The European Central Bank's First Pillar Reassessed*

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Abstract

This paper studies the importance of money for inflation that is underlined by the first pillar of the European Central Bank's policy concept. I focus on the quantity-theoretic link from core money growth to core inflation and embed it in a Phillips curve. The core components are approximated by the Hodrick-Prescott filter. It is shown that the data from the euro area fit the model well since the mid 1980s. A major result is that the money-to-inflation link has not been weakened by the start of EMU. I also discuss the merits of replacing the reference value by a range.

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1. Introduction

The European Central Bank (ECB) has recently decided to review its two-pillar concept of monetary policy making by mid this year.[1] As is well known, the first pillar gives to money a very prominent role by putting the focus of analysis on the growth in money and credit aggregates and by providing a "reference value" for the growth of the broad money stock M3. The reference value is considered to serve as a guide towards achieving and maintaining price stability in the medium run. The second pillar is supposed to supplement the first by providing an "assessment of the outlook for price developments" that is based on a wide range of real and financial economic indicators.

The concept has been criticised by observers over recent years for various reasons. For example, one may wonder whether it provides an information gain if the analysis of macroeconomic developments is divided into two separate compartments when in reality there is a unified process. Moreover, from the very beginning many economists felt uncomfortable with the existence of two instead of a single pillar on the grounds that two pillars may make it easier for central bankers to rationalise arbitrary decisions. Most importantly, there is a tendency among central bankers and economists to ease money out of the picture and to replace it by the interest rate (King, 2002). To some extent the entrenched criticism of the two-pillar concept reflects an uneasiness among some academic economists with a central bank that does not give in to their demands for adopting inflation targeting but continues to provide to money a prominent role. For example, a small group of economists, that regularly writes an annual report for CEPR, complains that the first pillar clouds the ECB's communication strategy. To quote: "Sensibly, the second pillar is the real deal. So why not say so?"[2] In fact, the concept of inflation targeting has become more fashionable over recent years among central bankers and model builders. In a way, the criticism that instead of a money variable an inflation target is to be put into the forefront of central bank statements is a little disturbing, though, given that most central banks, and certainly the ECB, subject their policies to an inflation objective. Moreover, in his report on the policy concept of the central bank of New Zealand Svensson (2001) has argued convincingly that the best practice of inflation targeting these days is adopting a medium-run orientation rather than putting the focus more narrowly on a strict control of inflation in the shorter run.

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[1] See ECB (1999) for a description of the concept.

[2] Begg at al. (2002), p. 2.

On that account the Bundesbank of the 1990s as well as the ECB belong to the large family of inflation targeting central banks.

To be sure, there is no point in haggling over trade marks. The relevant issue is whether a central bank that considers price stability to be the overriding objective, like the ECB, should give prominent attention to the analysis of monetary aggregates in its internal assessment of the medium-run prospects of inflation as well as in its communication with the public, or whether this practice is misleading and needs to be ended. In fact, it is a defendable position to put the monetary analysis into the asides provided there is no link between money creation and the evolution of inflation or, more sensibly, if this link is less strong and stable than, say, the link between an administered interest rate and future inflation.[3]

In this paper I will not reassess the ECB's two-pillar concept but rather concentrate on the question whether the first pillar has been built on sand rather than a stable foundation. The answer to this question depends on whether inflation continues to be driven by the growth of the money supply, even under the conditions of EMU. A number of recent studies, e.g. Trecroci and Vega (2000), Nicoletti-Altamari (2001) and Gerlach and Svensson (2002), find that money has informational value for inflation. But it is open whether this implies a lot or little. For example, Gerlach and Svensson (2002) report that the real money gap has considerable predictive power while deviations of money growth from the ECB's reference value appear to carry no (extra-) information. In this paper I will show that money growth has acted as the dominant source of inflation, pre-EMU as well as in EMU. This suggests that pillar one need not be dethroned. A different issue is whether there is a more informative way of communicating the role of money to the public.

The paper proceeds as follows: section 2 presents a model of inflation where the main link from money to inflation is modelled trough inflation expectations, with the special twist that what counts is not actual money growth but the perceived core growth of money. The model is estimated with filtered data. The data are briefly characterised in section 3 while estimates of the model's inflation equation are presented in section 4. Whether the ECB should amend pillar one, will be discussed in section 5. Concluding remarks follow in section 6.

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[3] But note that a pure interest rate policy that neglects induced money creation requires to determine a reference value for the real rate of interest, i.e. that time-varying level that is neutral with respect to the inflation objective.

2. A Monetary Model of Core Inflation

A simple model of inflation builds on the Phillips curve and an explanation of expected inflation. To make the model a monetary one requires to establish a link between inflation expectations and the growth of the money supply by invoking the quantity theory of money.

Consider a backward-looking Phillips curve

$$(1) \qquad \pi_{t+1} = \pi^{e}_{t+1,t} + \alpha_1 \left(y_t - \overline{y}_t \right) + \varepsilon_{t+1}$$

where π_{t+1} denotes the rate of inflation, $\pi_{t+1,t}{}^{e}$ the expected rate given period t information, y_t the log of output, hence $y_t - \overline{y}_t$ the output gap, defined as the short-run percentage deviation of output from trend, and ε a white-noise shock. The Phillips curve (1) provides two potential channels for money to generate inflation. The first and dominant channel is inflation expectations that are driven by expected money growth. A second channel is the output gap. Though the latter is likely to be dominated by real demand shocks, nominal money shocks may also play a role.

In this paper, I focus exclusively on the role of expected money and treat the output gap as a predetermined variable. Following Gerlach and Svensson (2002) the expected rate of inflation is modelled adaptively. They assume that the expected future inflation rate depends on the policy makers' target rate of inflation and on the observed deviation of actual inflation from target. In contrast, I postulate that the expected rate of inflation is related to the perceived core rate of inflation, denoted by $\overline{\pi}$, and to the observed short-run deviation of actual inflation from the core rate:

$$(2) \qquad \pi^{e}_{t+1,t} = \overline{\pi}_t + \beta \left(\pi_t - \overline{\pi}_t \right), \quad \text{where} \quad 1 > \beta \geq 0$$

The core rate of inflation is a theoretical construct that abstracts from transient noise.[4] It can be defined as the equilibrium rate of price change that is perceived by the public to persist over a medium-run horizon in the absence of transitory shocks to aggregate demand and supply. The core rate may reflect the monetary authorities' official inflation target, in general though this will not be the case given that most central banks try to achieve conflicting goals.

To model the core rate, consider first the following demand function for the log of the real money stock $m_{r,t}$

$$
\text{(3)} \qquad m_{r,t} = \lambda_1 \bar{y}_t - \lambda_2 \left(\bar{r}^l - \bar{r}^s\right)
$$

$$
+\lambda_3 \left(y_t - \bar{y}_t\right) - \lambda_4 \left[\left(i_t^l - \bar{r}^l\right) - \left(i_t^s - \bar{r}^s\right)\right] + v_t
$$

where v_t is a white-noise money demand shock, i_t^l is a long-term interest rate and i_t^s is the short-term deposit rate; the respective real rates are denoted by $\bar{r}^l$ and $\bar{r}^s$. Following Calza et al. (2001) and Gerlach and Svensson (2002), I consider the spread between the long and the short rate as representing the opportunity cost of holding money.

The demand function decomposes total money demand into two components: a core demand, that is defined by the first two terms, and a transitional demand. The core demand collects the agents' responses to the perceived medium-term trends of real income and real interest rates. Since such trends change slowly, so does the core demand for money. The transitional demand, in contrast, may be rather volatile due to transitional fluctuations in real income and the yield differential as well as white-noise money demand shocks. Note that the response coefficients in the transitional component may differ from the respective coefficients in core demand.

Similarly, the (log of the) nominal stock supply of money can be decomposed into a core or permanent component $\bar{M}_t$ and a transitory component s_t

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[4] See Eckstein (1981) who introduced the idea of core inflation. To quote:" The core rate of inflation can be viewed as the rate that would occur on the economy's long-term growth path, provided the path were free of shocks, and the state of demand were neutral in the sense that markets were in long-run equilibrium." (p. 8).

(4) $$M_t = \bar{M}_{t-1} + \Delta\bar{M}_t + s_t .$$

The core component of money growth, $\Delta\ \bar{M}_t$, can be thought to collect the authorities' planned trend rate plus the impact of systematic responses to deviations of core inflation from target. The transitory component, s_t, reflect responses to temporary events - for example the accomodation of money demand shocks - as well as discretionary innovations. For the purpose of this paper, I abstain from specifying the authorities' reactions but treat the stock supply of money as policy-controlled, hence as a predetermined variable.

Given money demand (3) and money supply (4) I define the core price level as the price level that equilibrates the core or permanent components of supply and demand. Thus we have

(5) $$\bar{P}_t = \bar{M}_t - \lambda_1 \bar{y}_t + \lambda_2 \left(\bar{r}^l - \bar{r}^s\right)$$

and, consequently,

(6) $$\bar{\pi}_t = \Delta\bar{M}_t - \lambda_1 \Delta\bar{y}_t .$$

Core inflation responds one-to-one to core money growth in medium-run equilibrium for given trend growth of real income.

To derive the solution for the rate of inflation, it remains to combine (1), (2) and (6). This gives

(7) $$\pi_{t+1} = (1-\beta)\left[\Delta\bar{M}_t - \lambda_1 \Delta\bar{y}_t\right] + \beta\pi_t + \alpha\,(y_t - \bar{y}_t) + \varepsilon_{t+1}$$

The solution indicates that core money growth affects next period's rate of inflation with an impact coefficient below unity. Thus it takes time until a change in the core rate of money growth is fully transmitted into inflation. The long-run equilibrium impact is unity, of course. Though the solution is silent on the question of how transitory changes in the money supply affect the rate of inflation, it is obvious that the output gap provides a potential channel for transmission.[5] This will not be pursued in what follows because I focus on tracing the role of Hamlet.

The inflation equation can be estimated, provided empirical counterparts for the core or permanent components of money and output growth are developed. This will be done in the next section.

3. Decomposing the Time Series into Permanent and Transitory Components

Core inflation and the permanent components of money and real growth will be empirically approximated by estimates of the low frequency components of the respective time series. Lucas (1980) was the first to explore the relations between low frequency components of inflation, money growth and nominal interest rates by means of graphical analysis.[6] Decomposing time series into components of different frequency requires to apply a filter, and there is a great variety to chose from. For example, Cogley (2002) has explored simple exponential smoothing in an attempt to estimate core inflation in the US. He finds values for the smoothing parameter useful that imply a half-life of adjustment to a shock between fife and and nine quarters. Gerlach (2002) employs those filters in decomposing the rates of inflation and money growth in the Euro area, spanning the period 1980:1- 2001:2. He generally finds that the resulting low frequency components of money and real growth have substantial explanatory power with regard to inflation over the 1980s though not thereafter.[7]

A drawback of these filters is that they are one-sided, i.e. each estimated value depends on past data only.[8] As a result, the estimated permanent component of a variable will move above (below) the actual values of the variable as long as the variable declines (rises). This is an undesirable feature and can be avoided by employing the Hodrick-Prescott (HP) filter

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[5] Gerlach and Svensson (2002) replace the output gap in (1) by the real money gap.

[6] McCallum (1984) has criticised Lucas and warns that the co-movements of low frequency components do not generally reflect the long-run relationships between variables because the empirical decomposition may not map the expected - unexpected distinction.

[7] Note that Gerlach employs a filter to output that differs from the filters chosen for inflation and money growth. This may introduce bias into the empirical analysis.

[8] Gerlach prefers a one-sided filter on the argument that the policymaker needs to do the decomposition in real time, i.e. does not know the future realization that the two-sided filter needs in computing the decomposition for the current period.

(Hodrick and Prescott, 1981). This filter is widely used in business cycle research and has recently been employed for modelling inflation expectations (Orr et al., 1995; Martins and Scarpetta, 1999). But note that the HP filter, too, is not without drawbacks as it may detect spurious cycles and correlations.[9]

The HP filter minimizes the variance of a variable around its permanent component. Specifically, it estimates the permanent component $\overline{x}(t)$ of a variable x (t) by minimizing

$$(8) \qquad \sum_{t=1}^{T}(x_t - \overline{x}_t)^2 + \lambda \sum_{t}^{T-i}\left[(\overline{x}_{t+1} - \overline{x}_t)\,(\overline{x}_t - \overline{x}_{t-1})\right]^2 .$$

The smoothness of the permanent component depends on the choice of the penalty parameter λ . To avoid the creation of spurious correlations between the variables investigated, they will have to be subjected to the same parameter value. It is common to set λ at the value 1,600 for quarterly data and this will be done below. There is quite some discussion in the literature on measuring the business cycle on whether the values for parameter λ, as suggested by Hodrick and Prescott for the filtering of annual, quarterly or monthly data, are informative or misleading (Maravall and del Rio, 2001). Without going into the details of that discussion, it is advisable in any case to check for robustness of the econometric estimates presented below by exploring alternative values of the penalty parameter.

The data used cover the euro area (of 11 countries) and span the period 1980:1 to 2002:4. Three time series are selected: the money stock M3, the harmonised consumer price index and gross domestic product (in prices of 1995). Before applying the HP filter to these series, the data were transformed into annualised quarterly rates of change. The time series of the rates of growth of money stock M3 and of gross domestic product were adjusted to take account of jumps in the years 1990 and 2001 that reflect the inclusion of former East-Germany and of Greece, respectively. Finally, the data were seasonally adjusted and thereafter filtered.

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[9] See Ahumada and Garegnani (1999) for a discussion. Ash et. al. (2002) claim that Hodrick-Prescott frecasts may be weakly rational.

As an example for what the chosen HP filter achieves consider Figure 1. It shows the time series of the annualised quarterly inflation rates and the computed trend component which I treat here as the empirical counterpart of the theoretical construct of 'core inflation'. The general characteristic of the HP filter is that the computed trend component comes close to what the researcher would draw by hand through the plot of the realisations. Table 1 provides summary information about the computed core and transitory components of the three time series under investigation, differentiating three sub-periods. Note that for each subperiod the transitory component of each variable averages close to zero but exhibits serial correlation, as can be read from the Box-Ljung statistic. The serial correlation is significant for transitory money growth and transitory inflation. It is close to significance in the case of transitory output growth.

4. Estimating the Inflation Equation

The model of section 2 implies that the rate of inflation is driven by core inflation and core inflation, in turn, by the permanent component of money growth for a given trend rate of output growth.

It is instructive to check first by a direct inspection of the data whether the conjectured relationship may exist. Figure 2 shows how the core components of inflation and M3 growth have developed since the early 1980s. The immediate visual impression is that core M3 growth has been a leading indicator of core inflation. The money series shows a local trough in 1986:3; it was followed by a trough in the inflation series in 1987:4. Another local M3 trough happened in 1996:4 and was followed by an inflation trough in 1998:3. Finally, we find a local peak in M3 growth in 1989:1, followed by a local peak of core inflation in 1991:2. The apparent lags between the turning points of core money growth and resulting inflation have not been constant but varied between 5 and 9 quarters.

Figure 3 highlights the relationship from a different angel. It is a scatter diagram that plots the relation between core money growth and concurrent core inflation.[10] The diagram shows in an impressively clean fashion that the core components of the two variables have moved together in a systematic fashion. The total period 1980 –2002 can be differentiated into three regimes. The first regime comprises the pronounced disinflation period 1980-85 when core inflation fell by about seven percentage points while core money growth declined by roughly two percentage points. The second regime lasted from 1986 until the end of 1998 when the Bundesbank handed monetary policy over to the ECB. During this second regime, core money growth declined by about three percentage points and core inflation by two percentage points. Finally, the ECB started the third regime. Until late 2002 core money growth has risen by two percentage points while core inflation by about one percentage point. Note that the steepness of the positive inflation-money slope is the same under the second and the third regime though the levels differ. This suggests for estimation that it is advisable to disregard the early 1980s. Consequently, I estimate the inflation equation for the sample period 1986 – 2002.

Core money drives core inflation, that is what Figure 2 suggests. The observation can be made more precise by testing for Granger causality; see the upper panel of Table 2. There we find for the 1990s and for the extended period 1986 – 2002 that the null hypothesis of no Granger causation can be rejected for up to three lags in both directions, money to inflation as well inflation to money. This was to be expected, given that we examine the relationships between smooth low-frequency components. However, starting with four lags the inflation to money chain looses significance while the money to inflation chain remains valid. This confirms the inflation model: permanent money growth causes inflation. So much for the dependencies between the core components.

Next consider the question of causal links between the volatile transitory components of M3 growth and inflation. The suggestive Figure 4 and the tests for Granger causation in the bottom panel of Table 2 essentially tell the same story: there is no significant relationship detectable over the first six quarters. Why this is so, may need some reflection. But note that my core model of inflation does not imply that such a link must exist.

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[10] The reader is invited to inspect Figure 3A for comparison where instead of the core components the realisations of M3 growth and of inflation are plotted. The comparison highlights the usefulness of the proposed decompositions of the data.

Now let us turn to the estimates of the inflation equation. Two sample periods are studied. The first sample period covers the pre-EMU period that ended in 1998, the second sample period includes in addition the first four years of EMU. All regressions contain the rate of change of the world market price of petrol as an additional regressor. For each regression four diagnostic tests are offered: the Box-Ljung Q-test that there is no autocorrelation up to order 4, the ARCH LM test that there is no autoregressive conditional heteroskedasticity up to order 4 in the residuals, the Jarque-Bera test of normality and White's test for heteroskedasticity. In all cases where the null hypothesis is rejected by the White statistic at a significance level of at least 10 %, White's heteroskedasticity consistent covariance estimator is used to correct the standard errors.

Consider the first regression in Table 3. Based on equations (1) and (2) it explains current inflation as a function of lagged core inflation and the lagged output gap. The estimate is significant, not troubled by serial correlation and displays homogeneity of degree one. While the point estimate for the core inflation rate is 0.7, the long-run impact equals unity. Regression 1 serves as a benchmark for the estimates of inflation equation (7). Accordingly, in regression 2 the core inflation rate is replaced by the core rates of M3 growth and real growth. Alternatively, one may restrict the income elasticity of money demand, denoted by λ_1 in inflation equation (7), to one as in regression 3. In both cases, we find that our model of inflation is not rejected by the data for the pre-EMU period. Extending the sample period to include EMU leads to similar results, regressions 4 – 6, though the coefficients change somewhat and the overall degree of explanation, as measured by the adjusted coefficient of determination, is lower.

The start of EMU in 1999 constituted a regime change and has given rise to the fundamental question whether the impact of core money growth on inflation has changed under the conditions of EMU and if so in which way. While a comparison of regressions 2 and 4 of Table 3 suggest that the money-inflation link may have weakened after 1998, the conjecture is not supported by regressions 3 and 6. A straightforward test of the potential impact of EMU is including a dummy variable that takes the value zero until the end of 1998 and the value one thereafter. This is done in regressions 1, 2 and 4 of Table 4. Not unexpectedly, the dummy EMU does not enter significantly if as in regression 1 inflation is regressed on core inflation rather than on money growth. However, when core inflation is replaced by core money growth, regressions 2 and 4, the EMU dummy shows up significantly and with a negative sign. What this says is: under the conditions of EMU the impact of inflation on monetary policy has apparently declined. If true, the question will be by how much the ECB will have to revise its reference value for medium-term money growth upward. After all, the reference value was invented in 1998, at a time when for lack of experience nobody could forecast this suggested loss of impact on inflation.

But, in fact, any such conclusion as regards the conditioning role of EMU would be premature because it can be shown that the dummy variable EMU is irrelevant. Consider regressions 3 and 5 of Table 4. They differ from regressions 2 and 4 by including as an additional regressor a variable S. The new variable enters significantly and carries a negative sign, too. At the same time it takes away the statistical significance from the EMU dummy. Technically speaking, the explanatory power of the regressions can be raised by dropping the EMU dummy in favour of the new variable S.

The variable S is a dummy that takes the value zero until mid 2001 and the value one thereafter. Thus it differs from the dummy EMU by postulating that a change of the inflation equation has not been generated by the start of the currency union in 1999 but by events that have occurred much later, namely in the fall of 2001. In fact, since the tragic events of September 11, 2001 we are living through a period of world-wide high uncertainty and a protracted loss of confidence among consumers and investors. In such periods it is likely that the agents' preference for liquidity rises, hence the velocity of money falls by more than usual. Figure 5 confirms this conjecture: starting the third quarter of 2001 the annual rate of velocity change fell strongly, from minus 2 to minus 5 %. The significant dummy S picks up this dramatic rise of money demand that most likely reflects spreading uncertainty.

On this interpretation the effectiveness of monetary policy as regards inflation has not been changed by the EMU regime. This can further be tested for by separating the effects of core money growth on inflation between the pre-EMU period and the EMU period. This is done in Table 5. There we learn from regressions 2 and 3 that the estimated impact coefficients of core money growth do not significantly differ between the pre-EMU and the EMU period. The respective point estimates are 0.62 and 0.66 in regression 2, and 0.56 and 0.61 in regression 3. So, monetary policy has remained intact.

Finally, it needs to be checked whether the estimates are robust with respect to the used definition of the HP filter. So far the penalty parameter λ has been set at the value 1,600 because this value is used in the literature in most applications of the HP filter. To check for robustness I chose as alternatives the values 800 and 2,400 and filter money growth, output and output growth accordingly. The resulting regressions 1 to 4 of Table 6 are to be compared to regressions 2 and 3 of Table 5. Surprising, as it may be, there is no need to discuss the alternative estimates in detail. The new regressions are not much different.[11] Again we find that the advent of EMU has not effected a change in the fundamental money to inflation relationship. In fact, it is consoling to learn that the evidence does not crucially depend on the chosen penalty parameter of the HP filter.

In sum, the evidence presented in this paper endorses the view that the switch from national monetary policies to the centralised monetary policy run by the ECB has not changed the basic relation between money growth and inflation. Core money growth remains the dominant source of inflation. While the estimates do not rule out that the output gap, too, contributes to inflation, it is a minor factor in comparison, given that it equals zero on average. The excessive money growth since fall 2001, finally is likely to reflect an increased preference for liquidity that is accommodated by the ECB. The estimates suggest that about 1.2 to 1.4 percentage points of money growth account for that.

5. A Reference Range or a Floating Reference Value?

At the start of EMU the ECB had announced a reference value for medium-term M3 growth of 4.5 % per annum. Since then the reference value has been reassessed annually but never been changed. Thus, the ECB's reference value has become an institution and as such come under attack by a number of academics and bank economists. The main arguments are: (i) a central bank does not need to define, let alone announce, a reference value for money growth, to be able to control inflation over the medium run; (ii) since the start of EMU the growth rate of M3 has exceeded for most of the time the reference value without inducing serious inflation.

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[11] But note that the HP filter with ? = 2,400 performs marginally less satisfactory, presumably because it flattens the ups and downs of the time series by too much.

As regards the *first* argument, it is to be noted that - while correct - the argument does bypass the fact that evaluating core money growth against the yardstick provided by the reference value generates valuable information on the inflation trend. The evidence presented in this paper confirms for the conditions of EMU that core inflation continues to be a monetary phenomenon and as such is crucially shaped by the trend rate of money growth, while actual inflation moves around trend, depending on short-run developments of aggregate demand and supply.

As regards the *second* argument, the derivation of the reference value needs to be examined. Using the quantity equation, the ECB defines the reference value as the sum of a normative rate of inflation ("less than 2 percent"), the trend growth rate of GDP, and the trend rate of change of the velocity of M3 (multiplied by minus one). The ECB sets the trend rate of GDP growth in the range of 2 - 2.5 % and the trend velocity decline in the range 0.5 - 1 % each year. Suppose one takes the means of these ranges, then the reference value of 4.5 % reveals that the ECB's true normative rate of inflation equals 1.5 %.[12]

The derived normative inflation rate fits the ECB's practice of identifying the state of price stability with an inflation rate of less than 2 % on the assumption that the ECB has an inflation range of 1 - 2 % in mind. If one adds the ECB's assumptions about the ranges of trend GDP growth and trend velocity decline, one arrives at a reference range for money growth of 3.5 - 5.5 %.

It seems that the announcement of this reference range would serve as a more helpful communication device than the announcement of a single value. The range would permit to signal to the public that there is uncertainty about the exact future relation between trend money growth and inflation. If one checks past actual M3 growth, one finds that for most of the time it was inside the above range even though for most of the time close to the upper border.[13] From the beginning the ECB has rejected the idea of a reference range on the argument that a range "might be falsely interpreted" as implying that the ECB will automatically adjust interest rates when money growth moves outside the announced

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[12] Note that a measured inflation rate of about 1 % reflects true zero inflation.

[13] Similarly, inflation has moved well above the ECB's normative value for most of the time.

range.[14] In fact, announcing a range would not force the ECB to "automatically" take action though it would call for an explanation why a violation of the reference range should be tolerated. While the demand for such transparency puts a burden on the ECB, it is not very demanding when a wide reference range is chosen.

But suppose the ECB will again reject the idea of a reference range. Then the question will be whether the ECB's assumption as regards the medium-run decline of the velocity of M3 is still justified. From Figure 5 can be read that the annual trend rate of decline, implied by the HP filter used in this paper, has gradually moved over time from – 0.5 % in 1998 to about –1.2 % last year. This suggests that the reference value has been generous in the past but has become too low, meanwhile due to the uncertainty-induced upward shift in liquidity preference. The observation invites the question whether perceived changes in the velocity's trend rate of decline should be taken into account each year.

To be sure, if the ECB would announce each year a very different reference value on the argument that the perceived trend rate of velocity had changed, it is likely to endanger its credibility, if the velocity assumption cannot easily be checked by outside observers. But suppose the ECB announces a rule-of-thumb of how it calculates the perceived trend rate of velocity change from past observations, then the practice of annually adjusting the reference value must not generate a credibility loss.

Suppose, for example, the reference value is re-examined towards the end of each year and that at that time the ECB knows the values of GDP for the first two quarters only. Under those conditions the ECB can compute the past velocity values up to mid-year, apply the HP filter and compute the arithmetic mean of the growth rates of the last four quarters. If the ECB had followed this practice, the bank would have computed the reference values printed in Table 7 though real time data might have made a little difference. For the years 1999 and 2002, the reference value would have been closer to 4 than to 4.5 %, for 2003 closer to 5 %. Of course, the procedure has the drawback that thethe reference value is affected by the most recent observations that impact strongly on the filtered values. But it needs to be acknowledged that much depends on how far backward-looking the procedure for estimating the trend rate of velocity change is chosen. For example the last eight quarters might be used for computing the mean values instead of the last four quarters. The problem

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[14] See ECB (1999), p. 49.

is that there is no unique approach available. As a consequence, any attempt at forecasting annual changes in trend velocity is likely to invite criticism. This suggests that keeping a single, though floating reference value does not have merits over the alternative discussed above of announcing a stable reference range. Replacing the reference value by a range would permit to convey the interpretation that maintaining price stability does not require that money growth hits a unique number but just that it does not permanently exceed the reference range.

6. Summary and Conclusions

Pillar one of the ECB's monetary policy concept gives prominent attention to the role of money. This paper provides a consistent theoretical and empirical analysis of how inflation is determined by money growth. Combining the Phillips curve with the quantity theory of money, it is shown that inflation is driven by core inflation, and core inflation, in turn, by permanent money growth. In the empirical implementation the Hodrick-Prescott filter is used to approximate the permanent components of inflation as well as of money and real growth. A major result is that the growth of money stock M3 has been the dominant source of inflation during the pre-EMU period 1986 - 98 and has remained so well into EMU. The result proves robust with respect to different specifications of the HP filter.

While the paper lends support to the ECB's view on the importance of money growth for inflation, it also discusses the usefulness of communicating a unique reference value for money growth to the public. A conclusion is that replacing the reference value by a reference range is an option that must not be ruled out.

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Table 1: Filtered Data

		1980 : 1	**1991 : 1**	**1986 : 1**
		1990 : 4	**2002 : 4**	**2002 : 4**
$\bar{p}$:	mean	5.60	2.43	2.71
	St. D.	2.72	0.75	0.78
$\triangle\bar{\mathbf{M}}$:	mean	8.61	5.50	6.23
	St. D.	0.84	0.99	1.41
$\triangle\bar{\mathbf{y}}$:	mean	2.09	1.94	2.18
	St. D.	1.16	0.44	0.40
$p - \bar{p}$	mean	- 0.03	0.03	- 0.05
	St. D.	0.93	0.88	0.91
	Q_4	21.4 **	1.46	11.6 **
		(0.00)	(0.83)	(0.02)
$\triangle\mathbf{M} - \triangle\bar{\mathbf{M}}$	mean	0.04	- 0.04	- 0.01
	St. D.	1.45	2.05	1.87
	Q_4	16.3 **	16.3 **	22.5 **
		(0.00)	(0.00)	(0.00)
$\triangle\mathbf{y} - \triangle\bar{\mathbf{y}}$	mean	0.13	- 0.11	- 0.01
	St. D.	2.16	1.57	1.93
	Q_4	6.7	6.9	3.0
		(0.15)	(0.14)	(0.56)

Note: Q_4 = Box-Ljung statistic at lag 4.

Table 2: Granger Causality Tests: Probabilities

	Lags					
	1	2	3	4	5	6
$\triangle\bar{p}$ ® $\triangle\bar{\mathbf{M}}$						
1980:1 - 1990:4	0.00	0.00	0.03	0.04	0.10	0.04
1991:1 - 2002:4	0.00	0.00	0.00	0.38	0.32	0.24
1986:1 - 2002:4	0.00	0.00	0.02	0.12	0.19	0.30
$\triangle\bar{\mathbf{M}}$ ® $\triangle\bar{p}$						
1980:1 - 1990:4	0.00	0.00	0.01	0.01	0.06	0.09
1991:1 - 2002:4	0.00	0.00	0.00	0.00	0.00	0.01
1986:1 - 2002:4	0.00	0.00	0.00	0.00	0.00	0.00
$p - \bar{p}$ ® $\triangle\mathbf{M} - \triangle\bar{\mathbf{M}}$						
1980:1 - 1990:4	0.52	0.64	0.51	0.30	0.50	0.59
1991:1 - 2002:4	0.97	0.65	0.59	0.77	0.85	0.93
1986:1 - 2002:4	0.66	0.45	0.39	0.29	0.37	0.52
$\triangle\mathbf{M} - \triangle\bar{\mathbf{M}}$ ® $p - \bar{p}$						
1980:1 - 1990:4	0.08	0.25	0.34	0.34	0.43	0.47
1991:1 - 2002:4	0.71	0.91	0.91	0.77	0.81	0.78
1986:1 - 2002:4	0.78	0.92	0.85	0.85	0.72	0.73

Note: ® = … does not Granger cause …

Table 3: Inflation and the Output Gap

	1986:1 - 1998:4			1986:1 - 2002:4		
Regression No.	**1**	**2**	**3**	**4**	**5**	**6**
$\bar{p}_{-1}$	0.70 ** (0.15)			0.98 ** (0.04)		
$\Delta \bar{M}_{-1}$		0.50 * (0.19)			0.38 ** (0.13)	
$\Delta \bar{y}_{-1}$		– 0.56 * (0.36)			- 0.27 (0.25)	
$\left(\Delta \bar{M} - \Delta \bar{y}\right)_{-1}$			0.46 ** (0.10)			0.45 ** (0.09)
p_{-1}	0.29 * (0.13)	0.32 * (0.14)	0.34 * (0.13)		0.32 ** (0.11)	0.32 ** (0.11)
$\left(y - \bar{y}\right)_{-1}$	0.28 * (0.10)	0.18 (0.13)	0.20 (0.12)	0.37 ** (0.10)	0.20 (0.12)	0.18 (0.13)
Δp^{petrol}_{-1}	0.008 ** (0.003)	0.006 (0.003)	0.007 (0.005)	0.008 ** (0.002)	0.007 ** (0.002)	0.006 (0.003)
$\bar{R}^2$	0.59	0.58	0.58	0.54	0.46	0.46
DW	1.89	1.95	1.96	1.63	2.00	1.98
			p-values:			
Q_4	0.97	0.89	0.88	0.51	0.25	0.30
ARCH$_4$	0.83	0.75	0.74	0.86	0.27	0.13
Normality	0.07	0.20	0.09	0.72	0.23	0.56
White	0.06	0.11	0.61	0.01	0.10	0.88

Note: Q_4 = probability of Box-Ljung statistic at lag 4.

Table 4: Testing for Effects of EMU

Regression No.	**1**	**2**	**3**	**4**	**5**
$\bar{p}_{-1}$	0.97^{**} (0.04)				
$\Delta\bar{M}_{-1}$		0.32^{**} (0.11)	0.53^{**} (0.13)		
$\Delta\bar{y}_{-1}$		-0.44^{*} (0.22)	-0.88^{**} (0.32)		
$\left(\Delta\bar{M} - \Delta\bar{y}\right)_{-1}$				0.31^{**} (0.11)	0.45^{**} (0.12)
p_{-1}		0.18 (0.12)	0.09 (0.12)	0.21 (0.12)	0.16 (0.12)
$\left(y - \bar{y}\right)_{-1}$	0.37^{**} (0.10)	0.37^{*} (0.14)	0.32^{**} (0.10)	0.36^{*} (0.14)	0.29^{*} (0.14)
Δp^{petrol}_{-1}	0.007^{*} (0.002)	0.009^{*} (0.003)	0.006^{**} (0.007)	$.009^{*}$ (.003)	0.007^{*} (0.003)
Const.		1.37^{*} (0.63)	1.30^{*} (0.60)	1.06^{*} (0.44)	0.58 (0.47)
EMU	0.07 (0.23)	-0.72^{*} (0.30)	- 0.08 (0.29)	-0.67^{*} (0.29)	- 0.14 (0.36)
S			-1.63^{**} (0.60)		-1.21^{*} (0.50)
$\bar{R}^2$	0.54	0.50	0.56	0.51	0.54
DW	1.64	1.91	1.84	1.93	1.89
p-values:					
Q_4	0.51	0.62	0.69	0.56	0.55
$ARCH_4$	0.82	0.50	0.66	0.51	0.60
Normality	0.71	0.28	0.48	0.15	0.12
White	0.01	0.10	0.01	0.68	0.65

Note: *EMU* is a dummy variable taking the value one starting 1999:1. - *S* is a dummy variable taking the value 1 starting 2001:3.

Table 5: Shift in the Preference for Liquidity

Regression No.		**1**	**2**	**3**
$\bar{p}_{-1}$	**1986 - 98**	0.97^{**} (0.04)		
	1999 - 02	1.01^{**} (0.12)		
$\Delta\bar{\mathbf{M}}_{-1}$	**1986 - 98**		0.62^{**} (0.15)	
	1999 - 02		0.66^{**} (0.18)	
$\Delta\bar{\mathbf{y}}_{-1}$			-0.71^{*} (0.29)	
$\left(\Delta\bar{\mathbf{M}} - \Delta\bar{\mathbf{y}}\right)_{-1}$	**1986 - 98**			0.56^{**} (0.08)
	1999 - 02			0.61^{**} (0.12)
p_{-1}			0.18 (0.11)	0.19 (0.11)
$\left(\mathbf{y} - \bar{\mathbf{y}}\right)_{-1}$		0.37^{**} (0.10)	0.18 (0.10)	0.20 (0.12)
$\Delta\mathbf{p}^{\mathbf{petrol}}_{-1}$		0.007^{*} (0.002)	0.005^{*} (0.002)	0.006 (0.003)
S			-1.73^{*} (0.69)	-1.56^{*} (0.59)
$\bar{\mathbf{R}}^2$		0.54	0.53	0.54
DW		1.64	1.87	1.88
		p-values:		
$\mathbf{Q}_4$		0.51	0.64	0.60
$\mathbf{ARCH}_4$		0.82	0.60	0.56
Normality		0.72	0.64	0.38
White		0.01	0.03	0.50

Note: *S* is a dummy variable taking the value one starting 2001:3.

Table 6: Robustness

Regression No.		**1** **HP-800**	**2** **HP-2,400**	**3** **HP-800**	**4** **HP-2,400**
$\Delta\bar{\mathbf{M}}_{-1}$	1986 - 98	0.62^{**}	0.65^{**}		
		(0.14)	(0.17)		
	1999 - 02	0.66^{**}	0.70^{**}		
		(0.17)	(0.21)		
$\left(\Delta\bar{\mathbf{M}} - \Delta\bar{\mathbf{y}}\right)_{-1}$	1986 - 98			0.59^{**}	0.56^{**}
				(0.08)	(0.08)
	1999 - 02			0.67^{**}	0.59^{**}
				(0.12)	(0.12)
$\Delta\bar{\mathbf{y}}_{-1}$		-0.65^{**}	-0.80^{*}		
		(0.25)	(0.35)		
$\left(\mathbf{y} - \bar{\mathbf{y}}\right)_{-1}$		0.20	0.25^{*}	0.21	0.27^{*}
		(0.11)	(0.09)	(0.14)	(0.11)
$\Delta\mathbf{p}_{-1}^{\mathbf{petrol}}$		0.006^{*}	0.006^{**}	0.006	0.007
		(0.002)	(0.002)	(0.003)	(0.003)
p_{-1}		0.14	0.17	0.14	0.19
		(0.12)	(0.11)	(0.12)	(0.11)
S		-1.34^{*}	-1.10^{*}	-1.35^{*}	- 0.93
		(0.59)	(0.60)	(0.56)	(0.54)
$\bar{\mathbf{R}}^2$		0.55	0.53	0.56	0.54
DW		1.86	1.89	1.86	1.91
			p-values:		
$\mathbf{Q}_4$		0.61	0.57	0.61	0.52
$\mathbf{ARCH}_4$		0.53	0.51	0.52	0.48
Normality		0.70	0.58	0.62	0.26
White		0.02	0.06	0.22	0.78

Note: HP denotes the Hodrick-Prescott filter, and the number is the value chosen for the penalty parameter.

Table 7: The Reference Value for M3 Growth

$\triangle\bar{M}^{Ref} = p^{*} + \triangle\bar{y} - \triangle\bar{V}$, **where:** $p^{*} = \mathbf{1.5}$; $\triangle\bar{y} = \mathbf{2.25}$.

for	**Medium-term velocity assumption** $\triangle\bar{V}_4$	**Implied reference value** $\triangle\bar{M}_4^{Ref}$
1999	- 0.41	4.16
2000	- 0.67	4.42
2001	- 0.65	4.40
2002	- 0.32	4.07
2003	- 1.06	4.81

Figure 1: Inflation and Its HP Component

Annualized quarterly rates

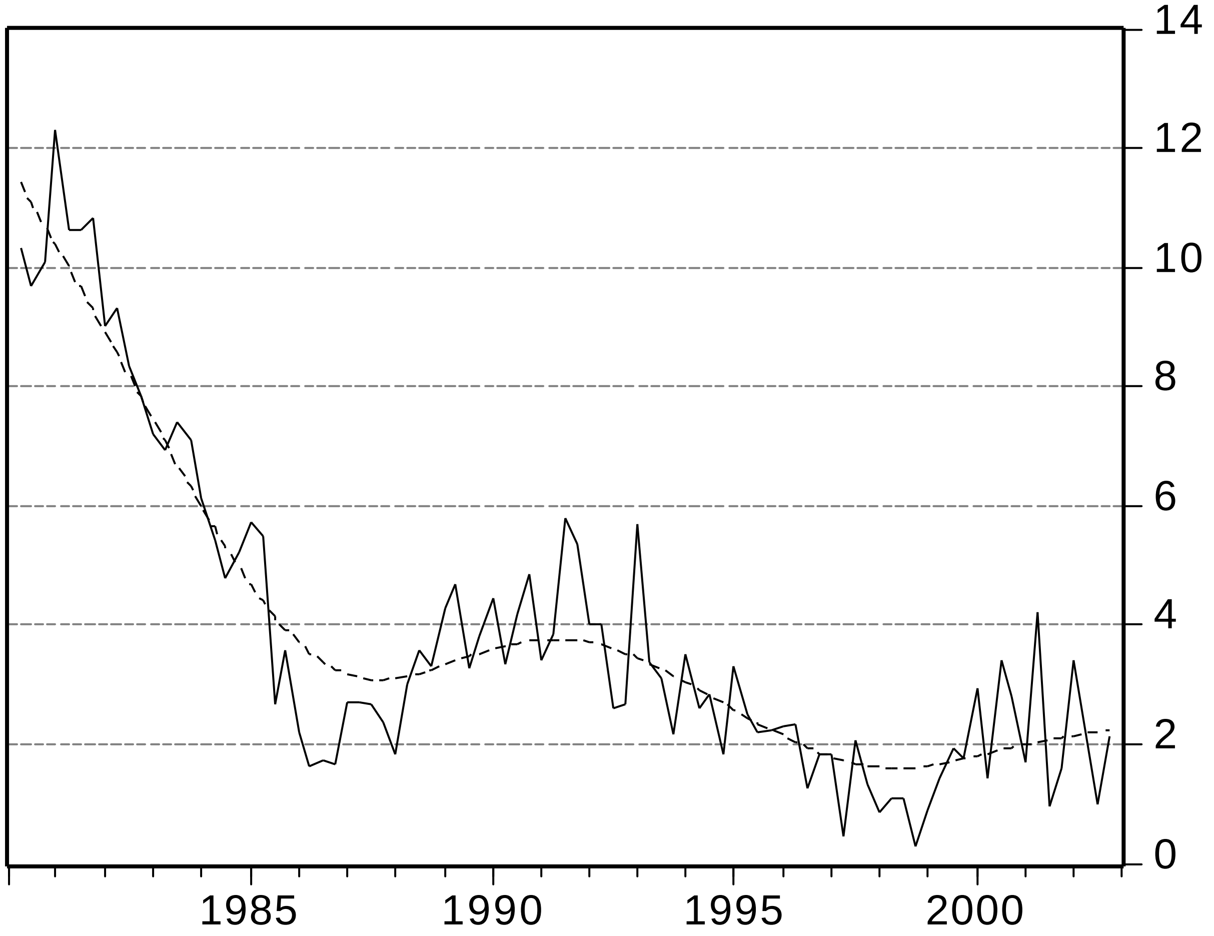

Figure 2: Core Inflation and Core M3-growth

Annualized quarterly rates of change

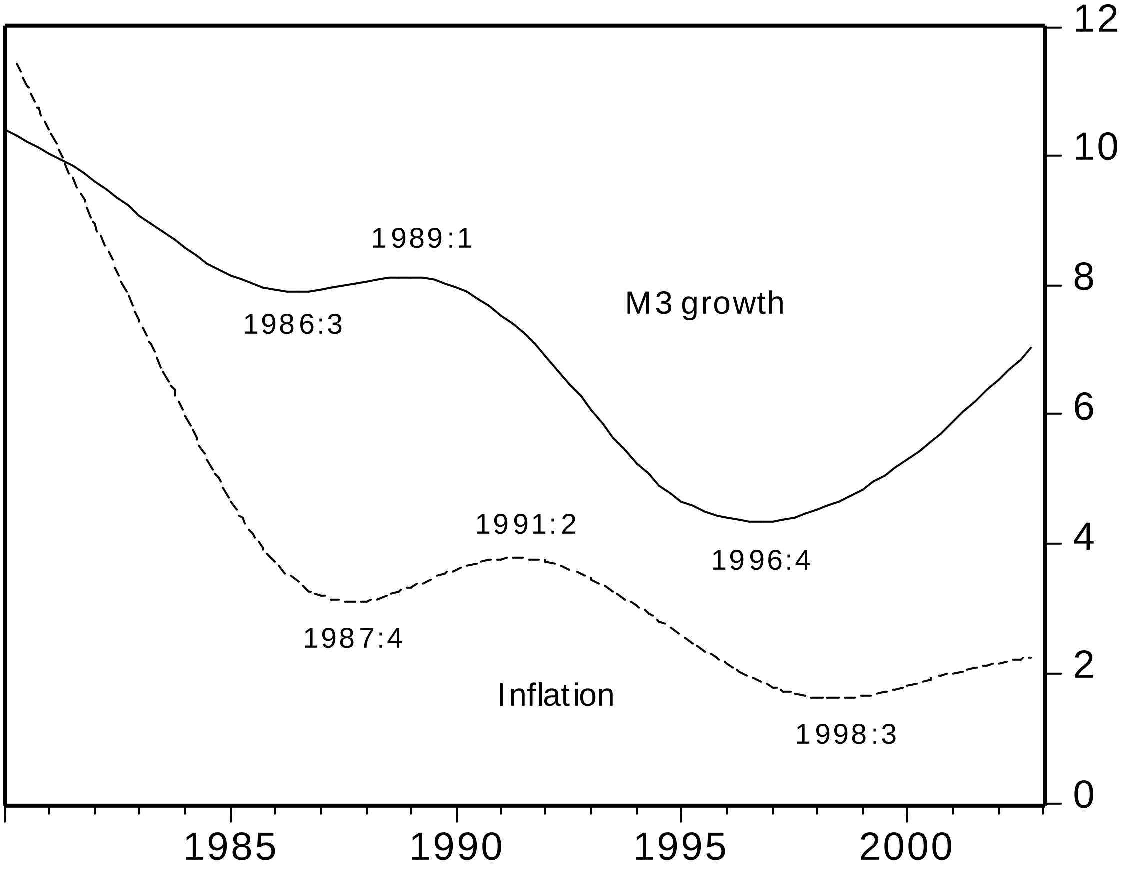

Fig. 3: Core Inflation and Core M3 Growth: 1980 - 2002

Annualized quarterly rates of change

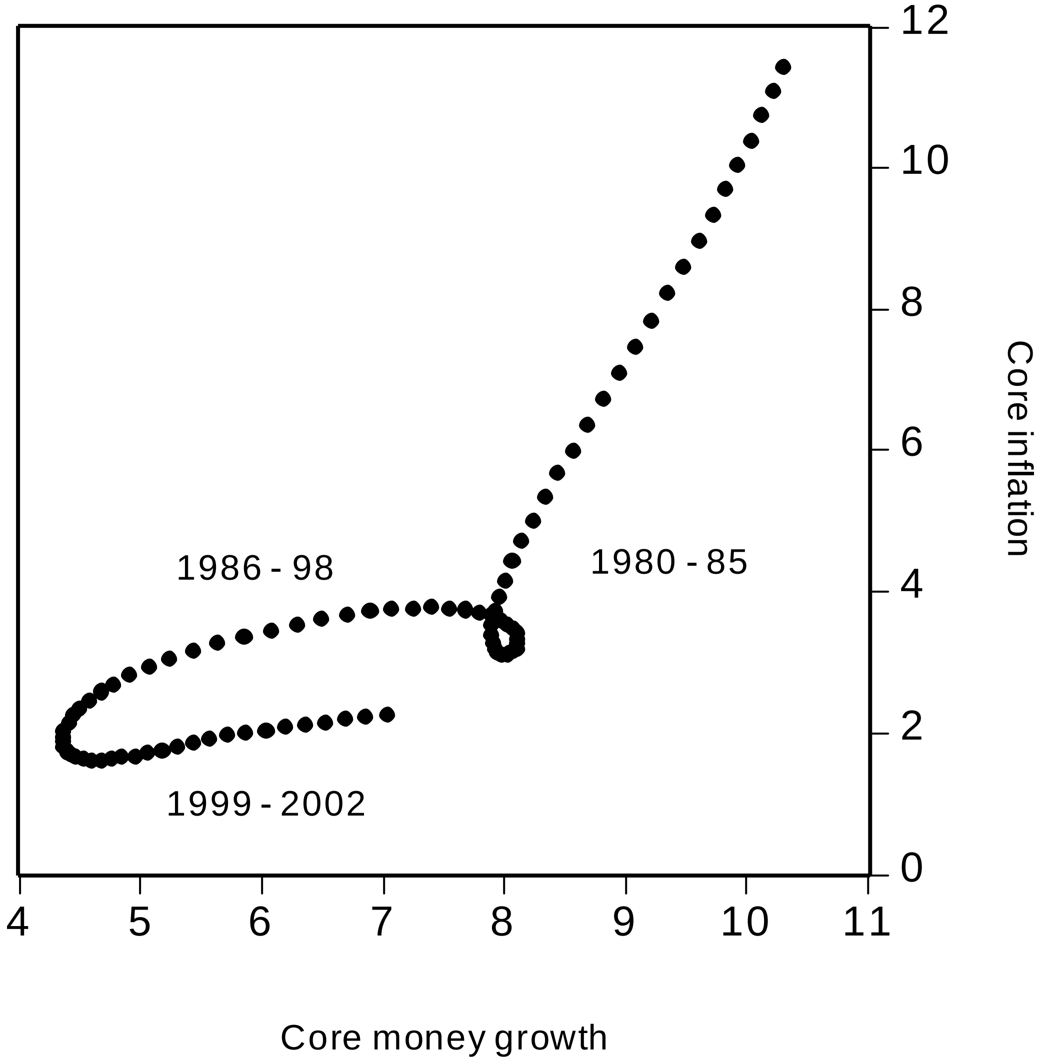

Fig. 4: Transitory Components of Inflation and M3 Growth

1986 - 2002

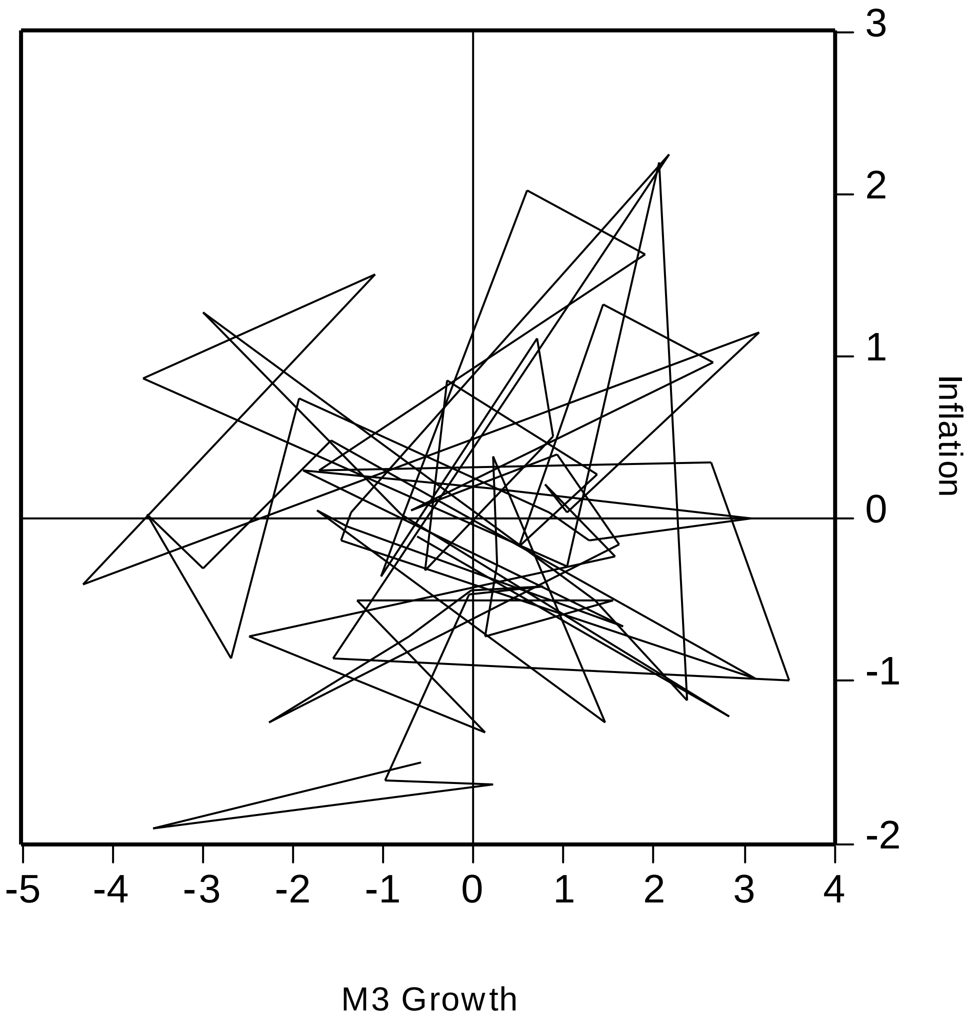

Fig. 5 : Annual Growth of M3 Velocity