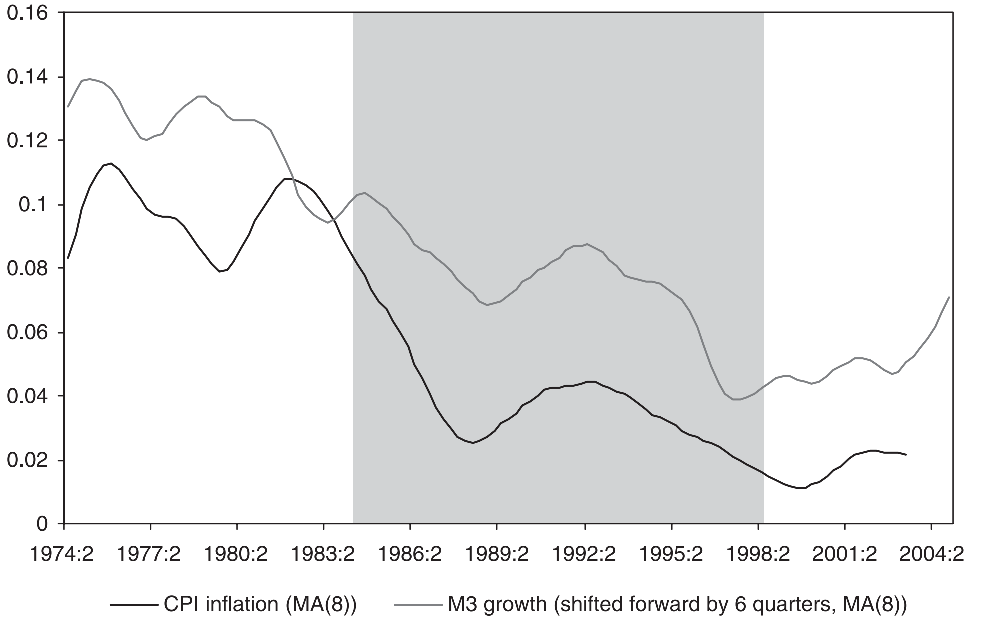

Figure 2. CPI inflation and M3 growth (6 quarters earlier)

Note: Shaded area indicates sample used in the ECB *Monthly Bulletin*, February 1999.

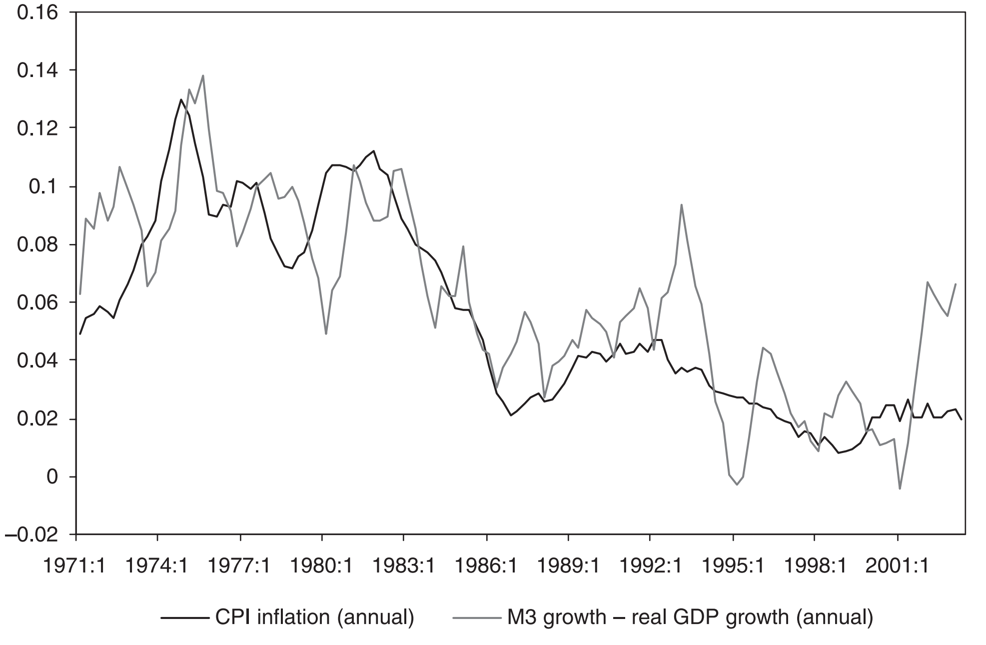

Figure 3. CPI inflation and adjusted M3 growth

Of course, the quantity theory suggests that the relationship between money growth and inflation depends on output growth and on velocity. While the ECB has taken the view that velocity is declining at a broadly stable rate over time (see Brand *et al.*, 2002), income growth does fluctuate. Figure 3 therefore contains a plot of inflation together with the growth rate of M3 minus the growth rate of real GDP (in what follows, I refer to this as money growth adjusted for income growth or 'adjusted money growth').[7] The relationship between inflation and adjusted money growth is perhaps even closer than the relationship between inflation and money growth. However, Figure 4, which is constructed in the same way as Figure 2, does not show any lag between adjusted money growth and inflation. This casts some doubt on the empirical regularity emphasized by the ECB in motivating the monetary pillar.

Further evidence on the relationship between money growth and prices in the euro area is provided by Gerlach (2003) who, following Cogley (2002), studies the behaviour of exponentially weighted moving averages of inflation and adjusted M3 growth obtained using a simple filter.[8] Here I simply note that applying the filter to an economic series, or 'filtering' the series, produces a more slowly moving series that I

[7] Alternatively, it could be thought of as the growth of money per unit output.

[8] In a paper related to Gerlach (2003), Neumann (2003) employs the Hodrick–Prescott filter to obtain a two-sided moving average of money growth and uses the resulting time series to model inflation in the euro area. Jaeger (2003) uses spectral analysis to study the relationship between money growth and inflation in the euro area in the short and long run.

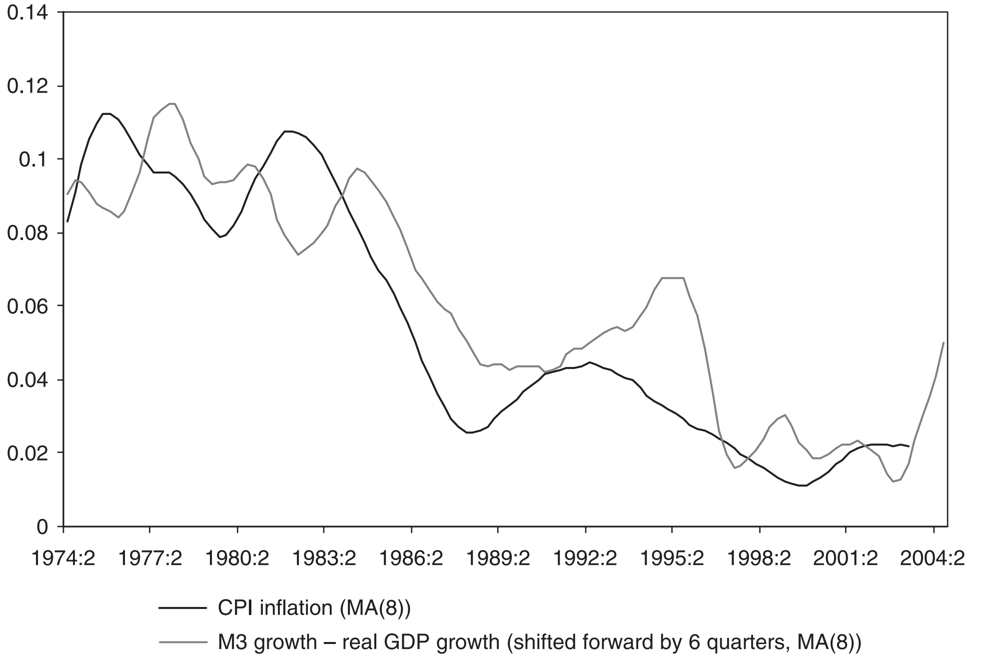

Figure 4. CPI inflation and adjusted M3 growth (6 quarters earlier)

refer to as the 'trend' version of the series in question. Thus, applying the filter to money growth, adjusted money growth or inflation generates 'trend money growth', 'adjusted trend money growth' and 'trend inflation'. The extent of the filtering depends on a 'smoothing parameter' which determines how smoothly the filtered series evolves over time. I assume the 0.075 value used by Gerlach (2003), which implies a half-life of 9.2 quarters; in the econometric analysis below I estimate this parameter (see Box 4 below for technical details).

Because of velocity shocks, there is no reason to expect a one-to-one relationship between trend inflation and money growth. To see more clearly the correlations between the variables, I therefore transform the data so that they have zero mean and unit variance. Figure 5 plots filtered inflation and M3 growth and Figure 6 plots filtered inflation and adjusted M3 growth. The figures show a close relationship between trend inflation and money growth, in particular adjusted money growth.[9]

Overall, these informal time series plots are supportive of a tight link between money and inflation in the euro area and are no doubt one reason why the ECB believes that a two-pillar framework is appropriate. As noted above, however, a relationship between money growth and inflation arises from the existence of a

[9] Lucas (1980) discusses how filtering can be used to clarify the relationship between inflation and money growth.

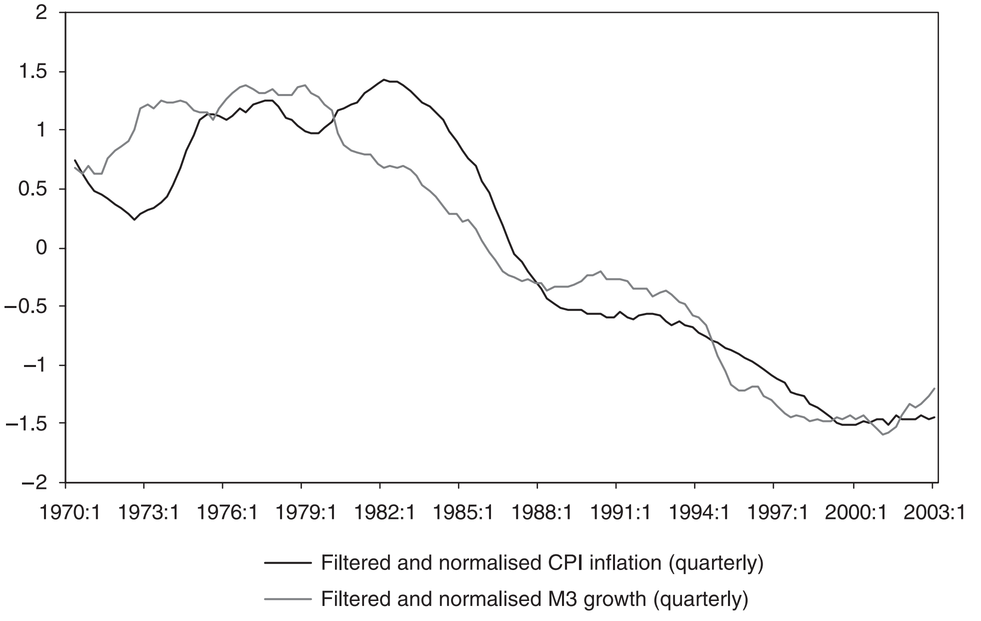

Figure 5. Filtered and normalized CPI inflation and M3 growth

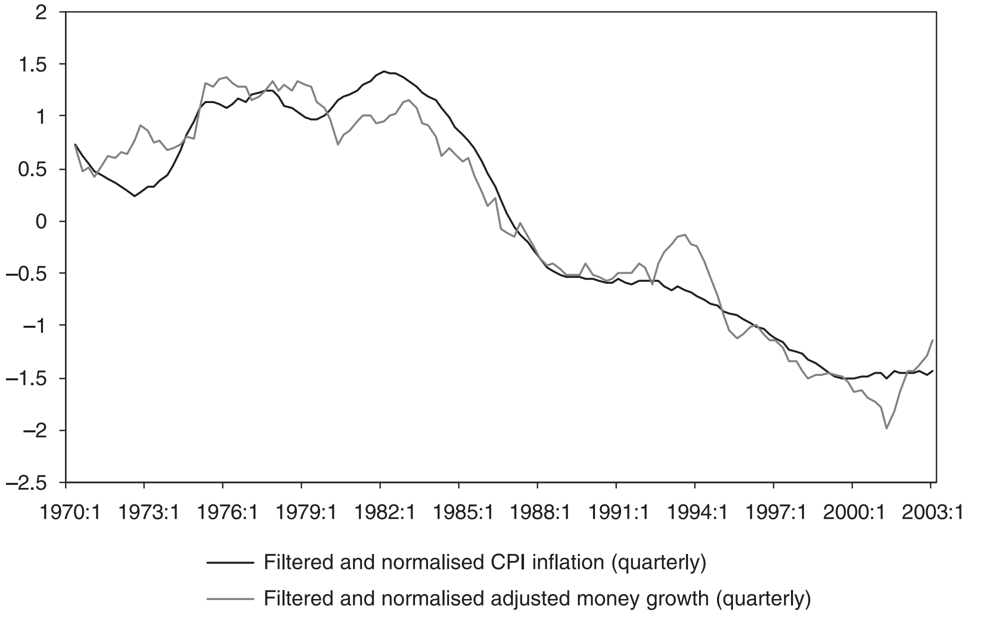

Figure 6. Filtered and normalized CPI inflation and adjusted M3 growth

money demand relationship. Thus, these figures are silent on the critical issue whether it is money growth that leads to inflation or inflation that leads to money growth.

3. MONEY AND PRICES: REDUCED-FORM EVIDENCE

Next I characterize the relationship between money growth and inflation somewhat more formally. While the figures reviewed above suggest that different measures of money growth are correlated with future inflation and therefore may contain information useful in judging 'risks to price stability', they by no means provide any firm evidence to that effect. For money to be a useful information variable, it must be that it contains information that is not already embedded in past inflation rates or other traditional indicator variables, in particular measures of the output gap. A large body of research conducted by the ECB and others demonstrates that money growth does contain such information (see Box 2). As a prelude to the econometric analysis, I explore the information content for future changes in inflation of the trend money growth measure discussed above.

Box 2. Money and inflation in the euro area

Much of the research on the relationship between money and prices in the euro area has focused on modelling the demand for money and has been contributed by the staff of the ECB. Masuch *et al.* (2003) summarize work in this area by the ECB; its predecessor, the European Monetary Institute, also conducted research on this issue: see, e.g., Fagan and Henry (1998). Coenen and Vega (2001) study quarterly data on real M3, real income, short and long interest rates and inflation for the period 1980–98. After testing for weak exogeneity, they estimate a single equation error-correction model, which appears stable and well behaved, for the demand for the real money stock. Brand and Cassola (2000) study the same variables over a slightly longer sample, and estimate a system comprising three long-run relationships. They also find a well-defined money demand relationship and detect no evidence of instability.

Calza *et al.* (2001) investigate the demand for money in the euro area. In contrast to the earlier literature, the authors focus on measuring the opportunity cost of holding M3 and argue that it is best captured by the spread between short-term interest rates and the own return on M3. They also estimate a system consisting of a demand equation for the real money stock and an equation for the opportunity cost. This system appears to have good statistical properties and to be stable. Fagan *et al.* (2001) estimate a money demand function as one equation of their econometric model of the euro area in which, as noted by Begg *et al.* (2002), money plays a purely passive role. Brand *et al.* (2002) study the income velocity of money in the euro area, which is of importance in the determination of the ECB's reference value for M3 growth. They find a well-defined empirical relationship between money, income, prices and the opportunity cost of holding money. However, there is some limited evidence that the income elasticity of money demand has risen from 1992Q1 onwards.

The models studied above all focus on the demand for the real money stock, and find that it moves over time to offset monetary disequilibria as captured by an error-correction term. One unfortunate implication of the use of the real money stock in the analysis is that the results are silent on whether it is the nominal money stock or the price level (or both) that adjust to offset disequilibria. Thus, these models do not permit conclusions to be drawn regarding the role of money in the inflation process.

The relationship between money and prices has been addressed directly by Trecroci and Vega (2000). They argue that while money does not appear to Granger cause inflation, that conclusion depends on the information set used in the forecasting exercise. Moreover, they find that the 'p-star' model – or, equivalently, the real money gap model of Gerlach and Svensson (2003) – indicates that money is informative about future inflation. Although the authors argue that the model can be refined, they show that it provides better longer-term forecasts of inflation than the non-monetary inflation equation in the econometric model of Fagan *et al.* (2001). Nicoletti-Altamari (2001) performs a simulated out-of-sample forecasting exercise to study the information content of money for prices in the euro area. The results suggest that monetary and credit aggregates provide useful information about price developments, particularly at medium-term horizons.

Batini (2002), in an ECB working paper, studies the relationship between money and prices in the euro area in a model-free manner. She finds that money growth, which she interprets as a measure of overall monetary conditions, impacts on inflation with a time lag of over a year.

While the findings discussed above are all compatible with the notion that money contains information that is useful in predicting inflation, it should be remembered that the results stem from non-structural models. They are therefore arguably best seen as establishing the empirical regularities that are to be explained.

Overall, I interpret this literature as indicating that money has predictive content for inflation in the euro area. However, the output gap is also relevant for forecasting inflation.

My approach is similar to that of Cogley (2002), who uses (what I call) trend inflation as a measure of core inflation and asks whether the discrepancy between headline and trend inflation is useful for predicting future changes in headline inflation. More formally, Cogley explores whether the change in headline inflation over the coming j quarters is predictable on the basis of the current spread between trend and headline inflation. He also generalizes this approach by asking how these results change if other variables are included in the analysis. As additional variables I incorporate the output gap and the spread between current trend money growth and trend inflation. My principal interest is to explore whether this latter variable is statistically significant and how it contributes to the explanatory power of the regression.

Before turning to the results three comments are in order. First, I focus on the wedge between trend money growth and trend inflation since it plays an important role in the analysis below and since its information content has not previously been studied. Of course, other measures of money, in particular 'headline' money growth, could also be used. Second, this is a reduced-form relationship. Woodford (1994) demonstrates that the usefulness of an information variable (in my case money growth) for forecasting a target variable (in my case inflation) depends on the policy regime in force. Woodford's argument implies that the correlation between money growth and inflation can be zero even if money is a structural determinant of inflation. Thus, a finding that money growth does not contain information about future inflation does not necessarily imply that money growth is irrelevant, from a structural perspective, for price formation. Moreover, the information content of money may shift over time in response to changes in the policy regime. Third, econometric work on the usefulness of information variables is inherently subject to the critique that the results are only valid in the estimation period. Since I am interested in whether a proposed information variable is operational at monetary-policy relevant time horizons, say 1–3 years ahead, one needs at least a sample several times longer than that to assess the information content. This makes it difficult to formally explore the hypothesis that money has lost its significance since the establishment of the ECB.

Appendix 1 contains a detailed discussion of the empirical work and the main results. For my purposes, the most important findings are:

- Trend money growth (relative to trend inflation) does generally contain information about future changes in headline inflation. The exact information content depends on the time horizon (2, 4, 8 and 12 quarters) and sample periods studied (1970–2003, 1970–1986 and 1987–2003). In particular, while money growth helps predict future inflation for all time horizons in the pre-1987 and the full sample, it appears significant only at the 2 and 4 quarter horizons in the post-1986 sample.
- The information in money growth is not already embodied in the output gap and the wedge between headline and trend inflation.

- The information in the output gap appears to have gained importance over time.[10] In particular, the output gap is about as significant as money growth in the post-1986 sample, but much less significant in the pre-1987 sample.
- These findings are important in that they provide a formal indication of the information content of money for future inflation.

4. A TWO-PILLAR PHILLIPS CURVE

In this section I present my interpretation of the ECB's monetary policy strategy. I start from the hypothesis that the strategy must be based on, at least implicitly, a 'two-pillar' view of inflation. The task I face, therefore, is to construct a model for forecasting inflation in which money plays an integral and non-trivial role.

As a first step, it is useful to clarify my interpretation of the ECB's view of the inflation process. This is difficult because the importance that the ECB has attached to money has evolved over time. In particular, the review of the monetary policy framework which the ECB announced in 2002 and which was completed in 2003 led to a reassessment of the role and importance of money (see Box 3 for greater detail).

Box 3. The ECB's 2003 review of the monetary policy strategy

In October 1998, the Governing Council of the ECB announced the main features of its monetary policy strategy, the core of which is a quantitative definition of price stability and a two-pillar framework for assessing the risks to price stability. After more than three years of experience, the ECB stated in 2002 that it would review the framework. The outcome of this evaluation was made public in May 2003. While it considered both the quantitative definition of price stability and the two-pillar framework, in the interest of brevity I focus here on the implications for the monetary pillar. Galí *et al.* (2004) contains a detailed analysis of the overall outcome of the review.

While the review does not say so explicitly, my interpretation of it is that the Governing Council decided to maintain, but to downplay, the monetary pillar (von Hagen and Hofman 2003). Three notable changes were made.

First, the Governing Council appeared to change, or at least clarify, the motivation for the monetary pillar. When the two-pillar strategy was first introduced, the ECB argued that, given the high degree of uncertainty under which policy is conducted, the two-pillar strategy 'reduces the risk of policy errors

[10] This is evidenced by the fact that the adjusted R-squared from, and the significance of the slope parameter in, the univariate regressions are systematically higher in the second sample.

caused by the overreliance on a single indicator or model. Since it adopts a diversified approach to the interpretation of economic conditions, the ECB's strategy may be regarded as facilitating the adoption of a robust monetary strategy' (ECB, *Monthly Bulletin*, November 2000, p. 45).

It went on to argue that a specific concern was the fact that the inflation process was so poorly understood. On the same page, it stated that 'A reflection of the uncertainties about, and the imperfect understanding of, the economy is the large range of models of the inflation process . . . Many of these models capture important elements of reality, but none of them appear to be able to describe reality in its entirety. Therefore, any single model is necessarily incomplete. As the set of plausible models is very broad, any policy analysis needs to be organised within a simplifying framework. The ECB has chosen to organise its analysis under two pillars.'

Thus, when it was initially announced, the ECB motivated the two-pillar strategy by appealing to the risks that could arise from putting too much faith in any single hypothesis of the price mechanism.

After the conclusion of the review, the ECB continued to emphasize that the two-pillar framework was intended to avoid an excessive reliance on a single conceptual model of inflation (ECB, 2003, p. 17): 'Monetary policy faces uncertainties about the functioning of the economy. The ECB's monetary policy strategy was designed with the aim of ensuring that no information is lost and that appropriate attention is paid to different analytical perspectives . . . The two-pillar approach is a means to convey the notion of diversification of analysis to the public and ensure robust decision-making on the basis of different analytical perspectives.'

However, following the review, the ECB's motivation focused on the need to combine information with different time dimensions (ECB, 2003, p. 18; see also the quotes in Section 4): 'Overall, the two-pillar approach provides a framework for cross-checking indications stemming from the shorter-term economic analysis with those from the monetary analysis, which provides information about the medium to long-term determinants of inflation.'

Moreover, in the summary article in the June 2003 *Monthly Bulletin*, it writes that: 'The Governing Council . . . indicated that monetary analysis mainly serves as a means of cross-checking, from a medium to long-term perspective, the short- to medium-term indications coming from economic analysis' (p. 87).

Overall, it seems that the motivation for the two-pillar approach changed as a consequence of review.

Second, the Governing Council decided to adopt a new structure for the President's Introductory Statement to the ECB's monthly press conference by reversing the order in which the information coming from the two pillars is presented. Thus, it was decided that the statement henceforth would start with the broadly based economic analysis under the second pillar before turning to the monetary analysis of the first pillar. One plausible explanation for this decision is that the economic analysis provides more information about the Governing Council's view of near-term inflation pressures, and therefore about the likelihood of interest rate changes, than the monetary analysis. I therefore believe this signals a reduction of the importance attached to the monetary pillar. This is supported by the fact that since December 2003, the term 'pillar' is no longer used in the editorials of the ECB's *Monthly Bulletin*, which contain a discussion of the Governing Council's view of economic developments and its assessment of the need for interest-rate changes.

The third change concerns the reference value for money growth. While the Governing Council in the past had reviewed this on an annual basis, it decided to discontinue this practice. This decision reflected the fact that since the monetary analysis pertained to the medium to long term, there would presumably be little reason to consider updating the reference value on an annual basis.

Despite this, I believe that the ECB's view is based on the following three propositions:

- Monetary policy impacts on inflation with a lag. It is therefore important to give monetary policy a 'medium-term orientation' and to forecast inflation at the time horizon relevant for monetary policy.
- Inflation depends on many factors. In the short run, it is largely influenced by cost variables (in particular energy prices and wages), the output gap, import and food prices, taxes and changes in administratively set prices. In the long run, however, it is determined solely by monetary factors. In the time horizon relevant for monetary policy, both sets of factors play a role and the central bank therefore faces a non-trivial forecasting problem.
- To assess the outlook for inflation at the medium-term time horizon, it is helpful to decompose inflation into two components or pillars. The first pillar is intended to capture the monetary factors that are useful for forecasting the long-run evolution of the price level. The second pillar is intended to reflect the factors that are helpful for predicting short-run movements in inflation.

Overall, this analysis suggests that the important conceptual difference between the pillars concerns the forecasting horizon that they apply to. This interpretation seems compatible with the ECB's own statements. In particular, in discussing the outcome of its widely noted review of the framework, it writes:

> 'The two pillars are: economic analysis to identify short- to medium-term risks to price stability; and monetary analysis to assess medium to long-term trends in inflation, given the close relationship between money and prices over extended horizons.'[11]

[11] See 'The outcome of the ECB's evaluation of its monetary policy strategy', ECB *Monthly Bulletin*, June 2003, pp. 79–92, in particular p. 79.

It goes on to state that:

> 'The inflation process can be broadly decomposed into two components, one associated with the interplay between demand and supply factors at a high frequency, and the other connected to more drawn-out and persistent trends . . . The latter component is empirically closely associated with the medium-term trend growth of money.'[12]

Furthermore, in an overview article directed to the scholarly community, the ECB (2003, p. 18) writes about the two pillars that:

> 'One aspect of this approach relates to *the different time perspectives* relevant to the analysis under the two pillars. This builds on the well-documented findings that long-term price movements are driven by trend money growth, while higher frequency inflation developments appear to reflect the interplay between supply and demand conditions at shorter horizons. Against this background, the broadly based economic analysis gives higher-frequency indications for policy decisions based on the assessment of non-monetary shocks to price developments and the likely evolution of prices over short to medium-term horizons. Monetary analysis and indices of monetary imbalances, on the other hand, provide information against which these indications can be evaluated and the stance of policy can be cross-checked from a longer-term perspective' (emphasis in the original).[13]

Thus, there can be little doubt that the main difference between the two pillars pertains to the time horizon they are supposed to be relevant for. Next I propose a model of inflation that combines monetary and non-monetary factors in this spirit.

4.1. The empirical model

Box 4 spells out the central elements of the model and the inflation equation that I estimate. Below I provide a non-technical discussion.

Box 4. The model

This box spells out the empirical model in detail. First I consider the filter discussed in the text. Sargent (1979, ch. 11) studies a consumption function in which permanent income is determined according to this filter. He states that Muth (1960) shows that this filter is compatible with the assumptions about expectations formation made by Friedman (1956).

[12] *Ibid.*, p. 87. See also Box 2 on p. 90.

[13] Interestingly, on the same page the ECB writes '[t]he medium to long-term focus of the monetary analysis implies that there is no direct link between short-term monetary developments and monetary policy decisions.'

Let x_t denote the annualized quarterly growth rate of some series. The smoothed or filtered series, x_t^*, is then given by:

$$x_t^* = \lambda x_t + (1 - \lambda)x_{t-1}^*. \tag{1}$$

I use this formula on x_t series corresponding to M3 growth, μ_t; adjusted money growth, $\tilde{\mu}_t \equiv \mu_t - \Delta y_t$, where Δy_t denotes the growth rate of real GDP; and inflation, π_t. I refer to the resulting x_t^*-series as 'trend money growth', 'adjusted trend money growth' or 'trend inflation'. All series are measured on an annualized quarterly basis: inflation, for example, is thus measured as $4 \times \log(p_t/p_{t-1})$. The 'smoothing parameter', λ, is important in that $\ln(2)/\lambda$ captures the time it takes for a permanent one-unit change in x_t to lead to a 0.5 unit change in x_t^* (Cogley, 2002, p. 103). In Sections 2 and 3, I assume that $\lambda = 0.075$; in Sections 5 and 6, I estimate λ.

Turning to the model, let g_t denote the output gap; ε_t denote a residual; and let a superscript e denote an expected value. I start from a standard, reduced-form Phillips-curve equation:

$$\pi_t = \alpha_f \pi_{t+1}^e + \alpha_b \pi_{t-1} + \alpha_g g_{t-1} + \varepsilon_t, \tag{2}$$

which states that current inflation depends on expected future inflation, past inflation and the once-lagged output gap. I use the Hodrick–Prescott filter to construct a measure of the gap. Since there is typically a time lag between movements in the output gap and movements in inflation, I assume a one-period lag.

The relative weights of past, α_b, and expected future, α_f, inflation in the determination of inflation are of particular interest. While theory suggests that $\alpha_f \approx 1$, a number of studies from a range of economies typically estimate a much smaller value. I therefore test three hypotheses regarding these parameters: that the weights on the forward and backward-looking elements sum to unity ($\alpha_f + \alpha_b = 1$), that inflation is fully backward looking ($\alpha_f = 0$ and $\alpha_b = 1$) and that it is fully forward looking ($\alpha_f = 1$ and $\alpha_b = 0$).

Next, I assume that inflation expectations depend on $x_t^* = \mu_t^*$, $\tilde{\mu}_t^*$ or π_t^*:

$$\pi_{t+1}^e = x_{t-1}^*, \tag{3}$$

where a constant has been disregarded. Using equations (1), (2) and (3) and assuming $x_t^* = \mu_t^*$, Appendix 2 derives the TPPC, which integrates monetary factors into a standard Phillips-curve equation and which constitutes my proposed interpretation of the ECB's view of the inflation process:

$$\pi_t = \beta_1 \mu_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t, \tag{4}$$

where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = (1 - \lambda + \alpha_b)$, $\beta_4 = -(1 - \lambda)\alpha_g$, $\beta_5 = -(1 - \lambda)\alpha_b$ and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ where $\rho = 1 - \lambda$. This equation is more complicated than a traditional Phillips curve, but has a straightforward interpretation.

First, nominal money growth, my proposed representation of the first pillar, enters because it influences trend money growth, which in turn impacts on inflation expectations. The impact of money growth depends on λ, which captures how rapidly expectations change when money growth changes, and the extent to which inflation is forward looking, α_f. Only if $\alpha_f = \lambda = 1$ is there a one-to-one relationship between (past) money growth and inflation.

Second, inflation depends on the output gap, which should be thought of as a shortcut for the many factors that enter in the second pillar. Needless to say, in a fully specified model it would be desirable to incorporate other elements capturing cost-push factors such as import and energy prices and changes in value added taxes.

Third, once-lagged inflation enters the equation for two reasons. Past inflation matters in the standard Phillips curve given by equation (2). The importance of this factor depends on α_b. Furthermore, past inflation captures the importance of μ^*_{t-1}, which plays a role in determining μ^*_t as evidenced by the term $(1 - \lambda)$.

Fourth, g_{t-2} and π_{t-2} enter, provided that $\lambda < 1$. Thus, these variables appear solely because of the assumed expectations-formation process. To see this most clearly, note that g_{t-2} and π_{t-2} do not enter the equation if $\lambda = 1$, in which case expected future inflation is given by μ_{t-1}.

Fifth, the error term follows an MA(1) model with a coefficient that depends on λ. Of course, this results from the assumption that the ε_t-errors are serially uncorrelated, which need not be the case. Preliminary estimates suggested that the restriction that the moving-average parameter equals $(1 - \lambda)$ was rejected for the full sample period. Indeed, and as shown by Figure 7, quarterly

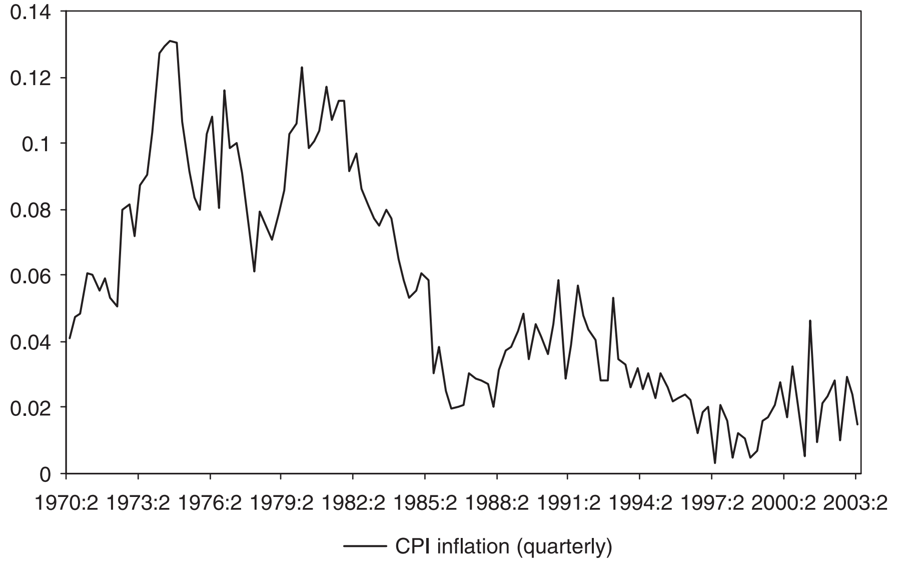

Figure 7. CPI inflation

changes of inflation display large negative first-order autocorrelation. This may be related to the way in which the price data are constructed or deseasonalized. I therefore do not impose the theoretical restriction that the moving-average parameter equals $(1 - \lambda)$, but rather estimate it as a free parameter, ρ. Thus, I fit $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$.

It is important to note that the β_i-parameters in the model depend on the underlying coefficients $(\alpha_f, \alpha_g, \alpha_b, \lambda)$. To fit the model thus entails estimating these latter parameters rather than the β_i's. The model is estimated by writing equation (4) in state-space form and using the Kalman filter to evaluate the likelihood function.

In modelling the ECB's view of the inflation process, I want to stay as close as possible to generally accepted macroeconomic building blocks. I therefore start from a standard Phillips-curve relationship that states that current inflation depends on expected future inflation, past inflation and the output gap.[14] As in Section 3, I use estimates of the output gap constructed using the Hodrick–Prescott filter. Since, empirically, there is typically a time lag between movements in the output gap and movements in inflation, I assume a one period lag. Before proceeding, I emphasize that Phillips curves are best seen as reduced-form relationships and therefore may shift if the policy regime changes.

An important aspect of Phillips-curve models concerns the relative weight of past and expected future inflation in the determination of inflation. While theory suggests that expected future inflation should play a dominant role, a number of studies from a range of economies indicate that past inflation may be more important. It is therefore of interest to test the hypotheses that the weights on the forward and backward-looking elements sum to unity, that inflation is fully backward looking and that it is fully forward looking.

To estimate the Phillips curve, the treatment of expected future inflation needs to be determined. The second building block of the model is therefore the assumption I make about how expectations are formed. If money growth is correlated with future inflation, as the data reviewed above suggest, then it should be correlated with inflation expectations. In fact, the ECB (2001, p. 42) has noted that one way in which money growth impacts on inflation is through induced movements in expected inflation:

> 'High money growth may also directly influence inflationary expectations and therefore also price developments. Similarly, low monetary growth may lead to deflationary expectations and price developments.'[15]

[14] Here I use the term 'output gap' in the older sense of the difference between actual and detrended real GDP (as opposed to the more modern sense of the difference between actual real GDP and the level that would be observed if prices were perfectly flexible).

[15] This passage has been deleted in the second edition of this volume (ECB, 2004).

I therefore assume that trend money growth determines inflation expectations. This specification constitutes the main novelty of the paper and plays a critical role in the analysis that follows. It therefore warrants several comments.

First, while the notion that money growth affects inflation expectations may capture the spirit of the ECB's view of the role of money in the inflation process, as suggested by the quote above, this assumption is arbitrary. However, the standard approach to modelling inflation expectations, that is to replace expected inflation by actual inflation and estimate the equation using statistical techniques appropriate for the resulting errors-in-variables problem as originally suggested by McCallum (1976), is also subject to important problems.[16] It is, from this perspective, interesting that several recent studies have modelled inflation using survey measures of expected inflation.[17] It therefore seems appropriate to consider competing measures of expected inflation in the euro area.

Second, since money growth does not enter the Phillips curve, it does not impact directly on inflation. One therefore wonders why it should impact indirectly through inflation expectations. To my mind, the assumption that money growth determines expected inflation should not be taken literally. The correlation between money growth and future inflation that has been established in the literature implies, however, that money growth is correlated with expected inflation. I therefore interpret the ECB as believing that money growth captures the stance of monetary policy and the general state of aggregate demand, and that it therefore can be used as a proxy for expected inflation. The public, of course, may form their inflation expectations by looking at a broader set of variables and need not focus on money growth, although the fact that money growth and future inflation have been strongly correlated, for whatever reason, suggests that that would not be an unreasonable shortcut to take.

Third, the assumption that money growth impacts on inflation expectations gives rise to a direct channel from money to prices. Nelson (2003) argues that monetarist models hold that changes in money growth impact on prices *indirectly* through the level of aggregate demand and the output gap, and therefore do not require such a direct effect. By contrast, Galí (2003) appears to view such a direct mechanism as an important precondition for the use of the first pillar.

Fourth, while I interpret the ECB as believing that inflation expectations depend on current and past nominal money growth, I consider two other specifications. Since the quantity theory suggests that inflation is determined by the difference between money and real income growth, I also estimate the model using adjusted

[16] In applied work, this approach is implemented by assuming that the expectation errors are uncorrelated with the regressors, which are used as instruments. If the regressors involve variables that are not instantaneously observed (such as the output gap or recent inflation rates), this assumption leads to inconsistent estimates. While in principle this problem can be overcome by using lagged values of the instruments, in practice the information lags are unknown. Furthermore, this approach is silent on what factors determine inflation expectations. This modelling approach is thus also subject to arbitrary assumptions.

[17] Adam and Padula (2003) study euro area and Roberts (1997 and 1998) investigates US data. Paloviita (2003) estimates forward-looking inflation equations on euro-area data, proxying expected inflation by OECD forecasts.

trend money growth. Moreover, since recent inflation is just as likely as money growth to be informative about future inflation, I also explore how well the model fits when trend inflation is used to model inflation expectations.

Fifth, since trend inflation depends on current inflation by construction, I lag it once to use it as a regressor in the inflation equation.

4.2. The two-pillar Phillips curve

Combining the Phillips curve, the expectations hypothesis and the definition of trend money growth discussed in Box 4, Appendix 2 shows how I can obtain a forecasting model for inflation, the 'two-pillar Phillips curve' (TPPC), that constitutes my proposed interpretation of the ECB's view of the inflation process. That equation can be thought of as integrating monetary factors in a conventional reduced-form Phillips curve. The monetary analysis of the first pillar is captured by the assumption that expected inflation depends on trend money growth, while the economic analysis of the second pillar is captured by the output gap.

Before estimating the model, it is desirable to consider what would happen if the assumption that money growth can serve as a proxy for inflation expectations is wrong. How would this impact on the empirical results?

First, consider the case in which inflation expectations incorrectly are modelled using trend money growth. Since trend money growth in this case contains little information useful for forecasting inflation, one would expect the weight on expected future inflation to be small and insignificant and instead the weight on past inflation to be large and significant, given the fact that inflation is strongly autocorrelated. As I show below, however, the opposite is true: the weight on expected future inflation is generally much larger and more significant than the weight on past inflation.

Second, if money growth were not correlated with future inflation, one would expect that assuming that trend inflation rather than trend money growth determines inflation expectations would improve the fit of the model since current inflation is closely tied to trend inflation. The results below, however, consistently show that the model fits much worse if trend inflation is used instead of trend money growth. Overall, the results are difficult to reconcile with the notion that money growth does not contain incremental information that is useful for predicting future inflation.

5. FITTING THE DATA

5.1. Estimates

Table 1 provides estimates for the sample period 1971Q1–2003Q1. For the time being, I do not impose any restrictions on the degree to which expectations are forward or backward looking. The estimates in the first column, where I assume that money growth drives expected inflation, are quite encouraging. The smoothing

Table 1. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1971Q1–2003Q1

x_t	Money growth, μ_t	Adjusted money growth, $\tilde{\mu}_t$	Inflation, π_t
Constant, β	–0.003*	–0.002	0.001
	(0.002)	(0.001)	(0.001)
Smoothing parameter, λ	0.089**	0.129***	0.224**
	(0.035)	(0.032)	(0.106)
Expected future inflation, α_f	1.041***	1.080***	0.922***
	(0.243)	(0.225)	(0.228)
Past inflation, α_b	0.029	0.020	0.005
	(0.172)	(0.182)	(0.232)
Output gap, α_g	0.553***	1.141***	0.628***
	(0.141)	(0.259)	(0.146)
MA(1) parameter, ρ	0.447**	0.436**	0.468***
	(0.191)	(0.194)	(0.197)
σ^2	$1.12*10^{-4}$	$1.09*10^{-4}$	$1.19*10^{-4}$
Log likelihood	403.631	405.521	399.641

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

parameter is highly significant and estimated to be 0.089, which is close to the 0.075 value assumed by Gerlach (2003) and implies a half-life of 7.8 quarters. The estimation suggests that the weight on future inflation is close to unity and is statistically significant. In turn, the weight on past inflation is 0.03 and highly insignificant. The parameter on the output gap is 0.55 and significant. Finally, the moving average parameter is 0.45. Since this is statistically significantly different from the value implied by the model (which is one minus the estimated value of the smoothing parameter: $1 - 0.089 = 0.911$) there is some evidence against it.

In column 2 I consider the case in which expected future inflation is determined by adjusted money growth. The results are broadly similar to those just reviewed, with three differences. First, the point estimate of the smoothing parameter is larger, 0.13, implying a faster impact of money growth on expected inflation (half-life of 5.5 quarters). Second, the estimated impact of the output gap is 1.11 rather than 0.55. The reason for this is that adjusted trend money growth (which contains a moving average of past quarterly changes in income) and the output gap are negatively correlated. Third, the log likelihood is higher than before, implying that the model fits the data better when adjusted money growth is used as an explanatory variable for expected inflation.

As noted above, the most natural counter-argument to the notion that money is important in judging future price pressures is that any information that is contained in observations on recent money growth rates must surely already be embedded in recent inflation rates. If so, rather than focusing on recent and past money growth rates in assessing the 'risks to price stability', it would make much better sense to concentrate on recent inflation rates. To assess this argument, I also consider the case in which expected future inflation is modelled as depending on trend inflation. The results, in column 3 of Table 1, are surprising. While most parameter estimates are similar to those obtained when inflation expectations are modelled as being tied to the growth rates of money or adjusted money, the fit of the model is clearly worse as evidenced by the sharp decline in the value of the likelihood function. The second major difference is that the smoothing parameter is much larger, 0.22, implying a half-life of 3.2 quarters.

5.2. Summary

In this section I have confronted the model for inflation arising from my proposed interpretation of the ECB's monetary pillar with the data over the period 1971Q1–2003Q1. While preliminary, these results are moderately encouraging in that the parameters are significant and take plausible values. The estimates of the extent to which inflation is backward looking are particularly interesting. In contrast to what one would expect from the literature, this parameter is numerically close to zero and statistically insignificant.

Next, I therefore refine the empirical work in two dimensions. First, I estimate the model for two sub-periods. I do so because it may be that while money growth played an important role in the high-inflation period in the 1970s and early 1980s, it lost its significance in the low-inflation environment of the 1990s. Gerlach (2003) presents evidence that suggests that the relationship between money growth and inflation in the euro area differed before and after 1992. The first subsample is the high-inflation period between 1971Q1 and 1991Q4, during which inflation averaged 7.1% per annum. The second is the low-inflation period 1992Q1–2003Q1, in which annual inflation averaged 2.3%.

The second refinement is that I investigate more closely some of the restrictions of the model. For instance, can I reject the hypothesis that the sum of the parameters on past and expected future inflation is unity or that inflation is entirely forward looking?

6. SUBSAMPLE ESTIMATES

6.1. Inflation in the euro area before 1992

In Table 2 I re-estimate the model on data ending in 1991Q4, assuming that nominal money growth determines inflation expectations. Column 1 shows the results when I do not impose the restriction on the moving-average parameter.[18] Interestingly, in this case I cannot reject this restriction and I therefore impose it. The results in column

[18] The restriction on the moving average parameter is given by $\rho = 1 - \lambda$.

Table 2. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1971Q1–1991Q4

x_t	Money growth, μ_t			
Constant, β	−0.003*** (0.000)	−0.002*** (0.001)	−0.001* (0.001)	−0.004** (0.001)
Smoothing parameter, λ	0.090** (0.036)	0.079** (0.037)	0.151 (0.100)	0.111*** (0.024)
Expected future inflation, α_f	0.492*** (0.139)	0.516*** (0.190)	0.269*** (0.085)	1
Past inflation, α_b	0.681*** (0.066)	0.664*** (0.088)	$(1-\alpha_f)$	0
Output gap, α_g	0.280** (0.117)	0.356*** (0.136)	0.306** (0.122)	0.673*** (0.178)
MA(1) parameter, ρ	0.968*** (0.043)	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
σ^2	$1.13*10^{-4}$	$1.16*10^{-4}$	$1.21*10^{-4}$	$3.02*10^{-4}$
Log likelihood	261.118	260.656	259.135	220.385

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

2 indicate that the sum of the weights on the forward- and backward-looking components is marginally above unity, but not significantly so. I therefore introduce this restriction as well (column 3). However, in this case the smoothing parameter is not significantly different from zero. While the degree to which inflation is forward looking is only about 0.27, I impose the restriction that inflation is fully forward looking, which leads to a sharp fall in the likelihood function. Overall, I therefore conclude that the empirical model fits the data quite well in the first subsample when inflation expectations are modelled as depending on money growth and if inflation is assumed to be part forward, part backward looking.

Next, I turn to the case in which inflation expectations are modelled as determined by adjusted money growth. Interestingly, the results in Table 3 indicate that the model in this case fits the data better, as evidenced by the uniform increase in the value of the likelihood function. The value of the smoothing parameter is also consistently higher than in Table 2 (around 0.2 rather than 0.1), indicating a shorter half-life, and is more significant. As in the case of Table 2, the point estimates in column 1 suggest that I can impose the restriction on the moving average parameter and I do so in column 2. In column 3 I also impose the restriction that the sum of the weights on expected future inflation and past inflation is unity. This results in an estimate of the degree to which inflation is forward looking of 0.36, which is somewhat higher than in Table 2. Finally, I restrict inflation to be fully forward looking, which again leads to a large fall in the value of the likelihood function.

In Table 4 I turn to the case in which inflation expectations are assumed to depend on trend inflation. The results are generally similar to those in Table 2, except that the fit of the equation is worse than before, as evidenced by the value of the likelihood

Table 3. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1971Q1–1991Q4

x_t	Adjusted money growth, $\tilde{\mu}_t$			
Constant, β	–0.002**	–0.002***	–0.001	–0.001**
	(0.001)	(0.001)	(0.000)	(0.001)
Smoothing parameter, λ	0.196***	0.188***	0.243***	0.236***
	(0.053)	(0.053)	(0.089)	(0.047)
Expected future inflation, α_f	0.518***	0.546***	0.361***	1
	(0.145)	(0.135)	(0.084)	
Past inflation, α_b	0.612***	0.582***	$(1-\alpha_f)$	0
	(0.096)	(0.087)		
Output gap, α_g	0.672***	0.714***	0.609***	1.345***
	(0.191)	(0.171)	(0.147)	(0.146)
MA(1) parameter, ρ	0.841***	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
	(0.106)			
σ^2	$1.10*10^{-4}$	$1.12*10^{-4}$	$1.16*10^{-4}$	$2.14*10^{-4}$
Log likelihood	262.609	262.456	260.778	235.306

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

Table 4. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1971Q1–1991Q4

x_t	Inflation, π_t			
Constant, β	0.001	0.001	0.000	0.000
	(0.003)	(0.002)	(0.000)	(0.001)
Smoothing parameter, λ	0.240	0.327	0.232*	0.647***
	(0.203)	(0.254)	(0.128)	(0.125)
Expected future inflation, α_f	0.647	0.440*	0.429**	1
	(0.426)	(0.260)	(0.197)	
Past inflation, α_b	0.259	0.505*	$(1-\alpha_f)$	0
	(0.480)	(0.266)		
Output gap, α_g	0.581***	0.454**	0.496***	0.346**
	(0.207)	(0.178)	(0.159)	(0.140)
MA(1) parameter, ρ	0.535	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
	(0.418)			
σ^2	$1.27*10^{-4}$	$1.29*10^{-4}$	$1.30*10^{-4}$	$1.37*10^{-4}$
Log likelihood	257.324	256.499	256.000	254.249

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

function. In particular, the results in column 1 suggest that the smoothing parameter is insignificant and I therefore impose the restriction on the moving-average parameter. The value of the likelihood function is essentially unaffected (column 2). Since the sum of the weights on expected and realized inflation is close to unity, I also impose that restriction. While the value of the likelihood function in this case rises somewhat, the parameter estimates are largely unchanged, except for the smoothing parameter, which falls in size but becomes significant. Interestingly, the degree to which inflation is forward looking is in this case estimated to be about 0.43, which is significantly different from unity. Not surprisingly, imposing the restriction that the weight on expected future inflation is unity and the weight on past inflation is zero (column 4) leads to a deterioration of the fit.

In sum, the results for the first sample period indicate that the model fits relatively well although inflation expectations appear largely backward looking.[19] Furthermore, the model typically fits worse when expected inflation is assumed to depend on trend inflation rather than on either of the measures of trend money growth.

6.2. Inflation in the euro area after 1991

Next I turn to the results for the post-1991 period which are inherently more interesting than the results for the 1971–91 period for the simple reason that even the ECB's most vocal critics would probably be willing to accept that money was useful for forecasting and assessing inflation in the high inflation era. The point of contention is rather whether money is useful in the current low-inflation environment (see the discussion in Begg *et al.*, 2002, in particular Box 2 on p. 21).

In Table 5 I therefore report re-estimates of the results in Table 2, using data for the period 1992Q1–2003Q1. Since the results are similar to those above, I review

Table 5. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1992Q1–2003Q1

x_t	Money growth, μ_t			
Constant, β	–0.003***	–0.003**	–0.003***	–0.003***
	(0.000)	(0.002)	(0.001)	(0.001)
Smoothing parameter, λ	0.088***	0.081**	0.083***	0.084***
	(0.026)	(0.040)	(0.017)	(0.024)
Expected future inflation, α_f	1.053***	1.227*	1.173***	1
	(0.171)	(0.667)	(0.102)	
Past inflation, α_b	–0.132	–0.162	$(1-\alpha_f)$	0
	(0.139)	(0.129)		
Output gap, α_g	0.491***	0.542***	0.540***	0.475***
	(0.137)	(0.159)	(0.122)	(0.128)
MA(1) parameter, ρ	0.979***	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
	(0.252)			
σ^2	5.52×10^{-5}	5.71×10^{-5}	5.43×10^{-5}	6.05×10^{-5}
Log likelihood	155.503	155.075	155.015	154.291

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10 / 5 / 1% level.

[19] One reason for this may be that since money demand depends inversely on the inflation rate, the decline in inflation in the first subsample raised the demand for money and led to a situation in which money growth (and therefore my proposed measure of expected inflation) exceeded headline inflation. Of course, this highlights one difficulty in extracting information from money growth.

them quite quickly. Note first that the moving average parameter is close to one minus the smoothing parameter, which implies that the degree of autocorrelation in the residuals is compatible with the model, and that the sum of the weights on past and expected future inflation is about unity. Imposing these restrictions yields the model in column 3, for which I do not reject the hypothesis that the weight on past inflation is zero and the weight on expected future inflation is unity. I therefore also impose these restrictions and obtain the model in column 4 in which all parameters are highly significant. The smoothing parameter is estimated to be 0.084, implying a half-life of 8.2 quarters.

Note that while the model in column 1 involves seven parameters, the model in column 4 involves only four. I can thus test whether the restrictions imposed by the simple empirical model are rejected, but find that they are not.[20] This implies that the notions that inflation is fully forward looking and that the expectations-formation mechanism is the only source of the serial correlation in the errors are compatible with the data. Furthermore, I can also use the models estimated for the sub-periods to test for parameter constancy before and after 1991–92. In this case, however, I reject the hypothesis.[21] The main reason for this appears to be that inflation is more forward looking in the second subsample.

Before turning to the issue regarding what these results imply, if anything, for the two-pillar framework, I redo the analysis for the case in which expected inflation is modelled as depending on adjusted trend money growth (Table 6) and trend inflation (Table 7). Since these estimates are very similar, in the interest of brevity I merely highlight the most interesting points.

First, judging by the values of the likelihood functions, it appears that the model fits best when nominal money growth is used, marginally less well when adjusted money growth is used, and much worse when trend inflation is used to model expected inflation.

Second, the estimate of the parameter on the output gap is much larger in the case when adjusted rather than actual money growth is used. Again, this result arises because of the correlation between the output gap and adjusted money growth.

Third, the restrictions imposed by the model in column 4 on that in column 1 are not rejected for the case of adjusted money growth, but are rejected in the case in which trend inflation is used to capture inflation expectations.[22]

6.3. Stability 1991–2003

The results so far show that the parameters are typically significant and of plausible magnitude. However, the hypothesis that the parameters are the same in the pre- and

[20] The p-value from a likelihood ratio test is 0.489.

[21] Focusing on the model in column 1, note that the value of the likelihood function when estimated over the full sample is (from Table 1) 403.631. The likelihoods for the sub-samples are 261.118 (from Table 3) and 155.503 (Table 5), or 416.621 in total. Thus, the likelihood increases by 12.990 when I estimate the model twice, that is, when I estimate 14 rather then 7 parameters. A chi-squared test with 7 degrees of freedom yields a p-value of zero, implying that I reject the hypothesis that the parameters are the same in the two subsamples.

[22] The p-values are 0.305 and 0.048, respectively.

Table 6. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1992Q1–2003Q1

x_t	Adjusted money growth, $\tilde{\mu}_t$			
Constant, β	0.000	0.000	−0.001***	−0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
Smoothing parameter, λ	0.120***	0.116***	0.094***	0.094***
	(0.036)	(0.044)	(0.020)	(0.019)
Expected future inflation, α_f	0.733**	0.701**	1.094***	1
	(0.298)	(0.294)	(0.103)	
Past inflation, α_b	−0.118	−0.153	$(1-\alpha_f)$	0
	(0.151)	(0.136)		
Output gap, α_g	0.876***	0.825***	1.084***	1.008***
	(0.224)	(0.204)	(0.163)	(0.158)
MA(1) parameter, ρ	1.002	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
	(5.241)			
σ^2	$5.52*10^{-5}$	$5.95*10^{-5}$	$6.14*10^{-5}$	$6.21*10^{-5}$
Log likelihood	155.037	154.314	153.484	153.225

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

Table 7. Estimates of $\pi_t = \beta + \beta_1 x_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t$ where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = 1 - \lambda + \alpha_b$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$, and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ Sample period 1992Q1–2003Q1

x_t	Inflation, π_t			
Constant, β	0.003	0.003*	0.000	0.000
	(0.002)	(0.002)	(0.000)	(0.000)
Smoothing parameter, λ	0.347	0.338*	0.265*	0.192*
	(0.721)	(0.186)	(0.149)	(0.101)
Expected future inflation, α_f	1.019	1.002**	1.281***	1
	(1.185)	(0.484)	(0.243)	
Past inflation, α_b	−0.432	−0.426	$(1-\alpha_f)$	0
	(0.566)	(0.354)		
Output gap, α_g	0.178	0.179	0.331*	0.386**
	(0.213)	(0.197)	(0.195)	(0.172)
MA(1) parameter, ρ	0.664***	$(1-\lambda)$	$(1-\lambda)$	$(1-\lambda)$
	(0.187)			
σ^2	$6.63*10^{-5}$	$6.64*10^{-5}$	$7.63*10^{-5}$	$7.82*10^{-5}$
Log likelihood	152.324	152.324	149.087	148.370

Notes: Standard errors in parentheses.
* / ** / *** denotes significance at the 10/5/1% level.

post-1991 sample is rejected, most likely because the extent to which inflation is forward looking has increased over time. Since a number of authors have argued that the information content of money is likely to be lower at lower average rates of inflation, it is of particular interest to investigate more closely the stability of the

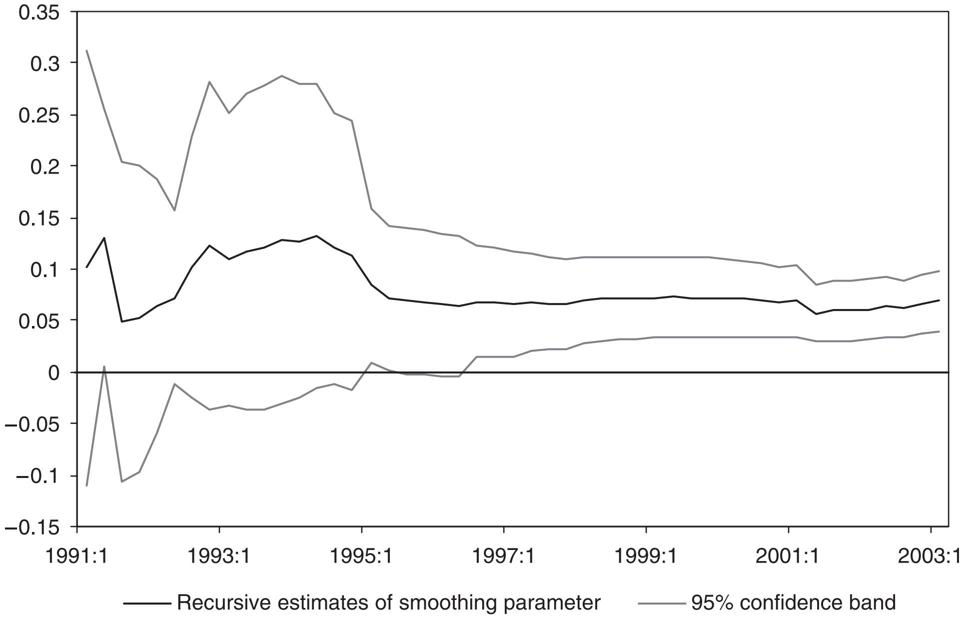

Figure 8. Recursive estimates of smoothing parameter

inflation equation in the 1991–2003 period.[23] I do so by presenting recursive estimates of the model. In the interest of brevity, I focus on the model in which expected inflation is driven by trend money growth since that appears to fit the data best. Furthermore, since the model is estimated by maximizing the likelihood function, convergence problems may arise if I estimate versions of the model containing insignificant parameters. I therefore consider the relatively restricted version of the model in column 4 of Table 5 in which the parameter on expected future inflation is unity, the parameter on past inflation is zero and the restriction on the moving-average parameter is imposed. That gives me four parameters to estimate: the degree of smoothing, the impact of the output gap on inflation, a constant and the variance of the errors. For space reasons, I only plot the recursive estimates of the first two parameters, since these are the most interesting. The estimates are obtained by initializing the model on data for the period 1987Q1–1991Q1 and then expanding the sample period by adding one observation at a time.

Figure 8 shows the results for the smoothing parameter together with a 95% confidence band. While the confidence band becomes narrower as observations are added, the point estimate remains relatively constant. Overall, the figure suggests that the smoothing parameter is stable in the 1991–2003 period. While the results for the

[23] Gerlach (1995) demonstrates that the relationship between inflation and money growth is weaker for economies with low money growth and low inflation. See also De Grauwe and Polan (2001), De Grauwe (2002) and Begg *et al.* (2002).

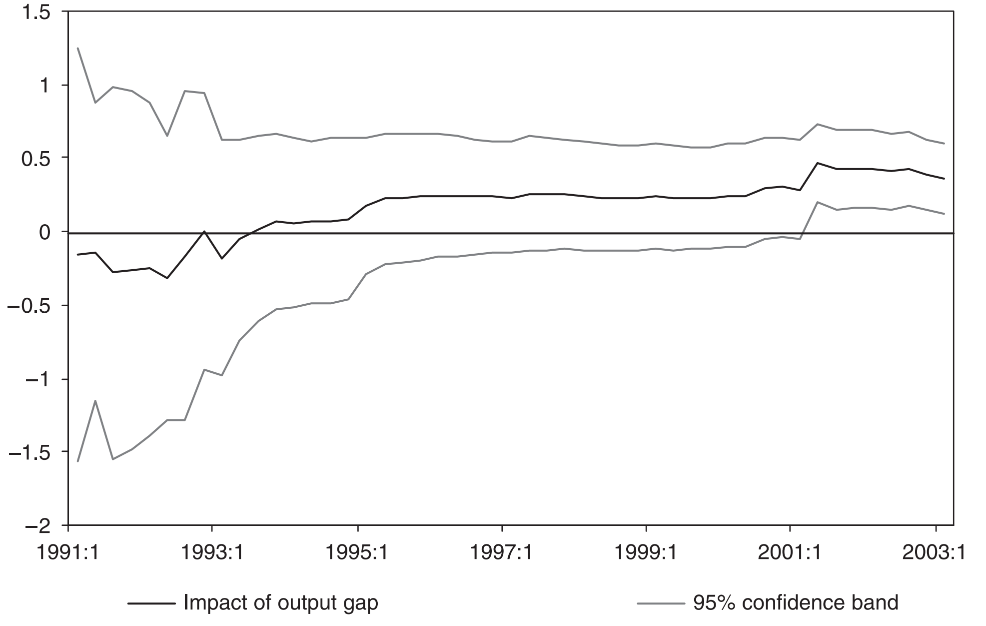

Figure 9. Recursive estimates of impact of output gap

coefficient on the output gap in Figure 9 also support the notion that the parameter is stable, the point estimate is rising modestly as the sample size is expanded. More interestingly, the parameter is only significant for samples ending in 2001 or later. I view these results as suggesting that it is difficult to find a strong link between inflation and the output gap in short samples.

6.4. Interpretation

The estimates for the period 1992–2003 give rise to a simple Phillips curve. To see this, note that the model performs best when inflation expectations are modelled as depending on trend money growth and that I do not reject the hypothesis that inflation is fully forward looking. This two-pillar Phillips curve says that inflation at any point in time depends on the two pillars.[24] First, inflation depends on trend money growth, the first pillar, with a unit coefficient. Changes in trend money growth, which evolves gradually over time, consequently explain gradual changes in the level of inflation over time. However, and as discussed by Nelson (2003), in empirical work on inflation dynamics the determination of steady-state inflation is typically downplayed. In empirical research on 'old-Keynesian' or new-Keynesian

[24] In the notation of Box 4 and disregarding time subscripts, we have that $\pi = \mu^* + \alpha_g g + e$.

Phillips curves, authors assume that the steady-state rate of inflation is constant and capture this with an intercept (see Galí and Gertler, 1999) or by first removing a time trend from inflation (see Coenen and Wieland, 2003).[25] Gerlach and Svensson (2003) instead capture trend shifts in inflation in the euro area by assuming that they arise from movements in central banks' inflation objectives. The analysis in this paper suggests that while money may not be useful for explaining movements of inflation *around the steady state*, it is helpful for understanding *changes over time in the steady state*.

Second, inflation also depends on the output gap, which should be understood as a catch-all for the economic analysis of the second pillar. As noted above, it would be desirable to incorporate proxies for other shocks that impact on prices. As the model currently stands, these influences are subsumed in the errors.

Finally, note that under the hypothesis that past inflation is more informative for future inflation than past money growth, we would have expected the model to fit best when trend inflation is assumed to determine expected inflation, or the weight on expected inflation to be close to zero and insignificant. However, and as discussed above, the model fits best when the weight on expected inflation is close to unity and money growth is assumed to influence inflation expectations.

6.5. Expected inflation

Before concluding this section, I return to the critical assumption of the model proposed above that trend money growth determines expected inflation. Since this assumption is non-standard and is likely to be controversial, it is desirable to explore how plausible it is. While this is difficult to do in the absence of good data on inflation expectations, next I compute the expected rate of inflation implied in the estimates of the inflation equation in the 1992–2003 period and compare it with two data sets on expected inflation in the euro area. The first of these is that used by Paloviita (2003), which is derived from OECD forecasts, for the economies constituting the euro area. Unfortunately, this measure pertains to the private consumption deflator rather than to the CPI. Moreover, the data are annual rather than quarterly. The second measure stems from forecasts by Consensus Economics for inflation 1–10 years ahead in some of the economies constituting the euro area. These forecasts are published in April and October. One problem with this measure is that it is based solely on data for Germany, Italy and France before 1995, when data for the Netherlands and Spain are added. It is consequently not representative of the overall euro area.

Figure 10 shows the quarterly rate of inflation together with the expected rate of inflation from my model and from Paloviita (2003). Note that actual and (the model-dependent measure of) expected inflation both decelerate between 1992 and 1997, remain roughly

[25] One reason for this approach is that, for statistical reasons, it is desirable to focus on time series that fluctuate around a fixed mean (that is, are stationary) rather than time series that trend over time.

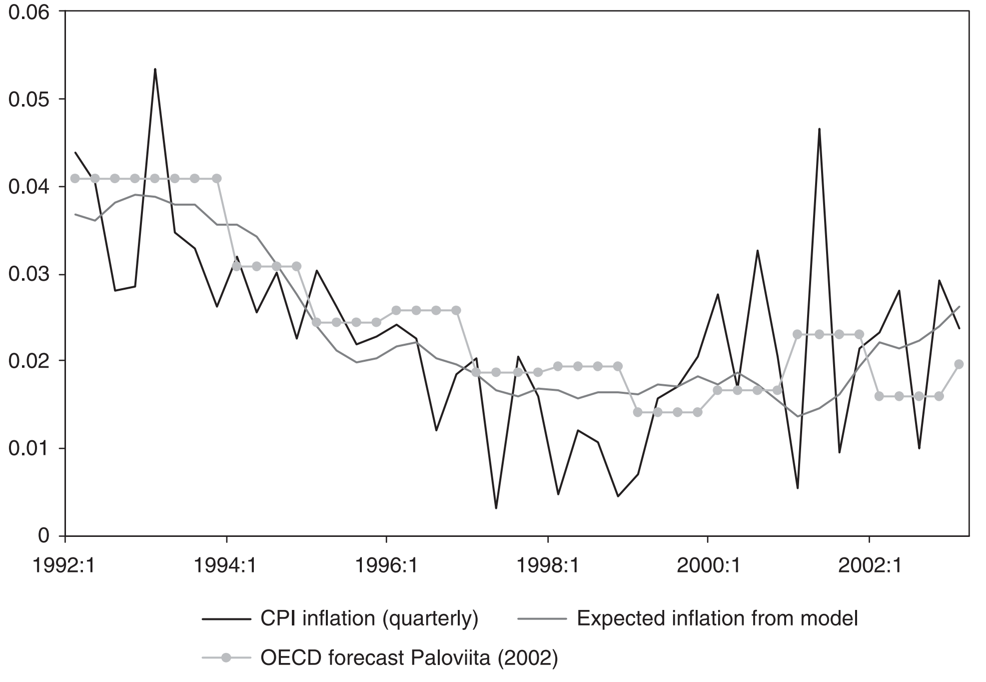

Figure 10. Actual and expected inflation

constant for a few years, and start to accelerate towards the end of the sample, and that Paloviita's measure of expected inflation evolves in much the same way over time as the model-dependent measure. In Figure 11, I replace Paloviita's measure with that arising from forecasts from Consensus Economics with horizons of one or two years. While these variables evolve over time in the same way as actual inflation and (the model-dependent measure of) expected inflation, they are systematically below these in the first part of the sample. This is probably due to the fact that the Consensus Economics measures of expected inflation do not cover the full euro area.

Overall I interpret these figures as suggesting that the estimate of expected inflation implied by the model is plausible.

6.6. Summary of the empirical results

The empirical analysis presented above shows that it is in fact possible, contrary to the ECB's claim, to integrate money in an explicit forecasting model of inflation. Moreover, I believe that the model provides a plausible interpretation of the ECB's two-pillar framework and that it fits the data about as well as many other ad hoc models of inflation. A particularly interesting aspect of the results is that the empirical models fit the data better if expected inflation is assumed to depend on actual or adjusted money growth rather than past inflation. This suggests that money does in

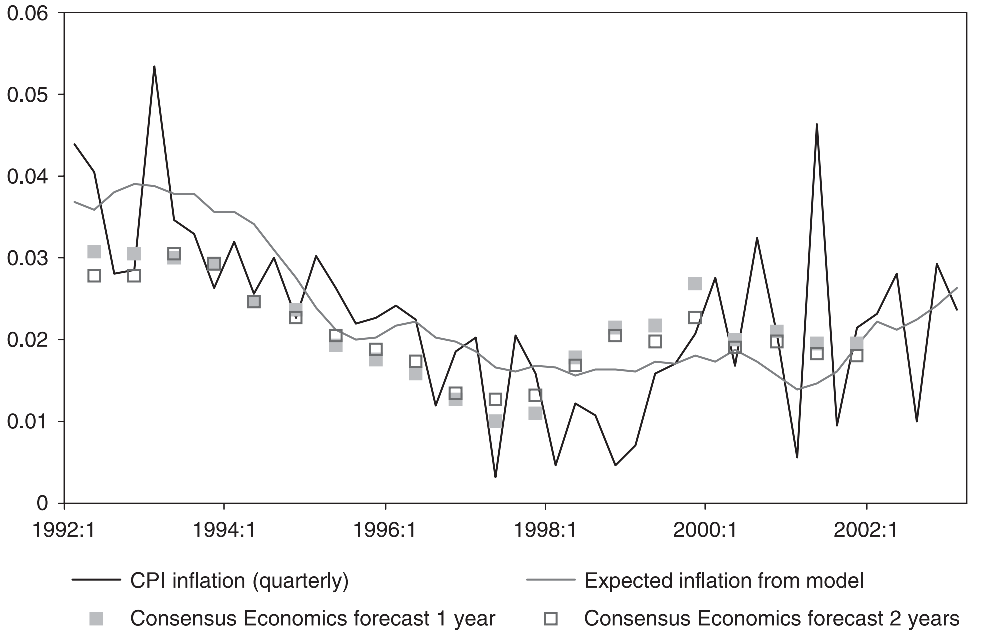

Figure 11. Actual and expected inflation

fact contain information about future inflation in the euro area beyond that embedded in the output gap and past inflation. It also appears that the model fits better when estimated on data for the low-inflation period after 1991 than on data from the 1970s and 80s. This finding calls into question the claim in the literature that the link between money and inflation is statistically less clear at low inflation rates.

7. CONCLUSIONS

What, then, do I conclude from the analysis regarding the desirability of the monetary pillar? To answer this question, it seems useful to proceed by first asking whether money can serve as an indicator, or information, variable for inflation and, if so, whether it should have its own pillar.

7.1. Money as an indicator

Does money growth contain information about the future rate of inflation in the euro area? Economists at the ECB and elsewhere have presented evidence that consistently suggests that there is a stable relationship between money growth and inflation in the euro area and that money growth does contain information useful in forecasting future inflation. Moreover, Gerlach and Svensson (2003) estimate an inflation equation for the euro area that incorporates money explicitly into the analysis and find that money plays about as important a role for future inflation as the output gap. My interpretation of the broad statistical evidence is that it is difficult to deny that money growth appears to contain information about future inflation in the euro area.[26]

Of course, that conclusion could be challenged by noting that while this has been true in the past, there is no reason to assume that it will remain true also in the future. The information content of money depends on the relative importance of the different shocks that are hitting the economy, which may vary over time. For instance, as argued by Begg *et al.* (2002), money may be more informative about future prices during episodes in which it is growing quickly and subject to large supply disturbances, leading to high and volatile inflation, than in episodes characterized by low and stable inflation such as that which the euro area is experiencing currently. However, Issing *et al.* (2001, p. 13) present evidence that the correlation between money growth and inflation appears high also in low-inflation environments, defined as periods with an average inflation rate of below 20%.

While undoubtedly valid, the critique that money growth may be an unreliable indicator of future inflation because it depends on the relative importance of the shocks impinging on the economy applies with equal force to other commonly used indicator variables.[27] For instance, the information content of the output gap (which suffers from the additional complication that it is unobservable and needs to be estimated) is likely to depend on the relative importance of shocks to aggregate demand and supply.[28] Similarly, the information content of the slope of the term structure of interest rates may depend on the nature of the monetary policy regime, as demonstrated by Estrella (2003).

Another potential argument against the use of money as an information variable is that while it is correlated with future information, it contains little information beyond that embedded in recently observed inflation rates. However, it is a striking finding that information variables typically do not improve much on univariate forecasts of future goal variables (e.g. Stock and Watson, 2003). Thus, money may not be much worse (or better) than other commonly used information variables.[29]

On balance, I believe that money growth is one of many useful indicator variables for inflation in the euro area.

7.2. A pillar for money?

Do these findings imply that money should be given a separate pillar in the ECB's monetary policy strategy? The empirical work presented above suggests that M3

[26] I thus do not share the sentiment in Galí (2003, p. 58) that 'the existing evidence even seems to question the "information content" of monetary aggregates.'

[27] Stock and Watson (2003) discuss reasons why the information content of indicator variables may shift over time.

[28] Here I am referring to the output gap in the sense of the difference between actual and 'detrended' output.

[29] Of course and as noted above, theory suggests that information variables ought not to be too informative about future inflation since, if they were, the central banks should react to them in setting policy and thus reduce their information content (Woodford, 1994).

growth contains information about future inflation in the euro area that is not already embedded in the current rate of inflation or in the output gap. Overall the paper is best seen as demonstrating how that information can be combined with non-monetary indicators to form the 'broadly based assessment of the outlook for future price developments and the risks to price stability in the euro area as a whole' that constitutes the ECB's *second* pillar. To my mind, there is nothing in the analysis suggesting that money should be treated differently from any other indicator of inflation pressures. In particular, the model does not imply that it is the best predictor of future inflation. I therefore do not interpret the empirical work in this paper as implying that a separate pillar for money growth is required. Rather, I view it as merely providing further evidence that it is desirable for the ECB to extract whatever information about future inflation it can from data on monetary aggregates when setting interest rates.

Discussion

Frank Browne
Central Bank and Financial Services Authority of Ireland

Stefan Gerlach is to be congratulated on a very interesting paper and a brave attempt to integrate the two pillars of the ECB's monetary policy strategy. Stefan starts from the proposition that there is a need for a model of the ECB's two-pillar framework. He then proposes such a model incorporating money explicitly. This is particularly interesting in light of the ECB's argument that 'it is not practically feasible to combine these two forms of analysis in a transparent manner in a single analytical framework'.[30] This could mean one of two things. It could mean that the theoretical foundations for the first pillar (largely monetarist) and the second pillar (largely new Keynesian) are not capable of being reconciled within a single framework because they subscribe to quite different views of the inflationary process. Alternatively, the statement could reflect the fact that most monetarist models of inflation are single equation reduced forms (such as the P* model, for example) while the second pillar of the ECB's strategy is to build on an elaborate structural model, or more accurately elaborate structural models,[31] and structural and reduced form models cannot be integrated into 'a single analytical approach'. Moreover, integrating money into a structural econometric model seems to be very difficult since nobody seems to have done it successfully to date. If the ECB is correct for either of these reasons, it makes the task that Stefan has set himself a very difficult one.

[30] Quoted by Stefan in his paper.

[31] There is both a euro area-wide structural model and a model that interlinks the structural models of individual member countries.

Decades of financial innovation have tended to erode the differences between financial instruments making them increasingly substitutable for one another. If we add to this improvement in access technologies to financial markets that has increased the ease, and reduced the cost, of participating in these markets, we see that it is becoming increasingly difficult to identify the demand for any subset of these assets (called money) that will continue to be stable under a variety of institutional, structural and fiscal shocks. Although the effect of these developments is to reduce the information content in monetary aggregates that is useful for monetary policy, I don't think it means that this information is entirely useless. If more attention were to be paid to the effects of financial innovation and these institutional, structural and fiscal changes in real time, and the appropriate corrections made for the resulting velocity shifts, then monetary aggregates could still be useful indicators for the central bank and could even warrant a special status among all indicators. An interesting example of this is given by Orphanides and Porter (2001) who argue that the trend increase in velocity throughout almost all of the 1990s in the US could have been picked up in real time, in which case the demand for money function would have remained a stable function of the standard arguments when the appropriate adjustment for the change in trend velocity is made.

Even before the recent change in emphasis with respect to what was previously the first pillar, the two pillars were not treated on an equal footing, in the context of the inflation forecasts, in the sense that equal analytical attention was not paid to both of them. The analysis under the second pillar dominates discussion on the inflation projections within the Eurosystem and, while there is a forecast of inflation produced using the first pillar, this is used merely as a cross check on the projections from the broad macroeconomic analysis (second pillar).

Stefan introduces money into his analysis by assuming that a moving average of money growth determines inflation expectations. I would have some difficulty with a model in which excess money does not disturb the relationship between aggregate demand and supply, generating inflationary tensions in the process, but does at the same time determine inflation expectations. If money does not affect objective behaviour of economic agents, it is hard to see how it would impact on their expectations of that behaviour. I think if money is to be integrated into the two-pillar framework, it has to be done according to a monetarist interpretation, which is based on the idea that money affects behaviour via liquidity constraints.

Patrick Honohan
World Bank and CEPR

The nostalgic slogan as lullaby?

A simplified motto for the Bundesbank's approach to monetary policy over the years could be 'We operate on monetary conditions to keep inflation low.' This also evokes the monetary pillar of the ECB's stated approach, and echoes ancient debates. In particular, it reflects the view that the hyperinflation of 1922 was *not* the work of foreign speculators or of self-fulfilling expectations, but instead was due to excessive money creation. Such a slogan also gave the institution a nominal anchor – perhaps unimportant when inflation is low and anti-inflation consensus strong, but a cudgel with which to beat opponents if and when pressure to accommodate other goals threatens to produce creeping inflation such as that which emerged in the 1970s, even in Germany.

Although most central banks in advanced countries behave in similar ways nowadays, they do so in very different rhetorical environments. For example, the US Fed was founded to ensure a greater 'elasticity of money supply in response to the variable needs of business' (a task in which it conspicuously failed in 1931–33), and its rhetoric tends to reflect that apparently broader remit. By evoking slogans that justified and underpinned the Bundesbank's credibility in the past, the inclusion of the monetary pillar in the ECB's stated strategy should probably best be seen as an attempt to sing a lullaby as the German public are gently moved from one bed to another.

What the data say

Turning from rhetoric to econometrics, money is of course not unimportant in the inflationary process. Stefan Gerlach proposes the following model to fit price inflation π for the whole period 1971–2003: ignoring a constant,

$$\pi_t = \sum_{i=1}^{\infty} \lambda^{i-1}\mu_{t-i} + \alpha_g g_{t-1} + \varepsilon_t \tag{1}$$

This is interpreted in the paper as an expectations-augmented Phillips Curve (though that term more properly refers to a wage inflation–unemployment relation): a relationship between inflation, the output gap (g) and an exponentially weighted average of past monetary growth, interpreted as a (somewhat nonstandard) inflation expectations term.[32]

Actually, the same equation can be rewritten in the equivalent but arguably simpler form:

$$\Delta\pi_t = \lambda(\mu_{t-i} - \pi_{t-1}) + \alpha_g g_{t-1} + \alpha_{gg}\Delta g_{t-1} + \varepsilon_t \tag{2}$$

where

$$\alpha_{gg} = -(1-\lambda)\alpha_g \tag{3}$$

Unless restriction (3) is satisfied – which I doubt – we are left with the unrestricted equation (2) as a representation of the data. This is just an error-correction model (money growth and inflation do not seem to have unit roots in the data, but that representation is nevertheless valid). It features both the change and level of the

[32] The adequacy of this weighted average as an inflation expectations proxy is not assessed directly in the paper: Section 6.5 instead compares predictions from a regression such as (1) with survey expectations data.

output gap as the short-term part (there is a long tradition going back to Lipsey of including both level and change of gap variables), and money growth (rather than Gerlach's *trend* money growth interpreted as inflation expectation) as the long-term driver.

So here is a rather simple monetarist relationship which might seem to underpin the ECB's monetary pillar. This is reinforced by the finding – not unrelated – that monetary growth helps forecast price inflation even after taking account of inflation's past history.

The business of central banks is money: these new findings seem to support the relevance of that role. So why do so many monetary economists question the emphasis, diluted though it evidently is, on money in the ECB's statement of its policy approach? One reason is that there are more macro series than just m, p and g. A glance at any issue of the Bank of England's *Inflation Report* shows the range of indicators that can usefully be taken into account in assessing inflation prospects. It is not surprising that m has a valuable role if it is almost the only explanatory variable tried: it would appear less central if other variables were allowed to compete.

Which money matters?

But there is a stronger reason for not over-emphasizing the monetary pillar in practical policy formation (and I do recognize that the ECB does not overemphasize it in practice). Here, too, history is revealing. The heyday of monetarist activism – the 1970s and 1980s – revealed the limitations of money as a sole guide to monetary policy. The aggressive policy contractions in the US and UK from 1979 had to cope with relatively sharp shifts in money demand. If a rigid monetary growth target had been adhered to in both cases, the contraction would have been substantially overshot. Among the causes of the shifting relationship were the sensitivity of money demand to the expected rate of inflation and rapid structural change in banking and finance, eroding the dividing lines which allowed the monetary aggregates to be defined in an unambiguous manner. Goodhart's law may also have been at work. As a result of this chastening experience, few central bankers will now risk getting locked into a monetary straitjacket.

And structural change in finance is not going away. To see this, consider the recent experience of zero or negligible correlation between money growth and inflation in the accession countries, plotted in Figure 12. If the ECB's anti-inflationary policy framework is to accommodate these, I fear that money will have to retreat into the background even more.

But perhaps the accession countries do not matter in this context because of their modest economic size or because their Eurozone membership is still some time in the future. If the accession countries are to be neglected in this way, it will be in a long tradition of ignoring the periphery. Indeed, the ECB monetary series used in the paper's regression is rather problematic for the more distant past. This may explain why the parameter estimates are rather different for the period 1971–91, and why

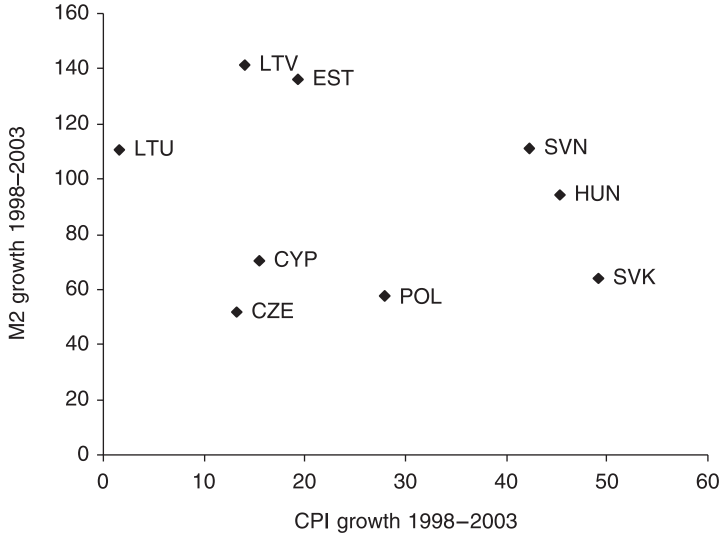

Figure 12. Accession countries: M2 and CPI growth

the models 'fit better' for the later period. In forming the monetary aggregate, each national currency is converted at the irrevocable euro conversion rates of end-1998. This greatly underweights the countries that had high inflation pre-EMU relative to Germany (and other low-inflation states). Italy's monetary growth in the early 1970s is underweight (relative to Germany) by a factor of 5.5: i.e. 1971 DMs are valued at 990 Italian liras, compared with an actual 1971 market exchange rate of 171. The underweighting factor for Spain is 4.5, for Finland 2.7, for France and Ireland about 2 (for Greece, more than 20). Perhaps none of this matters and the 'politically correct' use of theological conversion factors is more important than economic reality, but several other approaches that have been used in the literature, from series computed by weighting average monetary growth rates with GDP shares, to simply marking all quantities to market at current exchange rates (see Coenen and Vega, 2001, for a discussion: the choice does not matter too much for the period back to 1981, but of course the problem becomes more severe if the heterogeneous inflationary experiences of the 1970s are included in the sample).

How monetarist should one be?

One element that may be missing from the preferred specification is what Phillips (of the curve) would have called 'integral adjustment'. A simple monetarist equilibrium would predict not only equality of money and price growth rates, but proportionality of their levels (apart from the effects of structural change in equilibrium velocity). Unless the economy is always on its money demand curve, a monetary overhang could continue to drive inflation even when money growth had been halted. Even if the goal is to remain in the highly simplified world of m, p and g, it would be satisfying to close this potential loophole in the model, say by adding the lagged real money stock – perhaps detrended – to the list of explanatory variables. Even though central banks typically allow base drift (a missed inflation target in one year does not trigger a lower target for the next in order to bring the price *level* back on track), their models of inflation need to recognize the effects of stock disequilibrium.

Panel discussion

Stefan Gerlach replied to the discussion of Patrick Honohan that the empirical analysis is most interesting for the low-inflation period since 1991. Data measurement issues for earlier years do not drive those results. Moreover, he emphasized that the filter used in the paper can be consistent with rational expectations. Philip Lane agreed with Patrick Honohan in viewing money growth as a nominal anchor. Trend inflation, which is measured more precisely but is more difficult to communicate to the public, would be more appropriate in that role. Several panelists wondered how much predictive power money actually has for future inflation. Pierre-Olivier Gourinchas pointed out that the two-pillar Phillips curve implicitly assumes that trend inflation does not perform as well as money growth to predict future inflation. He also mentioned recent work on policy co-ordination as a possible rationale for noisy policy rules, which may play a role in preventing expectation traps. A comparison of the ECB with central banks in countries with pure inflation targeting could pinpoint differences between different central banks' beliefs about how the world works. Richard Portes noted that the ECB's reference value for money growth should be adjusted if productivity growth, as pointed out by the ECB itself, is as slow as it appears to be in the Euro area's recent experience.

APPENDIX 1. REDUCED-FORM EVIDENCE

Below I present some reduced-form evidence on the information contained in money growth for future inflation in the euro area. To this end, I estimate prediction equations of the form (suppressing the constant):

$$\pi_{t+j} - \pi_t = \phi_\pi(\pi_t^* - \pi_t) + \phi_g g_t + \phi_m(\mu_t^* - \pi_t^*) + \xi_t$$

and study whether the spread between trend and headline inflation, $\pi_t^* - \pi_t$, is correlated with the change in headline inflation over the coming j quarters, $\pi_{t+j} - \pi_t$. In the empirical work below I explore forecasting horizons of two, four, eight and twelve quarters ($j = 2$, 4, 8 and 12).

To understand the results, it is helpful to consider the interpretation of the parameters. The coefficient ϕ_π captures the extent to which the wedge between trend and headline inflation predicts future changes in headline inflation. Generally one would expect ϕ_π to be positive and significant. Moreover, since it may take some time for this wedge to be undone, ϕ_π is likely to rise with the length of the forecast horizon, j, and approach unity for longer horizons. The coefficient ϕ_g provides information about the extent to which the output gap impacts on future inflation. Given the importance many central banks attach to the output gap, one would expect ϕ_g to be positive and significant. Since movements in the output gap are transitory although persistent, it is possible that the importance of the output gap declines with the forecast horizon. Finally, the coefficient ϕ_m captures the information content of money growth. The hypothesis is that headline inflation will rise if trend money growth is exceeding trend inflation. A finding of a positive and significant ϕ_m would indicate that money is informative for future changes in inflation even in the presence of the output gap and the discrepancy between trend and headline inflation.

To estimate this model I use data for three sample periods. I first consider the full sample period of 1970Q2–2003Q1. Since the proposition that the high inflation observed in the 1970s was related to the rapid money growth is probably not too controversial, I also estimate the equation for the first subperiod ending in 1986Q4 and a second subperiod starting in 1987Q1. Since theory suggests that there should be serial correlation in the residuals of order $j - 1$, I allow for this in estimation.

Table A1 provides the results. To understand the table, consider the results for the full sample when a forecast horizon of two quarters ($j = 2$) is used. The estimate of ϕ_π indicates that if trend inflation is one percentage point above headline inflation, the latter is predicted to rise by 0.17 percentage points in the coming two quarters. The p-value for a test of the hypothesis that the parameter is zero is 9.5% and the adjusted R-squared is 4.6%.

Next I add the output gap to the regression. I find that ϕ_g is positive and highly significant ($p = 1.6\%$) and that the adjusted R-squared rises to 12.0%. Furthermore, ϕ_π rises to 0.28 and becomes highly significant ($p = 0.2\%$). This implies that the output gap contains information about future changes in inflation in addition to that embedded in the wedge between trend and headline inflation.

I proceed by also including trend money growth relative to trend inflation in the regression. I find that ϕ_m is highly significant ($p = 0.0\%$) and that the adjusted R-squared rises further to 28.0%. However, the estimate of ϕ_g declines and its significance falls ($p = 5.4\%$).

Overall, the results for the full sample period show that money growth contains information for future changes in inflation, irrespectively of the time horizon considered and whether or not the output gap is included. The output gap is also significant, at least at the 10% level, for $j = 2$, 4 and 12 when money is excluded from the model. However, when money is included, it is only significant for $j = 2$ (and then with a p-value of 5.4%). The wedge between trend and headline inflation is generally significant, with the point estimate of ϕ_π approaching unity for longer forecast horizons and in fact exceeding unity, but not significantly so, for $j = 12$. Furthermore, the

Table A1. Estimates of $\pi_{t+j} - \pi_t = \phi_\pi(\pi_t^* - \pi_t) + \phi_g g_t + \phi_m(\mu_t^* - \pi_t^*) + \xi_t$

Forecast horizon j (quarters)	Sample period: 1970Q2–2003Q1				Sample period: 1970Q2–1986Q4				Sample period: 1987Q1–2003Q1			
	ϕ_π	ϕ_g	ϕ_m	adj. R^2	ϕ_π	ϕ_g	ϕ_m	adj. R^2	ϕ_π	ϕ_g	ϕ_m	adj. R^2
2	0.159			0.038	0.105			0.009	0.532			0.209
	[0.125]				[0.344]				[0.000]			
2	0.277	0.469		0.120	0.244	0.578		0.113	0.694	0.415		0.284
	[0.002]	[0.016]			[0.029]	[0.058]			[0.000]	[0.006]		
2	0.401	0.315	0.652	0.280	0.380	0.407	0.678	0.327	0.787	0.322	0.528	0.313
	[0.000]	[0.054]	[0.000]		[0.000]	[0.078]	[0.000]		[0.000]	[0.018]	[0.010]	
2	0.341		0.725	0.248	0.302		0.750	0.281	0.706		0.706	0.278
	[0.000]		[0.000]		[0.002]		[0.000]		[0.001]		[0.007]	
4	0.272			0.068	0.224			0.039	0.604			0.239
	[0.072]				[0.192]				[0.000]			
4	0.398	0.501		0.117	0.347	0.514		0.070	0.837	0.599		0.389
	[0.006]	[0.080]			[0.048]	[0.241]			[0.000]	[0.000]		
4	0.632	0.211	1.227	0.442	0.620	0.172	1.354	0.497	0.922	0.514	0.479	0.408
	[0.000]	[0.363]	[0.000]		[0.000]	[0.543]	[0.000]		[0.000]	[0.000]	[0.016]	
4	0.591		1.277	0.437	0.587		1.385	0.500	0.792		0.763	0.310
	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.001]	
8	0.432			0.105	0.368			0.068	0.868			0.361
	[0.006]				[0.037]				[0.000]			
8	0.502	0.280		0.108	0.432	0.266		0.061	1.035	0.429		0.409
	[0.003]	[0.199]			[0.026]	[0.372]			[0.000]	[0.011]		
8	0.874	–0.181	1.947	0.595	0.874	–0.289	2.195	0.706	1.096	0.368	0.345	0.409
	[0.000]	[0.496]	[0.000]		[0.000]	[0.374]	[0.000]		[0.000]	[0.037]	[0.400]	
8	0.909		1.905	0.594	0.930		2.144	0.703	1.003		0.548	0.380
	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.184]	
12	0.624			0.161	0.602			0.139	0.836			0.308
	[0.001]				[0.004]				[0.000]			
12	0.743	0.467		0.174	0.765	0.681		0.157	0.915	0.184		0.304
	[0.000]	[0.093]			[0.000]	[0.064]			[0.000]	[0.409]		
12	1.158	–0.098	2.217	0.629	1.283	0.030	2.570	0.768	0.880	0.229	–0.200	0.294
	[0.000]	[0.739]	[0.000]		[0.000]	[0.914]	[0.000]		[0.000]	[0.366]	[0.751]	
12	1.177		2.193	0.632	1.277		2.575	0.771	0.820		–0.056	0.295
	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.917]	

Notes: p-values in brackets. All equations are estimated with GMM. The standard errors are computed allowing for serially correlated errors and heteroscedasticity.

adjusted R-squareds are consistently considerably higher when money growth is included in the model. Overall, these results suggest that money does contain information useful for predicting future changes in inflation.

Next I turn to the results for the two subsamples. Several findings are readily apparent. First, after 1986 money growth is generally less, and the output gap more, significant, particularly so for longer forecast horizons ($j = 8$ and 12). Interestingly, models estimated for the second subsample which include the output gap among the regressors have typically much higher adjusted R-squareds than the others. This is supportive of the notion that the information content of money has declined over time and that, if anything, the output gap may have become more useful for predicting changes in inflation. However, money growth appears to remain informative about future inflation in the post-1987 period for $j = 2$ and 4.

APPENDIX 2. DERIVING THE TWO-PILLAR PHILLIPS CURVE

To obtain the TPPC, I start from the inflation equation and the definition of expected inflation:

$$\pi_t = \alpha_f \pi^e_{t+1} + \alpha_b \pi_{t-1} + \alpha_g g_{t-1} + \varepsilon_t, \tag{A1}$$

$$\pi^e_{t+1} = \mu^*_{t-1}. \tag{A2}$$

Trend money growth is given by:

$$\mu^*_{t-1} = \lambda \mu_{t-1} + (1-\lambda)\mu^*_{t-2}. \tag{A3}$$

I can write the inflation equation in the compact form:

$$z_t = \alpha_f \mu^*_{t-1} + \varepsilon_t \tag{A4}$$

where $z_t \equiv \pi_t - \alpha_b \pi_{t-1} - \alpha_g g_{t-1}$. Note that (A4) implies that $\mu^*_{t-2} = (z_{t-1} - \varepsilon_{t-1})/\alpha_f$. Substituting (A3) into (A4) I obtain:

$$z_t = \alpha_f \lambda \mu_{t-1} + \alpha_f (1-\lambda)\mu^*_{t-2} + \varepsilon_t \tag{A5}$$

or

$$z_t = \alpha_f \lambda \mu_{t-1} + (1-\lambda) z_{t-1} + \varepsilon_t - (1-\lambda)\varepsilon_{t-1} \tag{A6}$$

Using the definition of z_t, the final inflation equation can be written as:

$$\pi_t = \beta_1 \mu_{t-1} + \beta_2 g_{t-1} + \beta_3 \pi_{t-1} + \beta_4 g_{t-2} + \beta_5 \pi_{t-2} + e_t, \tag{A7}$$

where $\beta_1 = \alpha_f \lambda$, $\beta_2 = \alpha_g$, $\beta_3 = (1 - \lambda + \alpha_b)$, $\beta_4 = -(1-\lambda)\alpha_g$, $\beta_5 = -(1-\lambda)\alpha_b$ and $e_t = \varepsilon_t - \rho\varepsilon_{t-1}$ and $\rho = (1-\lambda)$.

Note that obtaining significant estimates of the β_i's is not sufficient to conclude that the model is valid. In fact, a finding that money and the lagged output gap matter (β_1, $\beta_2 > 0$), that the parameter on lagged inflation is significant and has a plausible value ($0 < \beta_3 \leq 1$) and that the coefficients on the twice-lagged output gap and inflation are insignificant does not, on its own, provide support for the model. Rather, the underlying parameters – the degrees to which inflation is forward (α_f) and backward looking (α_b), the impact of the output gap on inflation (α_g) and the extent to which past money growth determines inflation expectations (λ) – need to be significant and of plausible magnitude. In particular, I would expect that $0 \leq \alpha_f, \alpha_b \leq 1$, $\alpha_f + \alpha_b \approx 1$, $\alpha_g > 0$ and that λ is significant and 'reasonably' close to the 0.075 value used by Gerlach (2003). Moreover, the errors should obey a first-order MA structure.

Furthermore, the fact that there are seven parameters in the empirical model (a constant, five β_i parameters, and σ^2), but only six parameters in the 'structural' model (a constant, α_f, α_g, α_b, λ, σ^2) implies that there are testable restrictions. Moreover, there are only five parameters if the restriction that $\alpha_f + \alpha_b = 1$ is imposed, and four if I also assume that $\alpha_f = 1$. In sum, the model, while simple, imposes conditions that the data must satisfy.

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