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ABSTRACT

The ECB’s Two Pillars*

This Paper suggests a formal interpretation of the ECB’s two-pillar framework for monetary policy. I decompose inflation in the euro area into high- and low-frequency (or short-run and medium/long-run) components, which are correlated with monetary growth and the output gap, respectively. I proceed to propose and estimate a ‘two-pillar’ Phillips curve that assumes that money causes prices. While the model fits well and the causality assumption seems compatible with the 1980-90 data, there appears to be reverse causality from prices to money in the 1991-2001 period, which would invalidate my model.

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1. Introduction

There is much consensus among academic and central bank economists that the fundamental proposition of monetary theory – that in the long run there is a one-to-one relationship between money and prices – is correct. A large number of authors have used cross-country data to demonstrate that the average growth rate of money over some period of time is close to the average rate of inflation in the same period.[1] The same proportional relationship has also been shown to be present in individual economies.[2] Despite this, there is little agreement about what role money should play, if any, in the conduct of monetary policy in countries experiencing low inflation. To the extent that a majority view exists, it is arguably best described as being that money is merely one of many indicators of inflation and should not be given any special emphasis in the setting of interest rates. In sum and as noted by King (2002), there appears to be a tension between economists' views about the role of money in the inflation process and their views about its role in the practical conduct of monetary policy.

Nowhere is this more readily apparent than in the debate about the ECB's monetary policy framework, which relies on two "pillars".[3] The first of these is defined as a "prominent role for money". The second is a "broadly based assessment of the outlook for future price developments". This framework, particularly the use of a monetary pillar, has been subject to intense criticism. A number of influential observers have argued that it is subject to shortcomings and needs to be replaced.[4]

One reason why the first pillar has become controversial is that the ECB has not explained satisfactorily the independent importance of money in the inflation process in the euro area. While the ECB has argued that the correlation between money growth and inflation is only apparent in the medium to long run, it has neither given that notion nor the two-pillar approach an explicit definition.[5] That has been seen by

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1 De Grauwe and Polan (2002) survey this literature and provide new evidence.
2 For instance, see King (2002). Sargent (1982) contains a classic analysis of the role of money in episodes of hyperinflation.
3 The ECB's monetary policy strategy is spelled out in ECB (1999 and 2001) and Issing et al. (2002).
4 Begg et al. (2002) and Svensson (2002) contain critiques of the framework.
5 For instance, ECB (2001, p. 47) states that *" ... there is widespread consensus among economists about the fundamentally monetary origin of inflation over the medium to longer term."*

many as the ECB having given itself an unwarranted degree of freedom in interpreting the first pillar.

Another reason for the controversy regarding the first pillar is that there is no discernible link between M3 growth and the ECB's interest rate decisions. This is most likely because "headline" movements in M3 have correctly been interpreted by the ECB as having little impact on the outlook for inflation and have therefore been disregarded in the setting of monetary policy.[6] If so, transparency would be raised if the ECB indicated what movements in money growth are worth worrying about. While it has announced a reference value for M3 growth that was intended to signal excessive monetary expansion, this indicator seems to have played little role in policy.[7]

This paper has two main objectives. The first of these is to suggest an interpretation of the ECB's views of the inflation process. I propose and estimate a "two-pillar Phillips curve" that renders explicit the role of money and the different time horizons underlying the two pillars, and which allows for a precise statement regarding what rate of monetary expansion "signals risks to price stability." The empirical model is strikingly compatible with the data and the suggested interpretation of the ECB's view of inflation. The second objective is to explore whether the two-pillar view is a useful device when thinking about inflation and the setting of monetary policy in the euro area. I argue that while money growth may have played an active role for inflation in the 1981-2001 period, that result hinges on the use of pre-1991 data. After 1991 money growth is better described as adjusting passively to movements in prices and in money demand. My main conclusion is that the two-pillar view of inflation is theoretically correct but of little practical relevance in setting policy in the euro area, largely because the achievement and maintenance of low inflation has reduced the degree of monetary instability that the first pillar was established to guard against.

The paper is organised as follows. The second section briefly reviews the role of money in monetary policy. It argues that one reason why money has become less important over time is that successful monetary policy has reduced the correlation

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6 This is argued forcefully by Begg et al. (2002, p. 20).

7 However, ECB (1999, p. 45) notes that: *"... the concept of a reference value does not entail a commitment on the part of the Eurosystem to correct deviations of money growth from the reference*

between money and inflation. The third section provides a selective review of the empirical literature on money and prices in the euro area. Section 4 attempts to give the ECB's two-pillar concept of inflation an explicit representation. The analysis is based on the observation that inflation may be decomposed into high- and low-frequency components (or, equivalently, "short-run" and "medium-term/long-run" factors) and the hypothesis that these may have separate determinants. If so, it seems natural to use a two-pronged approach when assessing inflation and setting policy. I use a simple linear filter to decompose quarterly euro area data spanning the period 1980-2001 on inflation and the growth rate of money relative to real GDP into high- and low-frequency components. I argue that inflation at a point in time can be thought of as given by a "local mean," which is strongly correlated with the growth rate of money relative to real GDP, and by deviations from that mean, which are captured by the output gap.

Section 5 proposes and estimates a simple "two-pillar" version of a standard Phillips curve. The key feature of the model is that the intercept at a given point in time is strongly correlated with the low-frequency component of inflation or, equivalently, money growth relative to real income growth, which is my interpretation of the first pillar. One interesting implication is that since the intercept changes only slowly over time, and not at all if inflation has reached a steady-state level, it is not surprising that it is difficult to find a role for money in the inflation process in the euro area.

Section 6 explores the validity of my interpretation of the two-pillar framework. While the model appears highly supportive of the ECB's view of the inflation process, it is important to understand the nature of the correlation between money and inflation. One view, which I think of as that of the ECB, is that low-frequency movements in money growth lead to low-frequency movements in inflation. The alternative hypothesis is that this correlation may merely reflect reverse causality from prices to money arising from shifts in money demand. The nature of the correlation may also have changed over time. Section 6 therefore allows for a break in the inflation equation in the early 1990s. The results indicate that while money is

value over the short run. Interest rates will not be changed "mechanistically" in response to such deviations in an attempt to return monetary growth to the reference value."

correlated with inflation in the first subsample, it is insignificant in the second subsample. I therefore go on and investigate the joint behaviour of the low-frequency components of money growth relative to real GDP and inflation. I find that in the first half of the sample, there was bivariate feedback between money growth and inflation, but that in the second half of the sample there is univariate feedback from inflation to money growth. These results suggest that while the first pillar may have been useful for thinking of inflation in the 1980s, it has lost its footage in the last decade. Section 7 contains the conclusions.

2. The demise of monetary aggregates

Although monetary aggregates played an important role in thinking about monetary policy in the 1970s, over time their role in interest-rate setting by central banks has declined.[8] King (2002) discusses two reasons for that. One explanation is that central banks experienced problems in controlling the aggregates, in many cases because financial deregulation and innovation had led to large and unpredictable shifts in velocity. A second reason, which arguably is more important, is that the correlation between money growth and inflation has declined in response to better inflation performance. Using cross-country data, De Grauwe (2002) shows that the correlation between these nominal variables is essentially zero among low inflation countries.[9] However, that implies neither that money plays no role in the inflation process nor that it can be disregarded in the setting of monetary policy. Rather it should be seen as reflecting good central banking.

While the argument is spelled out in greater detail below, it is useful to review it briefly at this stage. Suppose that money started to rise relative to prices and income, leading to an incipient increase in inflation. Central banks that gear policy to low inflation would then be required to raise interest rates irrespectively of their exact policy framework. By doing so, they would prevent prices from rising, thereby removing the information content of money for future prices. The increased importance attached to price stability has thus led central banks to reduce the volatility of money growth towards a floor that is given by shifts in the demand for

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8 Bernanke and Mishkin (1992) review of the experiences with monetary targets in six countries.

9 Gerlach (1995) also documents the instability of the relationship between inflation and money growth.

money that have no implications for the outlook for inflation. In fact, if central banks reacted perfectly to the information content in money, money growth would be orthogonal to deviations of inflation from the central bank's inflation objective.[10] The overarching lesson to be learned from the decline in the correlation between money growth and inflation is therefore not necessarily that money doesn't matter for monetary policy, but that it does matter and that central banks have had the good sense to act accordingly.

Before considering the concrete case of the role of money in the inflation process in the euro area, I review some of the existing literature on this topic.

3. 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.[11] Coenen and Vega (2001) study quarterly data on real M3, real income, short and long interest rates and inflation for the period 1980-1998. After testing for weak exogeneity, they estimate a single 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) also 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

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[10] Buiter (1984) and Granger (1988) discuss how (optimal) control affects the information contained in economic time series. See Rowe and Yetman (2002) for a related discussion of how one can infer what a central bank targets.

[11] As did the staff of its predecessor, the EMI, e.g., Fagan and Henry (1998).

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 the error-correction terms. 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.

However, 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 (2002), indicates that money is informative of 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).[12] 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. 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.

Gerlach and Svensson (2002) present evidence suggesting that money, as captured by the real money gap, and the output gap both contain information useful in forecasting future inflation. The results suggest that the real money gap may be marginally less useful than the output gap, but this ranking is likely to depend on the exact choice of sample period, data and econometric framework. It is thus open to debate.

This selected review of the literature indicates that money has predictive content for inflation in the euro area. However, the output gap is also relevant and may if anything be more useful than money in forecasting inflation. Indeed, it is possible to interpret the literature as suggesting that the marginal information content of money in addition to the output gap is zero.

4. An empirical model of inflation in the euro area

In this section I turn to the first main objective of this paper, which is to suggest a formal interpretation of the two-pillar view of inflation. It should be highlighted from the outset that the focus at this stage is on operationalising that view and not on assessing its validity. The discussion is therefore purposely as supportive as possible of (what I believe to be) the ECB's view of the role of money in the inflation process.

4.1 Decomposing inflation into two pillars

As a first step, consider the following decomposition of inflation, Δp_t:

$$\Delta p_t \equiv \Delta p_t^{LF} + \left(\Delta p_t - \Delta p_t^{LF}\right)$$

or, using $\Delta p_t^{HF} \equiv \left(\Delta p_t - \Delta p_t^{LF}\right)$,

$$\text{(1')} \qquad \Delta p_t \equiv \Delta p_t^{LF} + \Delta p_t^{HF}$$

where Δp_t^{LF} and Δp_t^{HF} denote, for reasons that are made clearer below, the low- and high frequency components of inflation.[13] The low frequency component may alternatively be thought of as the "medium-term/long-run" component of inflation, or the "local mean" of inflation, and the high-frequency component as "short-run" inflation.

[12] Trecroci and Vega (2000) use an earlier version of the Gerlach and Svensson (2002) model.

[13] Jaeger (2002) discusses the role of money in the ECB's policy framework. He uses data from several EMU members to show that the coherence between money growth and inflation is very high in the low-frequency band of the cross-spectrum even for economies that have experienced little inflation.

One way to interpret the ECB's framework is to suppose that these components have different determinants. For instance, slow-moving factors such as monetary aggregates may determine the low-frequency component, while economic forces of limited persistence, such as the output gap, may determine the high-frequency component. If so, it would seem sensible to employ a two-pronged approach to interest-rate setting. In the first step of that approach, policy makers would ensure that the local mean of inflation is at the appropriate level, and in the second step they would minimise the fluctuations of inflation around that local mean.[14]

Note that if the two components of inflation are orthogonal, the correlation between headline inflation and the low-frequency component of inflation depends solely on the variance of the low-frequency component, that is $\mathrm{Cov}\left(\Delta p_t, \Delta p_t^{LF}\right) = \mathrm{Var}\left(\Delta p_t^{LF}\right)$.[15] This implies, which is one source of the controversy regarding the ECB's first pillar, that the more successful policy makers are in stabilising inflation, that is, in reducing the variance of Δp_t^{LF}, the lower is the correlation between inflation and the determinants of the low-frequency component. In this situation, perfect stabilisation of inflation around a constant implies that there is no correlation at all between the determinants of Δp_t^{LF} and Δp_t. Indeed, the determinants of Δp_t^{LF} would spuriously fail to be significant if they were included in a Phillips curve model in which inflation is regressed on a constant and the output gap. This suggests that it will be difficult to judge the importance of money for inflation when inflation is relatively stable, as it was in the euro area in much of the 1990s.

Of course, the discussion so far is entirely hypothetical. For the analysis to be of relevance for the setting of monetary policy, it is necessary to add an interpretation of the ECB's views of the determination of the two components of inflation and to give them empirical content. I now turn to these issues.

4.2 Filtering

In order to operationalise the model outlined above, inflation must be decomposed into high- and low-frequency components. While this can be achieved in several

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[14] Of course, in minimising the fluctuations of inflation around the local mean, they may consider the implications for the volatility of output.

ways, there are two constraints that have important implications for how this should be done. [16] First, it is critical from a transparency perspective that the decomposition is simple and that it can easily be explained and replicated. This suggests that too refined methods, while perhaps superior from a time-series perspective, should be avoided. Second, for policy makers to be able to use the approach, it is important that the decomposition can be done in real time. This implies that only current and past data can be used, that is, a one-sided filter must be employed.

Cogley (2002) proposes such a filter and uses it to provide an estimate of core inflation in the US. Since core inflation can be interpreted as the local mean of inflation, it seems appropriate to apply this filter also for the problem at hand. The suggested filter is of a simple exponential smoothing form and is given by:

$$(2) \qquad \Delta p_t^{LF} = \Delta p_{t-1}^{LF} + \gamma\left(\Delta p_t - \Delta p_{t-1}^{LF}\right)$$

or

$$(3) \qquad \Delta p_t^{LF} = \gamma \sum_{j=0}^{\infty} (1-\gamma)^j \Delta p_{t-j}$$

or $\Delta p_t^{LF} = h(L)\Delta p_t$. Cogley (2002) studies the filter in the frequency domain and shows that depending on the choice of smoothing parameter, γ, it removes the high-frequency variation of the series. This is why it is appropriate to refer to the filtered series as the low-frequency component of the time series in question. In order to determine the smoothing parameter, one may think of it as capturing the speed by which a once-and-for-all change in the variable subject to filtering impacts on the filtered variable. In particular, $\ln(2)/\gamma$ captures the half-life of this adjustment. Cogley (2002) suggests that realistic values for the smoothing parameter lie in the range of 0.075 - 0.15, which correspond to a half-life of about 9.2 to 4.6 quarters. Given that

[15] Since current inflation is used to calculate the filtered version thereof, in the empirical work the two series generally display some positive correlation of trivial magnitude.

[16] It is interesting to note that the ECB itself thinks that filtering is helpful, as evidenced by the fact that it plots a three-month centred moving average of money growth over twelve months, that is, $(L^1+L+L^{-1})(1-L^{-12})/3$. See ECB (2002, p. 7).

the implicit hypothesis of this paper is that monetary factors determine the low-frequency component of inflation, Friedman's "long and variable lags" suggest using a low value for γ. I therefore set $\gamma = 0.075$, but as a check for robustness also report results for $\gamma = 0.15$.

Next I decompose inflation. Since the euro was introduced in January 1999, the analysis is conducted on synthetic euro area data for the period before that date. The data, which is quarterly, stem from Brand et al (2001) and span the period 1980Q1-2001Q2. Figure 1 shows actual inflation and the two filtered versions thereof. Not surprisingly, the latter declined gradually over the sample as central banks successfully restored and maintained price stability. Since the filter is one-sided and backward-looking, actual inflation, which declined, was below the low-frequency components for much of the sample. Needless to say, it would be desirable to explore other filters in future work.

- - - Insert Figure 1 - - -

4.3 The output gap and the high-frequency component of inflation

One way to interpret the ECB's view of the high frequency component of inflation is that it is determined by a Phillips curve relationship.[17] I therefore compute a measure of the output gap, g_t, in the euro area using the Hodrick-Prescott (1997) filter. Because the econometric method used below to estimate a Phillips curve implicitly normalises the data, I transform the output gap and the high-frequency component of inflation into unit normals. Figures 2-3 contain time series plots of Δp_t^{HF} for $\gamma = 0.075$ or $\gamma = 0.15$.[18] (Since the choice of smoothing parameter is not critical, in the interest of brevity I do not comment on the differences.)

- - - Insert Figures 2 - 3 - - -

The figures show that the two variables move jointly. This is formalised by the cross correlations presented in Table 1, which indicate that there is a strong contemporaneous relationship between them, although the correlations are trivially

[17] See Fagan et al. (2001).

[18] As starting values for the low-frequency components of inflation and money growth I use the actual inflation and money growth in 1980Q2. I set the growth rate of real GDP to zero since real income growth was negative in that quarter.

higher if the output gap is lagged two quarters. The scatter plots in Figures 4-5 also illustrate the close relationship between the series.

- - - Insert Table 1 and Figures 4-5 - - -

Overall, these results suggest that the output gap plays an important role in the inflation process in the euro area in that it is correlated with short-run movements in inflation.[19] But what then determines the long-run movements in inflation? The ECB's rhetoric suggests that this is the role of money. I will now investigate whether this claim is compatible with the data.

4.4 Money growth and the low-frequency component of inflation

In order to interpret the parameter estimates discussed in the next section, it is useful as a preliminary step rewrite the quantity theory of money to yield:

$$(4) \qquad \Delta p_t \equiv \Delta m_t - \Delta y_t + \Delta v_t$$

where Δm_t, Δy_t and Δv_t denote the growth rate of money, real income and velocity. Next, consider filtering both sides of equation (4):

$$(5) \qquad \Delta p_t^{LF} \equiv \Delta m_t^{LF} - \Delta y_t^{LF} + \Delta v_t^{LF}$$

Thus, the low-frequency component of inflation depends on the low-frequency components of money, real income and velocity growth. In the analysis below I look interchangeably at $\Delta m_t^{LF} - \Delta y_t^{LF}$ and Δp_t^{LF}, which raises the issue of how strongly related they are. To explore this issue, consider the projection:[20]

$$(6) \qquad \Delta p_t^{LF} = \theta_0 + \theta_1 \left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) + \zeta_t .$$

[19] It is notable that the ECB (1999, p. 44) also believes that short-run movements in prices (what I call the high-frequency component of inflation) are not due to monetary factors: e.g., " ... *acknowledges the existence of short-run volatility in prices, resulting from non-monetary shocks to the price level that cannot be controlled by monetary policy.*"

[20] See Sargent (1979, p. 209).

The main point here is that there should be no presumption that θ_1 is unity. To see this most easily, suppose that $\Delta m_t^{LF} - \Delta y_t^{LF}$ is uncorrelated with the growth of velocity, in which case:

$$\text{(7a)} \qquad 0 \le \theta_1 = \frac{Var\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right)}{Var\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) + Var\left(\Delta v_t^{LF}\right)} \le 1$$

$$\text{(7b)} \qquad \theta_0 = (1 - \theta_1) E\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) + E\left(\Delta v_t^{LF}\right)$$

Note that $\theta_1 = 1$ only if the low-frequency component of velocity is constant. If Δv_t^{LF} varies (but is uncorrelated with $\Delta m_t^{LF} - \Delta y_t^{LF}$), $0 < \theta_1 < 1$. Of course, θ_1 can take any value in the more general case in which Δv_t^{LF} is correlated with $\Delta m_t^{LF} - \Delta y_t^{LF}$.

Figures 6-7 contain plots of Δp_t^{LF} and $\Delta m_t^{LF} - \Delta y_t^{LF}$ for the two choices of γ. For the same reasons as before, the time series have been normalised. The figures and the scatterplots in Figures 8-9 indicate a tight relationship between the low-frequency movements of the two variables. The exception is the period around the ERM crisis between 1992Q3 and 1993Q3, when increased interest rate volatility led to a portfolio reallocation from bonds to money and an increase in M3 growth.

- - - Insert Figures 6 - 7 - - -

While the above analysis is strikingly compatible with the notion that monetary factors determine the local level of inflation and that the output gap affects movements in inflation around that level, it is important to recognise that it is not a test of that proposition. For the two-pillar view to be warranted, it is critical to understand why money growth and inflation are so strongly correlated.[21] For the time being I will disregard this issue and estimate a "two-pillar" or, alternatively, a "low- and high-frequency" Phillips curve. In Section 6 I return to critical issue of the nature of the correlation between money and prices.

[21] Svensson (2002) argues that this correlation is frequently misunderstood and notes that both variables are endogenous.

5. A "two-pillar" Phillips curve

To proceed, consider estimating a Phillips curve using the deviation of inflation from its low-frequency component as the dependent variable:[22]

(8) $$\Delta p_t - \Delta p_t^{LF} = \kappa + \alpha(L)\left(\Delta p_{t-1} - \Delta p_{t-1}^{LF}\right) + \beta g_t + \varepsilon_t$$

where $\alpha(L) = \alpha_1 - \alpha_2 L - \alpha_3 L^2 + \ldots$ and where L and ε_t denote the lag operator and the residual, respectively. While equation (8) is a standard, backward-looking Phillips curve, in future research it would seem desirable to include additional explanatory variables and to consider forward-looking versions thereof.[23] Preliminary regressions indicated that the current output is marginally more significant than once- or twice lagged output gaps, and I therefore include g_t in the regression.

To proceed, using equation (6), I rewrite equation (8) as:

(9) $$\Delta p_t = \kappa + \left(L^{-1} - \alpha(L)\right) \times \left\{\theta_0 + \theta_1\left(\Delta m_{t-1}^{LF} - \Delta y_{t-1}^{LF}\right)\right\} + \alpha(L)\Delta p_{t-1} + \beta g_t + u_t$$

where $u_t \equiv \varepsilon_t + \left(1 - \alpha(L)\right)\zeta_t$ and, as discussed above, θ_0 and θ_1 need not be zero and unity, respectively. Equation (9) is my proposed interpretation of the ECB's "two-pillar" view of the inflation process. Note that moving from equation (8) to (9) introduces the assumption that money growth causes, rather than is caused by, inflation.

Before proceeding, suppose that inflation has reached a steady-state level so that $\Delta p_t^{LF} = \Delta p^{LF}$ and $\Delta m_t^{LF} - \Delta y_t^{LF} = \Delta m^{LF} - \Delta y^{LF}$ are constant. Rewrite equation (8) as:

(8') $$\Delta p_t = \tilde{\kappa} + \alpha(L)\Delta p_{t-1} + \beta g_t + u_t$$

[22] See McCallum (1984) for a critical analysis of the use of low-frequency methods to study monetary neutrality. However, McCallum implicitly assumes that the economy is populated by a single agent (or a series of identical agents). It seems a plausible conjecture that the low-frequency component captures a common component of expectations in models with an infinity of heterogeneous agents.

[23] However, Fuhrer (1997) argues that forward-looking expectations are unimportant in Phillips curves estimated on US data.

where $\tilde{\kappa} \equiv \kappa + \{1-\alpha(1)\}\Delta p^{LF}$. Thus, the intercept of the standard Phillips curve is determined by the low-frequency component of inflation. Alternatively, rewrite equation (9) to yield:

(9') $\Delta p_t = \bar{\kappa} + \alpha(L)\Delta p_{t-1} + \beta g_t + u_t$

where $\bar{\kappa} = \kappa + (1-\alpha(1))\{\theta_0 + \theta_1(\Delta m^{LF} - \Delta y^{LF})\}$. Thus, equation (9') is a standard backward-looking Phillips curve, but with the intercept depending on the low-frequency component of money growth relative to income growth. This equation has the interesting implication that if the low-frequency inflation was constant and monetary variables were added to the equation as explanatory variables, they would be insignificant (or collinear with the constant) despite the fact that money may matter for inflation.

5.2 Estimation

Next I estimate equation (8), assuming a half-life for the low-frequency components of either 9.2 or 4.6 quarters, on the sample period 1980:4-2002:2. The results are presented in Table 2. Since preliminary regressions showed that two lags were sufficient in $\alpha(L)$, I imposed that restriction. The results indicate that all variables, except the constant, κ, are highly significant. To interpret the coefficient on the output gap, note that the dependent variable is inflation per quarter. If inflation is measured on an annual basis, the coefficient should be multiplied by four. The finding that β is about 0.14 thus implies that if the growth rates were annualised, the parameter would be about 0.5, that is, about twice as large as in the estimates of Gerlach and Svensson (2002). The explanation for this is that a standard Phillips curve does not discriminate between the variation in the high-frequency component of inflation, which the output gap affects, and the variation in the low-frequency component that it does not influence.

- - - Insert Tables 2 and 3 - - -

The results for equation (9) are presented in Table 3. The results are seemingly strikingly supportive of my interpretation of the ECB's views of the inflation process.

In particular, θ_1 is highly significant. The other parameters are similar to those estimated in Table 2 and remain highly significant.[24]

5.3 Summary

The analysis above has established three facts. First, the output gap is strongly correlated with high-frequency movements of inflation or, alternatively put, with movements of inflation around a local mean. This result is the main lesson from standard Phillips curves and is therefore by no means surprising. The second finding is that the low-frequency component of inflation is closely correlated with the low-frequency component of money growth relative to income growth in the twenty years of euro area data considered here. The third finding is that one can model the intercept in a Phillips curve as depending on the low-frequency component of either inflation or nominal money growth relative to income growth. Overall, these findings are supportive of two-pillar notion of inflation.

6. The correlation between money and inflation

In this section I turn to the second purpose of the paper, which is to explore the usefulness of the two-pillar view. While seemingly successful, the model estimated above introduces the *untested* assumption that low-frequency money growth relative to income growth causes inflation. This assumption is by no means innocent and is arguably the root cause of the disagreement regarding the usefulness of the first pillar. Indeed, there are two competing explanations for the association between money and prices. The first view is that the correlation between money and prices is due to money growth leading to inflation. The competing view is that the correlation reflects reverse causality from prices to money, arising from a money demand relationship. I will therefore proceed to explore the nature of this correlation.

6.1 The role of money

While a structural model is needed to properly understand the correlation between money growth and inflation, there is little agreement about what such a model should

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[24] As noted above, theory suggests that there should be serial correlation in the residuals of equation (9). However, if the variance of the ε-errors is much larger than that of the ζ-errors, which seems plausible, the serial correlation is of little practical relevance in estimation.

look like. I therefore proceed in an atheoretical manner, aiming to establish empirical regularities about the joint behaviour of the variables under study. To do so, consider first an "augmented" version of the Phillips curve in equation (8):

$$(10) \qquad \Delta p_t - \Delta p_t^{LF} = \kappa + \alpha(L)\left(\Delta p_{t-1} - \Delta p_{t-1}^{LF}\right) + \beta g_t + \lambda_{my}\left(\Delta m_{t-1}^{LF} - \Delta y_{t-1}^{LF}\right) + \lambda_p \Delta p_{t-1}^{LF} + \varepsilon_t$$

where I have added the lagged low-frequency components of money growth relative to income growth and inflation as additional regressors. Under the assumption that the Phillips curve is correctly specified in equation (7) and money is irrelevant for inflation, one would expect that $\lambda_{my} = \lambda_p = 0$. Under the alternative hypothesis that money does in fact cause inflation, so that the local level of inflation is not fully captured by Δp_{t-1}^{LF}, one would expect that $\lambda_{my} > 0 > \lambda_p$ and that these parameters are significant. If so, it follows that inflation is predictable on the basis of the information embedded in money growth relative to income growth.

Table 4 presents estimates of equation (10). The most interesting finding is that λ_{my} is estimated to be positive and λ_p negative and that both are highly significant. Moreover, the adjusted R-squared also rises relative to the results in Table 2. These results suggest that money does in fact play a role in determining the location of the intercept of the Phillips curve and that it contains information not embedded in the low-frequency component of inflation.

--- Insert Table 4 ---

As noted by Svensson (2002), the correlation between money growth and inflation is likely to depend on the choice of policy strategy. Since the usefulness of money for forecasting future inflation may have declined as inflation has fallen, it is of interest to explore the stability of equation (10). Given that the results presented above do not hinge on the choice of smoothing parameter, I focus on the case in which the low-frequency component has a half-life of 9.2 quarters, break the sample in the middle and compute a Chow test for parameter constancy in 1991Q1. The test rejects the hypothesis that the parameters are the same in the two samples ($p = 0.049$). I therefore reestimate the equation for the two subsamples and provide the results in Table 5. Given that there are fewer observations in these samples, it is not surprising that the significance of the parameters has declined. What is notable, however, is that while

λ_{my} and λ_p are highly significant in the first part of the sample, they are clearly insignificant in the second sample. Thus, the low-frequency component of money does not appear useful for predicting future inflation after 1991.

--- Insert Table 5 ---

6.2 The joint behaviour of $\Delta m_t^{LF} - \Delta y_t^{LF}$ *and* Δp_t^{LF}

Before commenting on these results, I further document the changing role of the low-frequency component of money in the euro area by studying the joint behaviour of $\Delta m_t^{LF} - \Delta y_t^{LF}$ and Δp_t^{LF}. Since these variables have gradually declined over the sample, I perform Johansen tests for cointegration and explore the patterns of weak exogeneity.

In Table 6 I provide the results for the Johansen test for the full sample, 1981Q3-2001Q2, and for two subsamples which end in 1990Q4 and start in 1991Q1, respectively. Consider first the full sample results, which show that there is one cointegrating relationship, which can be written as $\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) - 1.08\Delta p_t^{LF}$ and which thus captures the quantity theory of money. More interestingly, tests of weak exogeneity indicate that $\Delta m_t^{LF} - \Delta y_t^{LF}$ adjusts to restore monetary equilibrium but that Δp_t^{LF} does not. Thus, money growth responds to inflation rather than the converse. While these results are derived from the bivariate time-series behaviour of $\Delta m_t^{LF} - \Delta y_t^{LF}$ and Δp_t^{LF} rather than from a structural model, they do not square well with the notion that money has played an important causal role for inflation in the euro area during the sample period.

Next I turn to the sub-sample estimates. It is notoriously difficult to apply the Johansen technique to short samples, and the results reported in Table 6 for the subsamples do not provide much evidence on the number of cointegrating vectors. Using a 5% significance level, I do not reject the null hypothesis of no cointegrating vector in the first subsample. By contrast, in the second subsample I reject the hypothesis of at least one cointegrating vector. Since theory suggests that there should be one cointegrating vector, I assume that this is the case, estimate the vector and perform tests for weak exogeneity.

Two aspects of the results are of interest. First, the estimated cointegrating vector is $\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) - 1.16\Delta p_t^{LF}$ in the first subsample and $\left(\Delta m_t^{LF} - \Delta y_t^{LF}\right) - 1.19\Delta p_t^{LF}$ in the second subsample. They are thus quite similar. Second, the weak exogeneity tests indicate that the information content for money for inflation has changed over the sample. Thus, in the first subsample, both $\Delta m_t^{LF} - \Delta y_t^{LF}$ and Δp_t^{LF} adjust to disequilibria as captured by the cointegrating vector. In the second subsample, by contrast, the feedback parameter on money is highly significant, but that on prices is numerically small and highly insignificant. Overall, the low-frequency component of money growth relative to income growth appears to have lost the information it contained for the low-frequency component of inflation.

6.3 Summary

Overall, these findings suggest that the correlation between the low-frequency components of money growth relative to income growth and inflation is not stable over time, and that it in the period since 1991 is best thought of as money responding to prices rather than conversely. The declining information content of money is likely to reflect the successful disinflation in the euro area over the sample period.

7. Conclusions

The analysis above points to several conclusions. First, the first pillar of the ECB's monetary policy framework can be thought of as capturing the local mean of inflation or, equivalently, the constant of the Phillips curve, and the second pillar as capturing fluctuations around that mean. Thus, the two-pillar notion can be given an explicit, estimable representation that fits the data quite well. Second, the usefulness of the first pillar would seem to depend on the sources of the correlation between money and prices. Although it is difficult to determine the pattern of causality in the absence of a structural model, the simple time series evidence reviewed below suggests that while money may have played a forcing role before 1991, there appears to be reverse causality from prices to money after 1991. Thus, movements in money appear to largely reflect shifts in money demand that do not indicate risks to price stability. If so, it would invalidate the model proposed above and would raise doubts about the appropriateness of the two-pillar view of inflation. Third, the declining importance of money appears to be due to the achievement and maintenance of low inflation, which has been associated with increased monetary stability. My overall conclusion is thus that the two-pillar view of inflation is theoretically correct but of limited practical importance for interest-rate setting in the present low inflation environment.

What does this imply for the ECB's framework? Since a sustained increase in money growth over an extended period of time is likely to lead to higher inflation, one could argue for retaining the first pillar. However, the likelihood of a return to high inflation episodes similar to those of the 1970s and 80s appears remote. Thus, if the first pillar was kept, one would expect it very rarely to indicate risks to price stability, implying that in practice it would be of limited importance in the setting of interest rates. Alternatively, one could integrate the first and second pillar with the argument that attaching a small weight to money using a framework in which policy is determined by the near-term inflation outlook would provide ample safeguards against inflation rising out of control. Whatever decision is taken regarding the policy framework, it would be unlikely to imply a major change in the actual interest-rate setting behaviour of the ECB.

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Table 1

Cross-correlations between $\Delta p_t - \Delta p_t^{LF}$ and g_{t+j}

1980Q3 – 2001Q2

Half-life = 9.2 quarters

j	-8	-7	-6	-5	-4	-3	-2	-1	0
ρ	0.04	0.03	0.15	0.23	0.37	0.39	0.47	0.44	0.47

j	1	2	3	4	5	6	7	8
ρ	0.46	0.33	0.27	0.16	0.04	-0.03	0.02	-0.05

Half-life = 4.6 quarters

j	-8	-7	-6	-5	-4	-3	-2	-1	0
ρ	-0.07	-0.10	0.02	0.10	0.25	0.28	0.38	0.37	0.43

j	1	2	3	4	5	6	7	8
ρ	0.46	0.35	0.31	0.23	0.11	0.04	0.12	0.05

Table 2

OLS Estimates of

$$\left(\Delta p_t - \Delta p_t^{LF}\right) = \kappa + \alpha_1\left(\Delta p_{t-1} - \Delta p_{t-1}^{LF}\right) + \alpha_2\left(\Delta p_{t-2} - \Delta p_{t-2}^{LF}\right) + \beta g_t + \varepsilon_t$$

1980Q4 - 2001Q2

Regression	(1)	(2)
Dependent variable	$\Delta p_t - \Delta p_t^{LF}$	$\Delta p_t - \Delta p_t^{LF}$
Half-life for filtering	9.2 quarters	4.6 quarters
κ	-0.001	-0.001
	(0.000)	(0.000)
	[0.016]	[0.055]
β	0.090	0.084
	(0.036)	(0.034)
	[0.014]	[0.016]
α_1	0.191	0.113
	(0.108)	(0.112)
	[0.035]	[0.315]
α_2	0.341	0.272
	(0.106)	(0.112)
	[0.002]	[0.243]
Adj. R-sq.	0.366	0.258

Notes: Standard errors in parentheses, p-values in brackets.

Table 3

OLS Estimates of

$$\Delta p_t = \tilde{\kappa} + \theta_1 \left(L^{-1} - \alpha(L)\right) \times \left(\Delta m_{t-1}^{LF} - \Delta y_{t-1}^{LF}\right) + \alpha(L)\Delta p_{t-1} + \beta g_t + u_t$$

1980Q4 - 2001Q2

Regression	(1)	(2)
Dependent variable	Δp_t	Δp_t
Half-life for filtering	9.2 quarters	4.6 quarters
$\tilde{\kappa}$	-0.001	0.000
	(0.001)	(0.001)
	[0.133]	[0.848]
β	0.137	0.139
	(0.041)	(0.041)
	[0.001]	[0.001]
α_1	0.163	0.178
	(0.111)	(0.113)
	[0.145]	[0.117]
α_2	0.250	0.173
	(0.109)	(0.112)
	[0.025]	[0.129]
θ_1	0.839	0.747
	(0.089)	(0.075)
	[0.000]	[0.000]
Adj. R-sq.	0.814	0.791

Notes: Standard errors in parentheses, p-values in brackets. The constant is given by $\tilde{\kappa} \equiv \kappa + (1 - \alpha(1))\theta_0$.

Table 4

OLS Estimates of

$$\Delta p_t - \Delta p_t^{LF} = \kappa + \alpha(L)\left(\Delta p_{t-1} - \Delta p_{t-1}^{LF}\right) + \beta g_t + \lambda_{my}\left(\Delta m_{t-1}^{LF} - \Delta y_{t-1}^{LF}\right) + \lambda_p \Delta p_{t-1}^{LF} + \varepsilon_t$$

1980Q4 - 2001Q2

Regression	(1)	(2)
Dependent variable	$\Delta p_t - \Delta p_t^{LF}$	$\Delta p_t - \Delta p_t^{LF}$
Half-life for filtering	9.2 quarters	4.6 quarters
κ	-0.001	0.000
	(0.001)	(0.000)
	[0.093]	[0.724]
β	0.121	0.101
	(0.037)	(0.034)
	[0.002]	[0.004]
α_1	0.168	0.115
	(0.104)	(0.108)
	[0.111]	[0.290]
α_2	0.354	0.311
	(0.103)	(0.109)
	[0.001]	[0.005]
λ_{my}	0.802	0.345
	(0.284)	(0.139)
	[0.006]	[0.015]
λ_p	-0.950	-0.459
	(0.323)	(0.165)
	[0.004]	[0.007]
Adj. R-sq.	0.394	0.286

Notes: Standard errors in parentheses, p-values in brackets.

Table 5

OLS Estimates of

$$\Delta p_t - \Delta p_t^{LF} = \kappa + \alpha(L)\left(\Delta p_{t-1} - \Delta p_{t-1}^{LF}\right) + \beta g_t + \lambda_{my}\left(\Delta m_{t-1}^{LF} - \Delta y_{t-1}^{LF}\right) + \lambda_p \Delta p_{t-1}^{LF} + \varepsilon_t$$

Assuming a half-life of 9.2 Quarters

Regression	(1)	(2)
Dependent variable	$\Delta p_t - \Delta p_t^{LF}$	$\Delta p_t - \Delta p_t^{LF}$
Sample period	1980Q4-1990Q4	1991Q1-2001Q2
κ	-0.002	0.000
	(0.002)	(0.001)
	[0.331]	[0.959]
β	0.086	0.086
	(0.069)	(0.048)
	[0.221]	[0.083]
α_1	0.129	0.213
	(0.142)	(0.161)
	[0.371]	[0.194]
α_2	0.461	0.240
	(0.028)	(0.190)
	[0.001]	[0.214]
λ_{my}	2.309	0.195
	(0.552)	(0.484)
	[0.000]	[0.631]
λ_p	-2.705	-0.369
	(0.675)	(0.545)
	[0.000]	[0.502]
Adj. R-sq.	0.575	0.159

Notes: Standard errors in parentheses, p-values in brackets.

Table 6
Tests for Cointegration and Weak Exogeneity

Tests for Cointegration
Full sample: 1981Q3 – 2001Q2

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.227	23.954	15.41	20.04
At most 1	0.042	3.397	3.76	6.65

Notes: *(**) denotes rejection of the hypothesis at the 5% (1%) level
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels

First subsample: 1981Q3 – 1990Q4

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.310	18.290	15.41	20.04
At most 1 *	0.105	4.195	3.76	6.65

Notes: *(**) denotes rejection of the hypothesis at the 5% (1%) level
Trace test indicates 2 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level

Second subsample: 1991Q1 – 2001Q2

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.221	11.485	15.41	20.04
At most 1	0.023	0.971	3.76	6.65

Notes: *(**) denotes rejection of the hypothesis at the 5% (1%) level
Trace test indicates no cointegration at both 5% and 1% levels

Estimated Cointegrating Vector (std. err. in parentheses)

Sample	Full	First subsample	Second subsample
DMYF	1.000	1.000	1.000
DPF	-1.083	-1.157	-1.193
	(0.037)	(0.035)	(0.124)

Tests for Weak Exogeneity (std. err. in parentheses)

Sample	Full	First subsample	Second subsample
D(DMYF)	-0.275	-0.409	-0.240
	(0.060)	(0.190)	(0.078)
D(DPF)	0.026	0.256	-0.005
	(0.028)	(0.080)	(0.033)

Figure 1
Actual and the Low-Frequency Component of Inflation

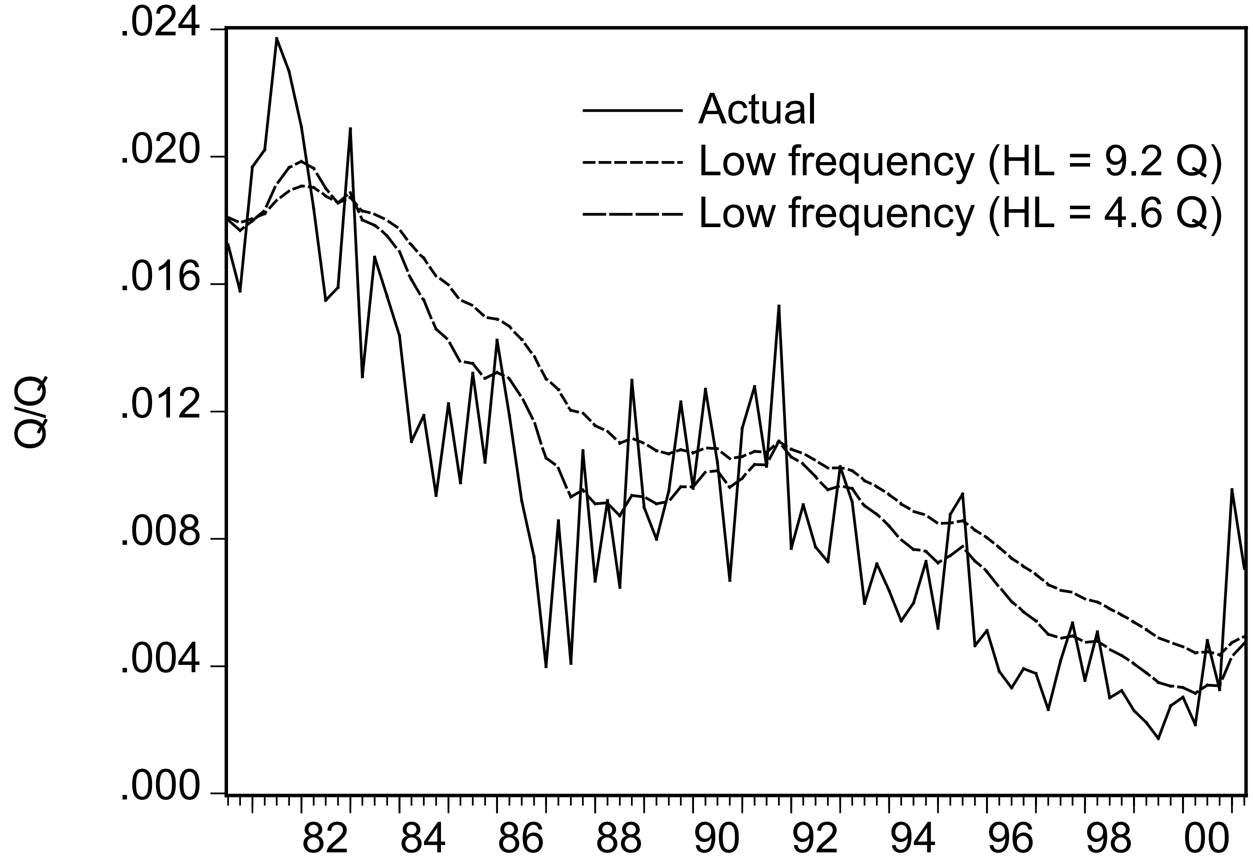

Figure 2
High-Frequency Inflation and the Output Gap

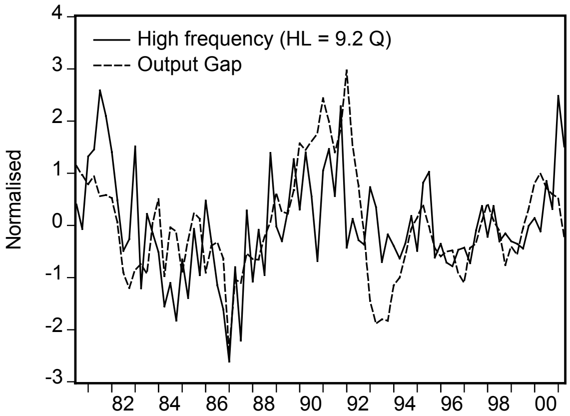

Figure 3
High-Frequency Inflation and the Output Gap

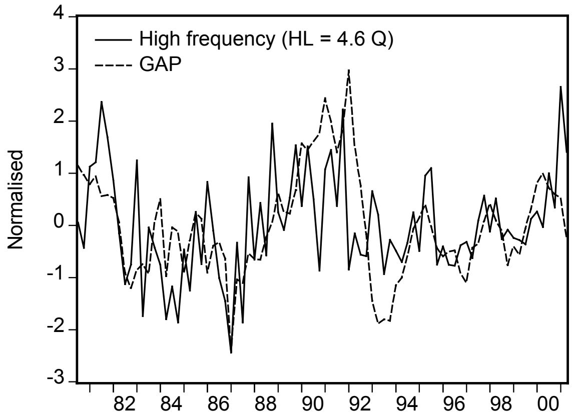

Figure 4
High-Frequency Inflation against Output Gap
(HL = 9.2 Q)

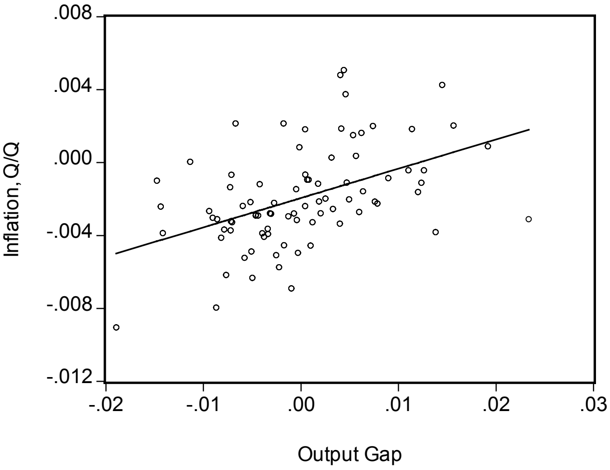

Figure 5
High-Frequency Inflation against Output Gap
(HL = 4.6 Q)

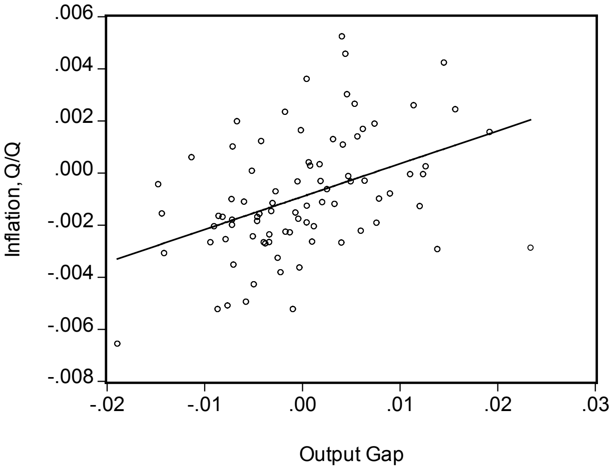

Figure 6
Inflation and Growth of Money Per Unit Output
Low-Frequency Components
(HL = 9.2 Q)

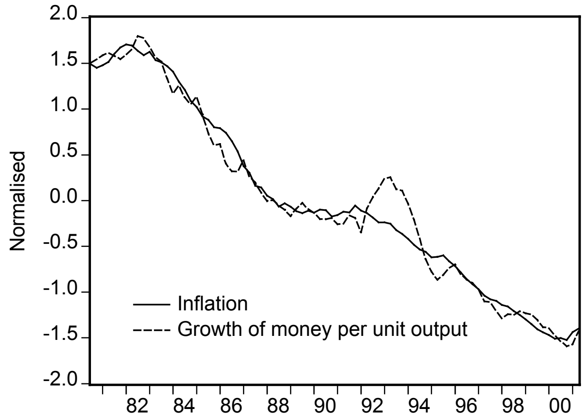

Figure 7
Inflation and Growth of Money Per Unit Output
Low-Frequency Components
(HL = 4.6 Q)

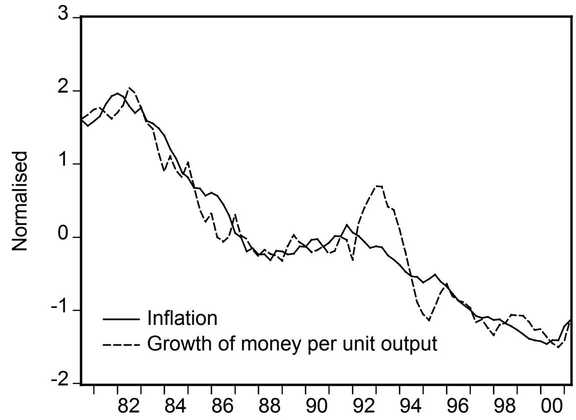

Figure 8
Inflation against Growth of Money Per Unit Output
Low-Frequency Components
(HL = 9.2 Q)

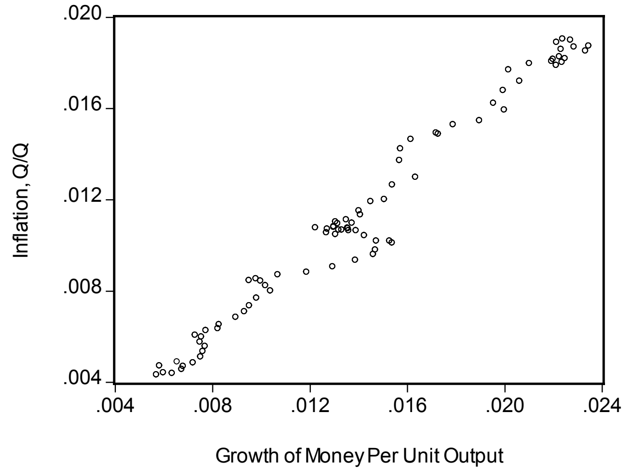

Figure 9
Inflation against Growth of Money Per Unit Output
Low-Frequency Components
(HL = 4.6 Q)