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Is M3 An Appropriate Aggregate for Guiding ECB Monetary Policy?

LEIGH DRAKE* AND TERENCE C. MILLS

DEPARTMENT OF ECONOMICS,
LOUGHBOROUGH UNIVERSITY,
LOUGHBOROUGH,
LE11 3TU
UK

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Abstract

This paper utilises an approach to long run modelling proposed by Pesaran, Shin and Smith (2001) to develop empirically weighted broad monetary aggregates for the Euro area. Two alternative aggregates are derived based upon the long run relationship between the M3 component assets and nominal income or prices respectively. The empirical results do not support the use of M3 as the key monetary indicator, as both aggregates accord a very low, or zero weight, to the broadest of the M3 component assets. The implied optimal weights are very different from those that would be implied by either simple sum or Divisia aggregation. Furthermore, recursive estimation reveals that the optimal weights do evolve over time in response to financial innovation and changes in wealth holder preferences. This implies that an aggregate such as M3, with *fixed* and equal weights of unity on all component assets, may not be a reliable leading indicator for inflation. Out of sample forecasts confirmed that the optimally weighted monetary aggregates have superior predictive content for inflation at longer forecast horizons such as 12 quarters.

Keywords: Monetary aggregation; Monetary policy; Leading indicators; Inflation.

JEL Categories: E41, E52, E58.

* Corresponding author.

E Mail: L.M.Drake@lboro.ac.uk, Tel No: (0) 1509 222707,
Fax No: (0) 1509 223910

1 Introduction

The launch of the single currency in the Euro zone in January 1999 ushered in a new era in monetary policy in these Euro zone economies. Specifically, the European Central Bank (ECB) was charged, under the Maastricht Treaty, with implementing a single monetary policy for the EU11 economies (EU12 following the entry of Greece in January 2001). Furthermore, the Maastricht Treaty assigned the ECB the primary and overriding objective of maintaining price stability in the Euro area, where price stability was to be defined in terms of a consumer price index. Beyond this, however, the Treaty did not specify how this objective was to be made operational in the context of the quantitative definition of the consumer price index and the conduct of monetary policy.

Hence, in October 1998, the Governing Council of the ECB announced the key elements of its stability-oriented monetary policy strategy. Price stability was defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the Euro area of below 2%, and the Governing Council also stressed that price stability should be maintained over the medium term. Significantly, in recognition of the fundamental monetary nature of inflation in the medium term, the ECB accorded a prominent role to money. The so-called “First Pillar” of the ECB's monetary policy strategy, therefore, underlined the significance of money by announcing a quantitative reference value of 4.5% for the growth of the harmonised broad monetary aggregate for the Euro zone, M3. Under the “Second Pillar”, the ECB regularly monitors a range of mainly non-monetary variables in order to provide forward-looking information relating to future inflationary pressures (see ECB, 1999a, 1999b, and 2000, for further details).

While the reference value for M3 growth should not be interpreted as a formal monetary target, it is clear that the ECB accords a more prominent role to monetary growth than most other central banks/monetary policy makers. Indeed, following the abandonment of formal monetary targeting by many countries, including the UK and the US, in the 1980s following periods of considerable money demand instability, central banks have tended to downgrade the status of money in the inflation targeting process. The Bank of England's Monetary Policy Committee, for example, operates under an inflation target of $2.5 \pm 1\%$ but does not specify any quantitative reference value for monetary growth.

The logic of the ECB's approach is that the reference value for M3 growth should indicate the rate of growth of the money supply that is broadly consistent with price stability over the medium term. Consequently, any sustained overshooting of this reference value should indicate potential inflationary problems in the future. While the absence of a formal M3 growth target implies that there will not be a mechanistic relationship between M3 overshoots and short term interest rate changes,

nevertheless the First Pillar ensures that monetary developments are given appropriate weight in the monetary policy decision making process.

In order for the First Pillar to work effectively in the context of the ECB's monetary policy framework, however, M3 must exhibit a stable or predictable relationship with prices or nominal income over the medium term, and the evolution of M3 should contain useful information regarding future price and inflationary developments. Studies such as Coenen and Vega (1999), Brand and Cassola (2000), and Calza, Gerdesmeier and Levy (2001) have provided some evidence in support of the former, while Trecroci and Vega (2000) and Altimari (2001) demonstrate reasonable leading indicator properties of M3 for future inflation, especially over the medium term. It is well established, however, that simple sum aggregates such as M3 can be prone to severe money demand instabilities. Indeed, as mentioned above, this was one of the main reasons why formal monetary targeting was abandoned in the US, UK and elsewhere in the 1980s. Clearly, if an aggregate such as simple sum M3 were to exhibit instability, the implied relationship between monetary growth and variables such as real income and prices would also be affected. In turn, this would impact on the leading indicator properties of the aggregate, as the precise nature of the change in the relationship between monetary growth and prices/inflation would typically not be clear at the time of the money demand instability

A particular problem with simple sum aggregates, such as M3, in this context is that the fixed and equal weights (of unity) on the underlying monetary components imply that they are unable to handle financial innovations which impact on asset holders preferences and hence on money demand. A further potential problem with simple sum M3 is that the process of monetary union itself, and the structural change associated with the introduction of a new monetary policy regime, may produce instability in a previously stable money demand relationship. What is required, therefore, is a monetary aggregate that can endogenously respond to financial innovations and changes in wealth holder preferences which impinge upon the information content of monetary aggregates, or their sub-components.

A possible theoretical solution to this problem is to employ the Divisia aggregation procedure, advocated by Barnett (1980, 1982), and adopted by many central banks around the world. This type of weighted monetary aggregate allows the composition of the aggregate to respond to financial innovations which impact upon relative rates of return. A number of studies have produced evidence of stable broad money demand relationships using Divisia aggregation (Belongia and Chalfont, 1989, for the US, Belongia and Chrystal, 1992, and Drake and Chrystal, 1994, 1997, for the UK), while Drake, Mullineux and Agung (1997), *inter alia*, demonstrate that a broad Divisia aggregate has good leading indicator properties for an aggregate of Euro zone countries.

An alternative approach proposed by Feldstein and Stock (1996), however, is to produce empirically weighted monetary aggregates. Feldstein and Stock argue that “our objective is to develop a procedure that automatically adjusts the composition of the monetary aggregate in a way that makes the resulting measure of the money stock a stable leading indicator of nominal GDP and potentially a useful control instrument for altering nominal GDP” (page 5). Feldstein and Stock (1996) employ two alternative methodologies to produce the empirically weighted monetary aggregates. The first is a switching regression methodology which attaches weights of either one or zero to monetary aggregate subcomponents and in which the switch dates are established on the basis of the ability of the aggregate to forecast GDP growth. The second is a time varying parameter model in which the component weights evolve over time so as to produce an aggregate with a stable predictive relationship to nominal GDP.

In this paper, we produce an empirically weighted M3 aggregate based upon a new approach to testing for the existence of a linear long run relationship when the orders of integration in, or the form of cointegration between, the underlying regressors are not known with certainty. Hence, in contrast to Feldstein and Stock (1996), the component weights derived at any point in time are drawn from the cointegrating relationship between the component assets and nominal GDP or prices. We focus on prices as well as nominal GDP in this paper in recognition of the primacy accorded to price stability by the ECB. Furthermore, by using this approach in a recursive fashion we are able to analyse how the “optimal” weights evolve over time.

We evaluate the information content of the optimally weighted aggregates relative to conventional simple sum M3 using the simulated out of sample forecasting framework for inflation suggested by Stock and Watson (1999). In this context, two alternative weighted monetary aggregates are evaluated that consist of components weighted on the basis of either the long run nominal income or long run price relationship.

2 A Methodology for Constructing a Weighted Monetary Aggregate for the Euro Zone

2.1 Methodological Framework

The first data set used to construct an empirically determined weighted monetary aggregate contains quarterly observations from 1980.1 to 2001.4 on the logarithms of nominal GDP, denoted y_t , and three monetary components (see Appendix 1 for further details);

$$\begin{aligned} x_1: & \quad \log(M1) \\ x_2: & \quad \log(M2 - M1) \\ x_3: & \quad \log(M3 - M2) \end{aligned}$$

The levels of the three components are shown in Figure 1, where it is clear that x_3 follows a more variable growth path than x_1 or x_2 .

Two approaches are taken to construct the weighted aggregate. The first is that proposed by Pesaran, Shin and Smith (2001), henceforth PSS, which has been used successfully in respect of UK and US monetary aggregates by Drake and Mills (2001, 2002). This begins by considering the following vector autoregressive model of order p (VAR(p)) in the vector of variables $\mathbf{z}_t = (y_t, \mathbf{x}'_t)'$, where $\mathbf{x}_t = (x_{1t}, \dots, x_{kt})'$ is the vector of monetary components:

$$\mathbf{z}_t = \mathbf{b} + \mathbf{c}t + \sum_{i=1}^p \Phi_i \mathbf{z}_{t-i} + \varepsilon_t, \quad (1)$$

where \mathbf{b} and \mathbf{c} are vectors of intercepts and trend coefficients and Φ_i , $i = 1, 2, \dots, p$, are matrices of coefficients. We assume that the roots of

$$\left| \mathbf{I}_5 - \sum_{i=1}^p \Phi_i z^i \right| = 0$$

are outside the unit circle $|z|=1$ or satisfy $z=1$, so that the elements of \mathbf{z}_t are permitted to be either $I(0)$, $I(1)$ or cointegrated. The *unrestricted vector error correction form* of (1) is given by

$$\Delta \mathbf{z}_t = \mathbf{b} + \mathbf{c}t + \Pi \mathbf{z}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathbf{z}_{t-1} + \varepsilon_t, \quad (2)$$

where

$$\Pi = -\left(\mathbf{I}_5 - \sum_{i=1}^p \Phi_i \right)$$

and

$$\Gamma_i = -\sum_{j=i+1}^p \Phi_j, \quad i=1, \dots, p-1$$

are matrices containing the long-run multipliers and the short-run dynamic coefficients, respectively.

Given the partition $\mathbf{z}_t = (y_t, \mathbf{x}'_t)'$, we define the conformable partitions $\boldsymbol{\varepsilon}_t = (\varepsilon_{1t}, \boldsymbol{\varepsilon}'_{2t})'$ and

$$\mathbf{b} = \begin{bmatrix} b_1 \\ \mathbf{b}_2 \end{bmatrix}, \quad \mathbf{c} = \begin{bmatrix} c_1 \\ \mathbf{c}_2 \end{bmatrix}, \quad \Pi = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \Pi_{22} \end{bmatrix}, \quad \Gamma_i = \begin{bmatrix} \gamma_{11,i} & \gamma_{12,i} \\ \gamma_{21,i} & \Gamma_{22,i} \end{bmatrix}$$

and make the standard assumption that $\boldsymbol{\varepsilon}_t = (\varepsilon_{1t}, \boldsymbol{\varepsilon}'_{2t})'$ follows a multivariate i.i.d. process having mean zero, non-singular covariance matrix

$$\Sigma_{\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}} = \begin{bmatrix} \sigma_{11} & \boldsymbol{\sigma}_{12} \\ \boldsymbol{\sigma}_{21} & \Sigma_{22} \end{bmatrix},$$

and finite fourth moments. We also assume that $\pi_{21} = \mathbf{0}$, which ensures that there exists at most one (non-degenerate) long-run relationship between y_t and \mathbf{x}_t , irrespective of the level of integration of the \mathbf{x}_t process.

With this assumption and the partitioning given above, (2) can be written in terms of the *dependent* variable y_t and the *forcing* variables \mathbf{x}_t as

$$\Delta y_t = b_1 + c_1 t + \pi_{11} y_{t-1} + \pi_{12} \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \gamma_{11,i} \Delta y_{t-i} + \sum_{i=1}^{p-1} \gamma_{12,i} \Delta \mathbf{x}_{t-i} + \varepsilon_{1t} \quad (3)$$

$$\Delta \mathbf{x}_t = \mathbf{b}_2 + \mathbf{c}_2 t + \Pi_{22} \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \gamma_{21,i} \Delta y_{t-i} + \sum_{i=1}^{p-1} \Gamma_{22,i} \Delta \mathbf{x}_{t-i} + \boldsymbol{\varepsilon}_{2t} \quad (4)$$

The contemporaneous correlation between ε_{1t} and $\boldsymbol{\varepsilon}_{2t}$ can be characterised by the regression

$$\varepsilon_{1t} = \omega' \boldsymbol{\varepsilon}_{2t} + \xi_t \quad (5)$$

where $\omega = \Sigma_{22}^{-1} \boldsymbol{\sigma}_{21}$, $\{\xi_t\}$ is an i.i.d. $(0, \sigma_\xi^2)$ process with $\sigma_\xi^2 = \sigma_{11} - \boldsymbol{\sigma}_{12} \Sigma_{22}^{-1} \boldsymbol{\sigma}_{21}$, and the $\{\xi_t\}$ and $\{\boldsymbol{\varepsilon}_{2t}\}$ processes are uncorrelated by construction. Substituting (4) and (5) into (3) yields

$$\Delta y_t = a_0 + a_1 t + \phi y_{t-1} + \boldsymbol{\delta}' \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \phi_{12,i} \Delta \mathbf{x}_{t-i} + \xi_t \quad (6)$$

where

$$a_0 \equiv b_1 - \omega' \mathbf{b}_2, \quad a_1 \equiv c_1 - \omega' \mathbf{c}_2, \quad \phi \equiv \pi_{11}, \quad \boldsymbol{\delta}' \equiv \pi'_{12} - \Pi'_{22} \omega$$

$$\psi_i \equiv \gamma_{11,i} - \omega' \gamma_{21,i}, \quad \varphi_0 \equiv \omega', \quad \varphi_i \equiv \gamma_{12,i} - \omega' \Gamma_{22,i}$$

It follows from (6) that, if $\phi \neq 0$ and $\delta \neq \mathbf{0}$, there exists a long-run relationship between the levels of y_t and \mathbf{x}_t , given by

$$y_t = \theta_0 + \theta_1 t + \theta' \mathbf{x}_t + \nu_t \quad (7)$$

where $\theta_0 \equiv -a_0/\phi$, $\theta_1 \equiv -a_1/\phi$, $\theta \equiv -\delta/\phi$ is the vector of long-run response parameters and $\{\nu_t\}$ is a mean zero stationary process. If $\phi < 0$ then this long run relationship is *stable* and (6) can be written in the error correction model (ECM) form

$$\Delta y_t = a_0 + a_1 t + \phi(y_{t-1} - \theta' \mathbf{x}_{t-1}) + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \varphi_{12,i} \Delta \mathbf{x}_{t-i} + \xi_t \quad (8)$$

If $\phi = 0$ in (8) then no long-run relationship exists between y_t and \mathbf{x}_t . However, a test for $\phi = 0$ runs into the difficulty that the long-run parameter vector θ is no longer identified under this null, being present only under the alternative hypothesis. Consequently, PSS test for the absence of a long-run relationship, and avoid the lack of identifiability of θ , by examining the joint null hypothesis $\phi = 0$ and $\delta = \mathbf{0}$ in the unrestricted ECM (6). Note that it is then possible for the long-run relationship to be *degenerate*, in that $\phi \neq 0$ but $\delta = \mathbf{0}$, in which case the long-run relationship involves only y_t and possibly a linear trend.

PSS consider the conventional Wald statistic of the null $\phi = 0$, $\delta = \mathbf{0}$ and show that its asymptotic distribution involves the non-standard unit root distribution and depends on both the dimension and cointegration rank ($0 \leq r \leq k$) of the forcing variables \mathbf{x}_t . This cointegration rank is the rank of the matrix Π_{22} appearing in (4). PSS obtain this asymptotic distribution in two polar cases: (i) when Π_{22} is of full rank, in which case \mathbf{x}_t is an $I(0)$ vector process, and (ii) when the \mathbf{x}_t process is not mutually cointegrated ($r = 0$ and $\Pi_{22} = \mathbf{0}$) and hence is an $I(1)$ process. They point out that the critical values obtained from stochastically simulating these two distributions must provide lower and upper critical value bounds for all possible classifications of the forcing variables into $I(0)$, $I(1)$ and cointegrated processes. A *bounds procedure* to test for the existence of a long-run relationship within the unrestricted ECM (6) is thus as follows. If the Wald (or related F -) statistic falls below the lower critical value bound, then the null $\phi = 0$, $\delta = \mathbf{0}$ is not rejected, irrespective of the order of integration or cointegration rank of the variables. Similarly, if the statistics are greater than their upper critical value bounds, the null is rejected and we conclude that there is a long-run relationship between y_t and \mathbf{x}_t . If the statistics fall within the bounds, inference is inconclusive and detailed information about the integration-cointegration properties of the variables is then necessary in order to proceed further. It is the fact that we may be able to make firm inferences

without this information, and thus avoid the severe pre-testing problems usually involved in this type of analysis, that makes this procedure attractive in applied situations. PSS provide critical values for alternative values of k under various situations. The two that are relevant here are Case 1: $a_0 \neq 0, a_1 = 0$ (with an intercept but no trend in (6)), and Case 2: $a_0 \neq 0, a_1 \neq 0$ (with both an intercept and a trend in (6)).

PSS show that this testing procedure is consistent and that the approach is applicable in quite general situations. For example, equation (6) can be regarded as an autoregressive distributed lag model in y_t and \mathbf{x}_t having all lag orders equal to p . Differential lag lengths can be used without affecting the asymptotic distribution of the test statistic.

The second approach that we consider relaxes the assumption that $\boldsymbol{\pi}_{21} = \mathbf{0}$, so that more than one long-run relation is allowed to exist. Relaxing this assumption necessitates strengthening other assumptions; we now assume that $\mathbf{z}_t = (y_t, \mathbf{x}'_t)'$ is a, possibly cointegrated, $I(1)$ process. We can now work within the vector error correction form (2), using standard techniques of testing for, and estimating under, cointegration.

2.2 Empirical Results

In implementing the PSS approach, our first task is to check that the assumptions required for attention to focus solely on equation (6) are satisfied. One underlying assumption, implicit in the discussion above, is that the maximal order of integration of the $\{\mathbf{z}_t\}$ process is unity. Unit root tests of the individual series making up $\{\Delta \mathbf{z}_t\}$ show that a unit root is rejected at the 5% level in each case. A second assumption, explicitly discussed above, is that $\boldsymbol{\pi}_{21} = \mathbf{0}$ in (the partitioned form of) the unrestricted vector error correction (2).

Estimation of this equation with p set equal to 4, a setting chosen on the basis of a sequence of likelihood ratio tests from a maximum of $p = 8$, produced t -statistics on the coefficients of y_{t-1} in the equations for Δx_{it} , $i = 1, 2, 3$, of 1.64, 2.71 and 2.25, thus producing some evidence against the null hypothesis $\boldsymbol{\pi}_{21} = \mathbf{0}$. Ignoring such evidence for the moment, the estimated equation (2) is

$$\begin{aligned} \Delta y_t = & 0.323 - 0.285 y_{t-1} + 0.092 x_{1,t-1} + 0.130 x_{2,t-1} + 0.013 x_{3,t-1} \\ & (0.115) \quad (0.083) \quad (0.029) \quad (0.052) \quad (0.006) \end{aligned} \quad (9)$$

$$+ \sum_{i=1}^3 (\hat{\gamma}_{11i} \Delta y_{t-i} + \hat{\gamma}_{12i} \Delta \mathbf{x}_{t-i}) + \sum_{i=1}^2 \hat{\lambda}_i d_{i,t}$$

Sample: 1981:1 - 2001:4 $R^2 = 0.666$ $\hat{\sigma}_\xi = 0.00472$
 $AUTO(4) = 3.49[0.48]$ $NORM = 4.07[0.13]$

$$HET = 1.20[0.28] \quad RESET(1) = 0.38[0.55]$$

The standard diagnostic checks (probability-values are shown in brackets) indicate no evidence of misspecification: d_{1t} and d_{2t} are 0-1 dummies that account for outliers at 1984:2 and 2001:1 and were included to mitigate problems of nonnormality.

The Wald statistic for testing whether there exists a long run relationship between y_t and \mathbf{x}_t produces an F -statistic of 8.95. This is well beyond the 1% significance level upper bound in both Cases 1 and 2: with three regressors these upper bounds are 5.61 and 5.23, respectively (note that the trend was found to be insignificant and hence has been omitted from the chosen specification). We must therefore conclude that such a long run relationship certainly exists and, given our estimates, the long run relationship (7) is

$$y_t = 0.32 + \hat{\theta}\mathbf{x}_t = 0.32 + 0.82(0.40x_{1,t} + 0.55x_{2,t} + 0.05x_{3,t}) \quad (10)$$

However, as we have seen, the underlying assumption of at most one long-run relationship may be questionable, so we supplement this model with standard cointegration analysis. Estimation of the vector error correction (2) with d_{1t} and d_{2t} included in each equation produced trace and max-eigenvalue statistics that indicate that there are indeed two cointegrating vectors (we assumed that there was a linear trend in the data but not in the cointegrating relationships). The trace statistic of 43.3 rejects the null of one cointegrating vector in favour of there being two at the 1% level (the critical value is 35.7), while the max-eigenvalue statistic of 33.6 also rejects this null at the 1% level (critical value 25.5). The first cointegrating vector, when appropriately normalised, implies long run weights of 0.40, 0.54 and 0.06 on x_1 , x_2 and x_3 , respectively, almost identical to those obtained from the PSS analysis.

The exercise was repeated using the logarithms of the HIPC price index, rather than nominal income. Denoting this variable h_t , the following long-run relationship was obtained

$$h_t = 0.69(0.36x_{1,t} + 0.64x_{2,t})$$

The weight on x_3 is set to zero as the unrestricted estimate of δ_3 was insignificantly negative. Similarly, the exercises were repeated using the simple sum aggregate $m_t = \log(\exp(x_{1t}) + \exp(x_{2t}) + \exp(x_{3t}))$, in place of x_{1t} , x_{2t} and x_{3t} . The long-run relationship between y_t and m_t was found to be degenerate, in that, although ϕ and δ were jointly significantly different from zero, individually they were insignificant when both y_{t-1} and m_{t-1} were included in the equation. A significant long-run relationship between h_t and m_t was found ($h_t = 0.08 + 0.47m_t$), but the underlying

equation produced an inferior fit to that containing the components: the standard errors of the two regressions being 0.00231 and 0.00227 respectively.

An interesting feature to emerge from the nominal income ($w_{1t} = 0.40x_{1t} + 0.55x_{2t} + 0.05x_{3t}$) and HIPC ($w_{2t} = 0.36x_{1t} + 0.64x_{2t}$) optimally weighted monetary aggregates is that both place either a very low (0.05), or a zero weight, respectively, on the broad M3 component assets of M3 (x_3). This is significant given that the ECB formally opted to set a reference growth rate for M3 in recognition of the fundamental monetary nature of inflation in the medium term. Our results suggest, however, that the bulk of the broad M3 assets (x_3) held in the Euro area are held as a result of an asset motive rather than a transactions motive. Hence, rapid growth in the M3 asset components (x_3) has no particular significance for future nominal income growth or inflation. This has important monetary policy implications given that the M3 aggregate utilised by the ECB will accord an equal weight of unity to all component assets and hence overstate monetary growth at times when the broad money components are increasing rapidly. As Figure 1 indicates, the x_3 component of M3 exhibited very rapid growth over the period 1987/88 to 1993, at a time when the x_1 and x_2 components were exhibiting relatively steady growth. This suggests that simple sum M3 would be growing much faster than either w_1 or w_2 over that period and, given the construction of the optimally weighted aggregates, this implies that M3 would have overstated the future demand and inflationary pressures.

To see this more clearly, we contrast the growth of the weighted monetary aggregates with simple sum M3. Figure 2 plots combinations of the annual growth rates of the two weighted aggregates and the growth rate of the conventionally defined simple sum aggregate (these growth rates are calculated as $w_{it} - w_{i,t-4}$, $i = 1, 2$, and $m_t - m_{t-4}$ respectively). Figure 2 indicates that, although the correspondence between the growth rates of weighted money and M3 is generally reasonably high, M3 does indeed exhibit much higher growth rates over the period 1987/88 to 1993. Interestingly, this discrepancy is most evident with respect to w_2 , which tends to exhibit lower average growth rates over this period than either M3 or w_1 . Given that w_2 incorporates weights derived explicitly from the long run relationship between HICP and the monetary components, it would be expected that w_2 would prove to be more accurate in signalling future inflationary pressures over this period than w_1 and, especially, M3.

Although the correspondence between the growth rate of M3 and weighted money increased considerably after 1995 (particularly in respect of w_1), there is clear evidence of further divergence in growth rates after 1998/99. Again, this is highly significant from a monetary policy perspective as it suggests that, since the onset of the single currency and the single monetary policy administered by the ECB, the growth rate of simple sum M3 may be becoming increasingly unreliable as a leading indicator of inflationary pressures. This is particularly evident in the most recent

period since late 2000, during which, although all the monetary aggregates have been exhibiting rapid increases in annual growth rates, the growth of M3 has considerably outstripped the growth of weighted money, and especially w_2 . Part of the reason for this may be the recent renewed growth in the x_3 component of M3 evident in Figure 1, following a period of very slow growth between 1993 and 1999. The implication of this, however, is that the recent strong growth in M3 may be overstating the medium term inflation pressures.

2.3 Recursive Estimation

Having established the long run relationship between the monetary components (x_1 , x_2 and x_3) and both nominal income and HICP over the full sample period, it is potentially informative to analyse the stability of, and any trends in, the implied component weights. This is important in a monetary policy context given the well-documented evidence of money demand instability in many countries over the past three decades or so. In this case, any evidence of instability or strong trends in the component weights may be indicative of potential money demand instabilities in the context of M3, as they would indicate that the relationship between the monetary components and either nominal income or prices was evolving through time. This may be due to financial innovations and changes in wealth holder preferences in response to changes in the macro-economy. The key point, however, is that simple sum aggregates such as M3 cannot incorporate these changes since the component asset weights are all fixed at unity.

Figure 3 illustrates the recursive weights for the weighted aggregate w_1 derived from the long run nominal income relationship. These were calculated by recursively estimating equation (9) and deriving the long-run relationship à la (10) at each observation. Once the recursive weights have "settled down" by 1992, they show remarkable stability until late 1996. As might be expected, the largest weight of around 0.6, or just below, is accorded to the x_1 "narrow money component", while the weight on x_2 is around 0.35 or slightly higher. Finally, as suggested by the full sample results, the weight on x_3 is very low at around 0.05 or less. Following this period of relative stability, however, the optimal weight on x_2 increases markedly to around 0.55 by the end of the sample period. At the same time, the implied optimal weight on x_1 declines from just under 0.6 to around 0.4. In contrast, the implied optimal weight on x_3 has remained remarkably stable since 1992, increasing only very slightly after 1999. Hence, these recursive estimates suggest that the ECB's chosen monetary aggregate, M3, may well exhibit worsening demand instabilities in the future as financial innovations and macroeconomic changes in the Euro zone economy affect the underlying long run relationship between the components of M3 and the economy, as measured in this case by nominal income. Furthermore, it is

clear that, as there is no tendency for the implied weight on x_3 to increase appreciably over time, simple sum M3 will continue to overstate monetary growth from a policy perspective as long as x_3 growth remains buoyant.

Finally, the weights illustrated in Figure 3 represent an interesting contrast with the weights that would be implied by the theoretical Divisia aggregation procedure. The Divisia weights (on the growth of the component assets) are based on monetary expenditure shares, which in turn depend on both the component asset quantities and their rental prices. Furthermore, since these rental prices depend on the differential between the own return on the component assets and a benchmark return (often proxied by a bond yield), Divisia monetary aggregates tend to accord a higher weight to the narrow money components such as cash and current accounts which typically offer a zero or relatively low return. Similarly, broader monetary component assets such as x_2 and x_3 would tend to be accorded lower weights. This contrasts markedly with Figure 3, where the highest weight is accorded to x_2 rather than x_1 . Furthermore, assuming similar growth rates for x_1 and x_2 , the growth rates of w_1 and the corresponding Divisia aggregate would be expected to increasingly diverge after 1996 given the marked increase in the optimal weight on x_2 and the corresponding decline in the weight on x_1 . Such a marked change in the component weights could only occur in the context of a Divisia aggregate if the own rate of return on the x_1 assets increased significantly relative to the own rate of return on x_2 . Hence, Divisia aggregates can only respond to financial innovations that are fully reflected in relative interest rates.

Figure 4 illustrates the recursive weights for w_2 , based on the long run relationship between the component assets and HICP. As the recursive weights were very volatile in the earlier period, however, these have only been reported from 1992 onwards. Even over this more limited sample period, however, it is clear that the implied optimal weights on x_1 and x_2 are somewhat more volatile than the corresponding weights for w_1 , derived from the long run nominal income relationship (Figure 3). This is particularly evident over the period 1992 to 1996, where the x_1 weight generally varies between unity and 0.6, while the weight on x_2 varies between zero (or slightly negative on occasions) to around 0.4. Hence, for much of this period, the w_2 aggregate would accord a much higher weight to narrow money, x_1 , than would w_1 . From 1996, however, similar trends to those seen in Figure 3 are evident in the recursive weights, although they are more dramatic in the case of w_2 . Specifically, the optimal implied weight on x_1 declines substantially to around 0.1 by early 1999, while the optimal weight on x_2 increases to around 0.9. Interestingly, however, these weights begin to stabilise shortly after the introduction of the single currency in January 1999 and by late 2000 have converged towards their full sample estimates and remained highly stable at around 0.35 and 0.65 for x_1 and x_2 , respectively. Hence, in contrast to the views of many commentators who anticipated

considerable money demand instability as a consequence of the regime shift associated with the single currency and the ECB's single monetary policy, the evidence from the HICP relationship suggests that there was greater instability in the transitional period, i.e., between the Maastricht agreement in 1992 and the onset of the single currency in January 1999.

With respect to the appropriateness of M3 as a guide for ECB monetary policy, the results in Figure 4 for w_2 emphatically underline the results provided by the recursive estimates for w_1 . Specifically, there is no support for the broad M3 aggregate, as the implied weight on x_3 is consistently close to zero in all time periods. Again, this suggests that M3 will give more weight to the growth in x_3 than is appropriate in the context of a leading indicator of inflationary pressures. This could be particularly serious at times when the x_3 component is exhibiting strong growth, as has been the case recently. Finally, both the recent recursive estimates and the full sample results suggest that simple sum M3, and any constructed Divisia M3 aggregate, accord an overly large weight to x_1 and too low a weight on x_2 relative to the optimal weights implied by the long run relationship between the monetary components and HICP. In the case of simple sum M3, the implication is that this aggregate may have poor leading indicator properties for HICP inflation, particularly at times when x_1 or x_3 , or both, are exhibiting relatively rapid growth. This issue of leading indicator properties is discussed in more detail in the next section.

3 Inflation Forecasting Tests

So far in this paper we have intimated that, by virtue of their construction, the optimally weighted monetary aggregates should exhibit better leading indicator properties in respect of future inflation than the M3 aggregate currently used by the ECB for guiding monetary policy. In order to ascertain whether this is actually the case, however, we now evaluate the relative performance of M3, w_1 and w_2 in the context of an out-of-sample inflation forecasting analysis conducted over various forecasting horizons.

In order to conduct the appropriate inflation forecasting tests, we utilise a modified version of the approach adopted by Stock and Watson (1999). This uses the forecasting model

$$\pi_{t+k}^k = a + \sum_{i=1}^q b_i \pi_{t-i}^k + \sum_{i=1}^r c_i x_{t-i}^k + e_{t+k}$$

where $\pi_t^k = (4/k)(h_t - h_{t-k})$ is k -period HIPC inflation and x_t^k is a similarly defined growth rate of the indicator variable, which is either m_t , w_{1t} or w_{2t} . This modifies the Stock and Watson approach by using k -period growth rates as regressors rather than one-period rates. The lag lengths were set at $q=4$, $r=1$ for $k=4$ and $q=r=4$ for $k=8,12$. Although it could be argued that the recursive long run weights may be more appropriate for w_1 and w_2 , rather than the fixed full sample long run weights, the initial volatility in the recursive weights combined with sample size constraints implied that this was not feasible. It is important to note, however, that the use of fixed rather than variable weights may actually understate the true leading indicator properties of the empirically weighted aggregates, as the weights will not necessarily reflect the optimal weights at all points in time. In a real time policy making context, however, the long run relationship, and the implied optimal weights, could be continually updated, prior to the growth rates of w_1 and w_2 being used in a forward looking inflation forecasting exercise.

The previous graphical analysis suggested that any superior inflation forecasting performance of the weighted monetary aggregates (and especially w_2) was likely to be most apparent over the period 1987/88 to 1993, and in respect of the period from late 2000. Unfortunately, sample size constraints imply that out-of-sample forecast tests can only be conducted from 1992 onwards. Furthermore, given optimal forecasting horizons of 8 quarters or more, the recent period of rapid monetary growth (most especially in respect of M3) cannot yet be evaluated in terms of the subsequent inflation outcome. Nevertheless, in Table 1 we provide details of the out-of-sample inflation forecasting tests for the maximum possible sample period 1992 to 2001.

The full period results show that, over the 4 quarter horizon, w_2 is marginally superior to M3, whereas w_1 is marginally worse. Interestingly, however, the forecasting accuracy of both w_1 and w_2 deteriorates markedly relative to M3 at the 8 quarter horizon, but is significantly better at the 3 year horizon. The RMSEs for M3, w_1 and w_2 at the 12 quarter horizon are 11532, 7849 and 7988 respectively (all expressed in units multiplied by 10^6). This suggests that the weighted monetary aggregates have particularly good longer leading indicator properties for inflation. Furthermore, the fact that the forecasting accuracy of the weighted aggregates actually improves significantly between the 8 quarter and 12 quarter horizons (10143 to 7849 for w_1 , for example), whereas the accuracy of M3 deteriorates significantly (6900 to 11532), strongly suggests that the lags in the monetary transmission mechanism in respect of prices/inflation are in fact longer than the Friedman chronology of around two years on average. This is an important result in the sense that the long run relationship between the monetary components and prices or nominal incomes suggests that the optimal medium term inflation targeting/forecasting horizon may be

closer to 12 quarters, rather than the 8 quarters typically employed by central banks such as the ECB and the Bank of England.

4. Conclusions

The ECB is one of the few central banks to accord a high profile to the growth of a specified monetary aggregate. In the case of the Euro zone economies, this is the harmonised broad monetary aggregate, M3. Most central banks, including the Bank of England and the US Federal Reserve, have significantly downgraded the role of monetary growth relative to the prominent role afforded to it at the height of monetary aggregate targeting in the late 1970s and 1980s. This was largely associated with the well-documented problem of money demand instability, and the consequent potential for monetary growth to provide misleading signals to policy makers on the likely future growth of nominal incomes and prices. In the context of the trend towards inflation targeting witnessed since the early 1990s, most central banks treat monetary growth as only one element in a potentially wide information set used to indicate future inflationary pressures and therefore to guide current monetary policy. The ECB in contrast, explicitly acknowledges the monetary nature of inflation in the medium term by specifying a reference rate of growth for M3 of 4.5%.

In this paper we question the appropriateness of M3 as a guide to ECB monetary policy. Specifically, we utilise an innovative approach to long run modelling in order to develop new empirically weighted monetary aggregates for the Euro zone. These monetary aggregates should, by construction, have good leading indicator properties in respect of nominal income growth (w_1) and inflation (w_2), given that the optimal empirical weights are derived from the long run relationship between the component assets and either nominal income or prices, as measured by the Harmonised Index of Consumer Prices (HICP) for the Euro zone.

The results show that the optimal empirical weights for the component assets are very different from those that would be implied by either simple sum M3 (in which each component is given a fixed and equal weight of unity) or a corresponding Divisia aggregate. A particularly noteworthy result is that both empirically weighted aggregates accord a very low or zero weight to the x_3 component, suggesting that the M3 aggregate is overly broad and that an M2 type aggregate (suitably weighted) may be more appropriate in an inflation-targeting context. In a policy context, the recent buoyant growth in x_3 has been reflected in strong growth in M3, relative to the empirically weighted aggregates. Hence, there is a danger that M3 could provide overly pessimistic signals on future inflationary pressures at a time when the global economy, and the European economy in particular, is experiencing a slowdown in growth.

The recursive estimations confirm that financial innovations and changes in the preferences of wealth holders can and do impact on the relationship between money (or the monetary asset components) and the economy (nominal income and prices), as reflected in the optimal weights on the component assets. Such changes cannot be reflected in simple sum aggregates, and can only be incorporated into Divisia aggregates to the extent that they are manifested in relative interest rate differentials. Hence, the impact of such financial innovations has frequently shown up in the past in the form of money demand instability. While academic research can often restore the stability of these money demand functions ex-post, the associated time lag is often too great for monetary policy purposes. An example of this is the case of the M2 money demand instability (“missing M2”) which became apparent in the US from the early 1990s. While some economists (for example, Carlson et al, 2000) claimed to have restored stability to this money demand function by the late 1990s, the US Fed had downgraded the role of M2 as a policy variable as early as 1993.

Hence, the advantage of empirically weighted monetary aggregates, such as w_1 and w_2 , is that they can be allowed to adjust automatically in response to financial innovations and changing preferences, so as to maintain the optimal long run relationship between the component assets and the target variable (nominal income or prices). Furthermore, from a policy perspective such aggregates are relatively easy to compute and can be sequentially updated in real time as more data becomes available. This is potentially highly valuable, as monetary policy-making is conducted in real time and policy-makers are often called upon to interpret the, often confusing, signals coming from the growth of monetary aggregates and their components, most especially during times of money demand/velocity instability.

Finally, out of sample inflation forecasting tests confirm that, although M3 does perform relatively well at the shorter forecasting horizons, the empirically weighted monetary aggregates, and especially w_1 , exhibit much superior longer leading indicator properties at forecasting horizons such as 12 quarters. This is a very significant result as the considerable improvement in the forecasting accuracy of the weighted aggregates between the 8 and 12 quarter horizons suggests that the medium term link between monetary growth and inflation emphasised by the ECB may actually be longer than the two-year horizon typically assumed. Clearly, from a monetary policy perspective, any increase in the lead-time between indicator variables and the target variable of the inflation rate is potentially very valuable to policy makers such as the ECB.

Furthermore, as was emphasised previously, the reported inflation-forecasting tests may well understate the full advantages of the empirically weighted aggregates on two counts. Firstly, it was not possible to conduct the post-sample inflation forecasting tests using the recursive weights, which might be expected to more

accurately reflect the relationship between the component assets and nominal income or prices at the time the forecasts are actually made. Clearly, in a policy-making context, forecasts could be made sequentially and conditional upon the latest data and the updated optimal long run component asset weights. Secondly, the post-sample forecasting tests could not fully reflect those periods (1987-1993 and post 2001) when the graphical analysis (Figure 2) suggested that w_1 , and especially w_2 , were exhibiting markedly different growth rates from M3. The incorporation of such periods may have produced more accurate inflation forecasts on the part of w_1 and w_2 .

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RMSE ($\times 10^6$): 1992 - 2001

k	$M3$	w_1	w_2
4	4845	5356	4772
8	6900	10143	11681
12	11532	7849	7988

Table 1. Inflation forecasts.

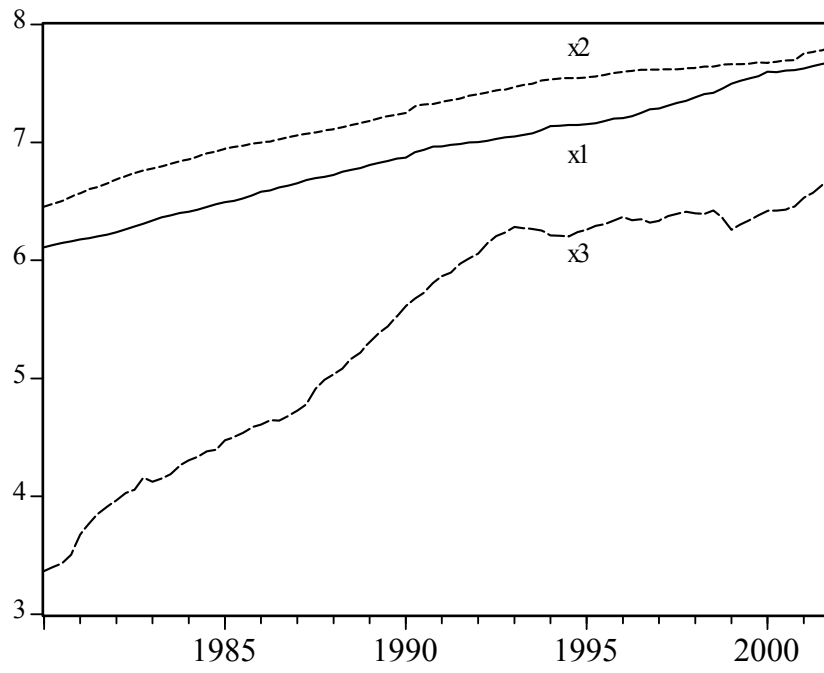
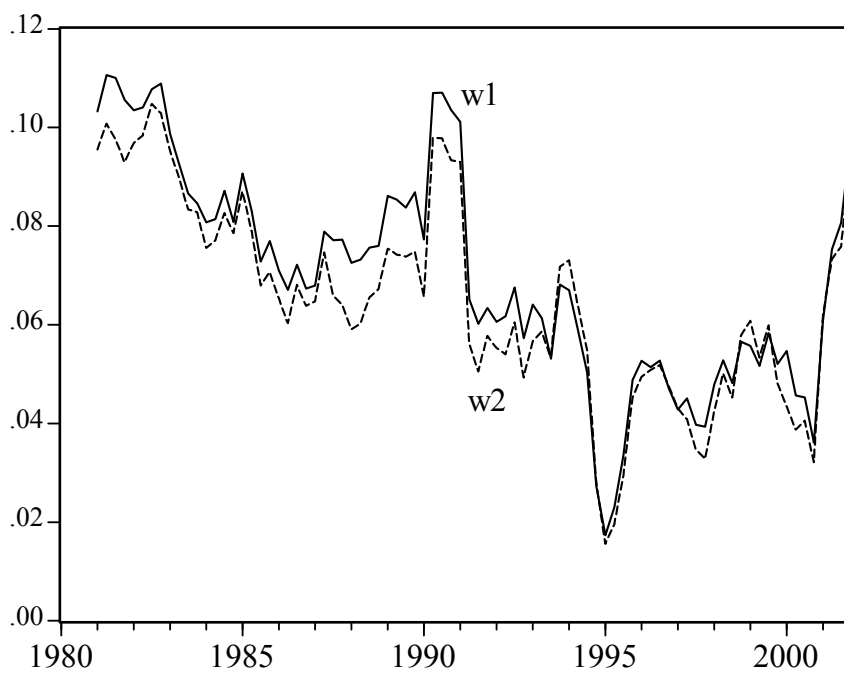
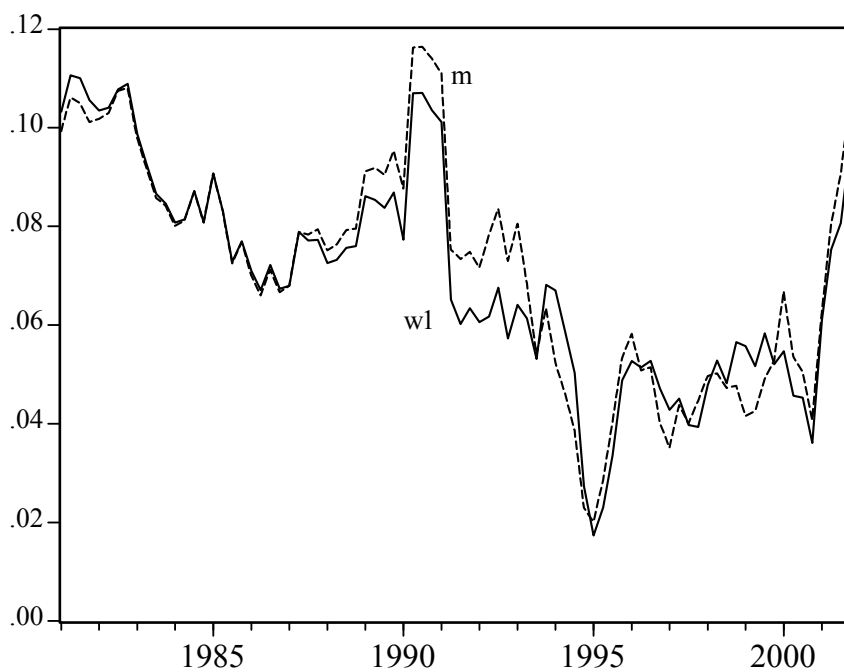


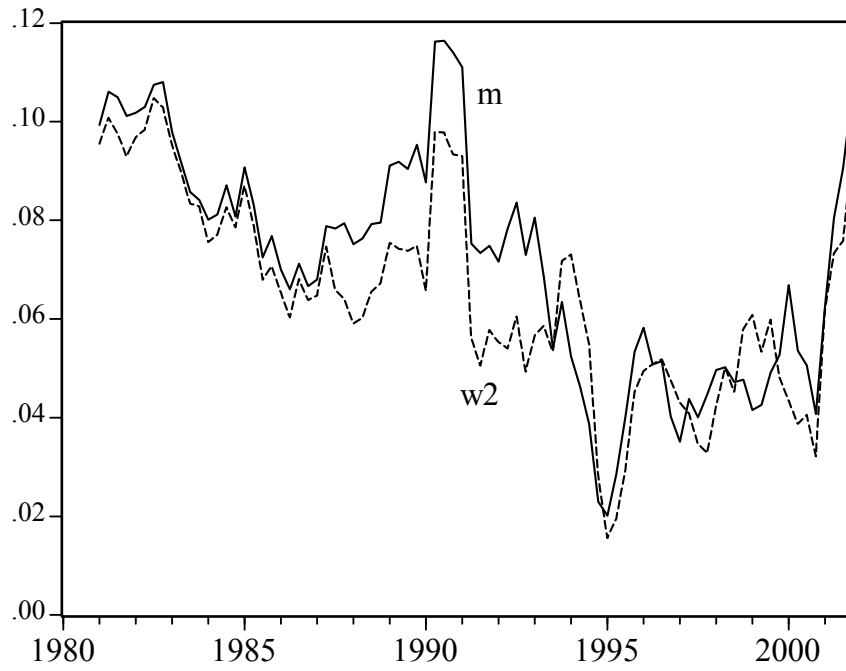
Figure 1. Monetary components: logarithms, 1980:1 - 2001:4.



(a) Growth rates of the w_1 and w_2 aggregates.



(b) Growth rates of the w_1 and M3 aggregates.



(c) Growth rates of the w_2 and M3 aggregates.

Figure 2. Annual growth rates of simple sum and weighted M3: 1981.1 - 2001.4.

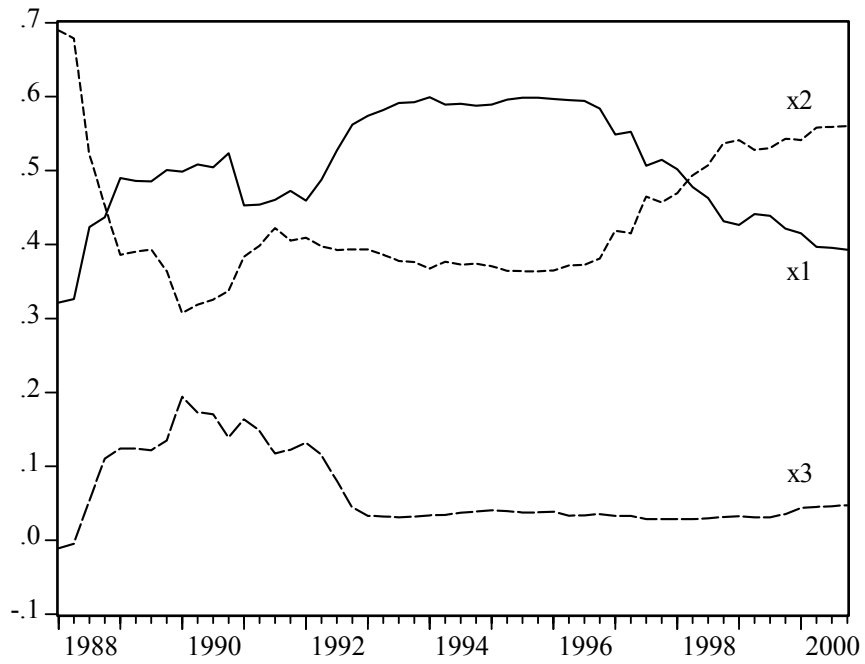


Figure 3. Recursively estimated component weights for aggregate w_1 : 1988.1 - 2001.4.

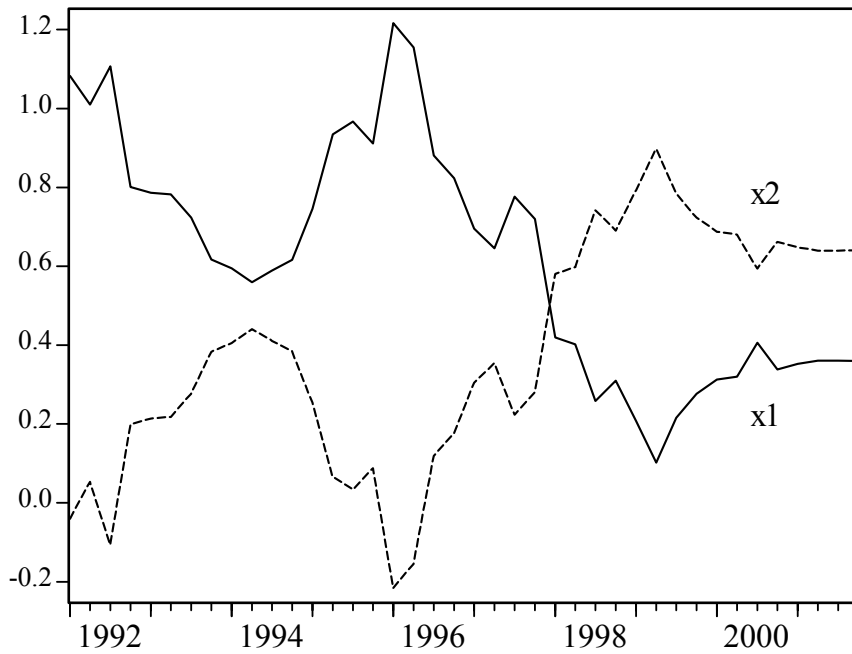


Figure 4. Recursively estimated component weights for weighted aggregate w_2 : 1992.1 - 2001.4.

APPENDIX 1

The data utilised in this study relates to the Euro zone economies. Prior to 2001.1, this relates to the EU-11 economies which formed the “first wave” of countries to join the single currency, the Euro, in January 1999. From 2001.1, however, the data relates to the EU-12 economies following the accession of Greece to the single currency.

Wherever possible, official data produced by the ECB is utilised in this paper. In respect of the monetary aggregate M3, and the component assets, x_1 , x_2 and x_3 , the ECB produces this data back to 1980.1. With respect to HICP, real GDP and the GDP deflator, ECB data is available only from 1995.1, 1990.1 and 1990.1, respectively. Hence, prior to these dates we have utilised the Euro area database constructed by Golinelli, and we gratefully acknowledge the use of this database. This data has been constructed (and verified) to be consistent with the official ECB data (see Golinelli and Pastorello, 2000, for further details). As consistent Euro zone data was not available for the whole sample period for nominal GDP, however, this series has been constructed from data on the GDP deflator and real GDP. This series has also been inspected for consistency against the official ECB data.