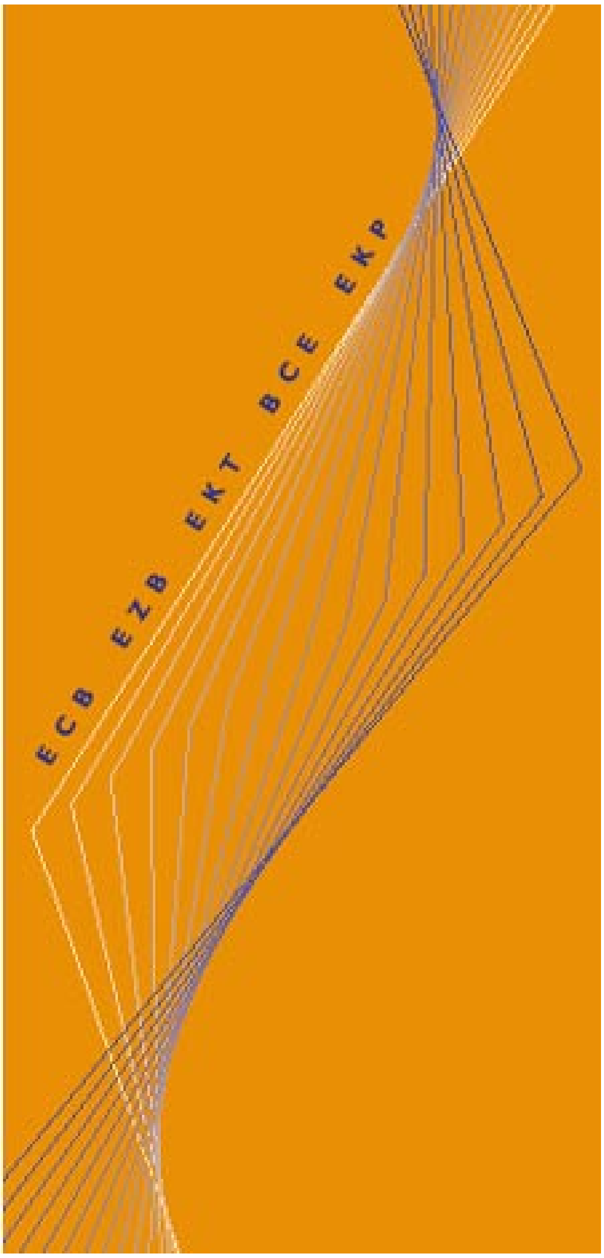
EUROPEAN CENTRAL BANK

WORKING PAPER SERIES



WORKING PAPER NO. 39

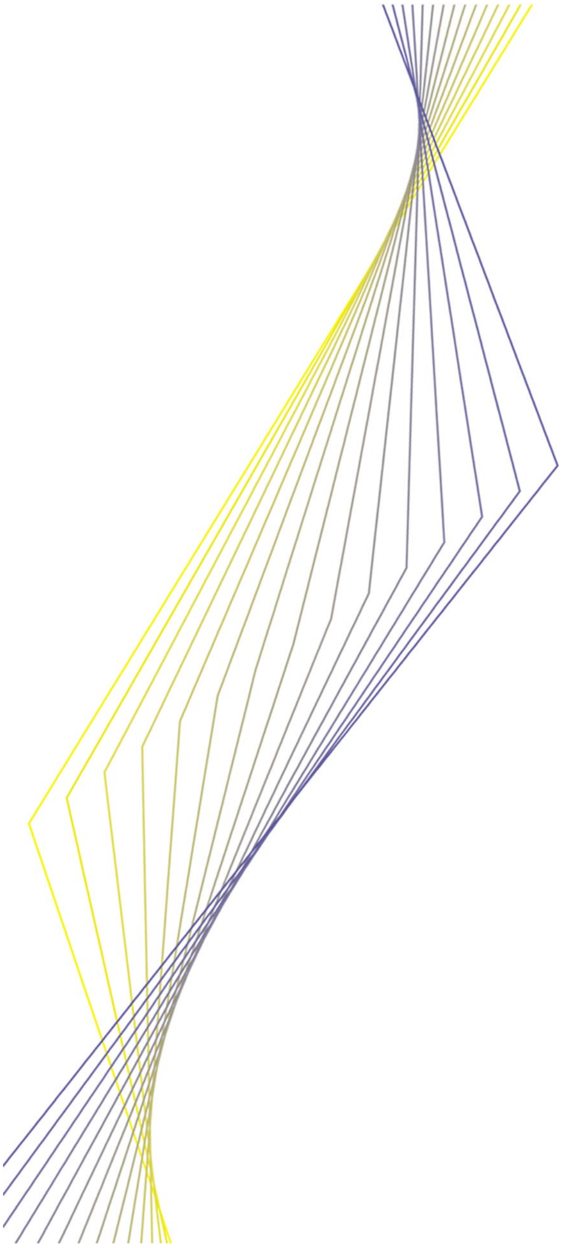
A MONEY DEMAND SYSTEM FOR EURO AREA M3

BY CLAUS BRAND
AND NUNO CASSOLA

November 2000

EUROPEAN CENTRAL BANK

WORKING PAPER SERIES



WORKING PAPER NO. 39

A MONEY DEMAND SYSTEM FOR EURO AREA M3

BY CLAUS BRAND
AND NUNO CASSOLA*

November 2000

---

* *European Central Bank, Kaiserstraße 29, 60311 Frankfurt am Main, Germany, Phone: +49-69-1344-6471/6415, Fax:+49-69-1344-7604, E-mail addresses: claus.brand@ecb.int, nuno.cassola@ecb.int. We gratefully acknowledge comments, insights and suggestions provided by an anonymous referee, Günter Coenen, Dieter Gerdesmeier, David Hendry, Kirstin Hubrich, Katharina Juselius, Geoff Kenny, Joaquim Levi, Helmut Lütkepohl, Klaus Masuch, Sergio Nicoletti-Altimari, Huw Pill, Mette Felding Schrøder, Juan-Luis Vega, Javier Valles and Jürgen Wolters. The views expressed in this paper represent exclusively the opinion of the authors and do not necessarily reflect those of the European Central Bank. The usual disclaimer applies.*

Address	**Kaiserstrasse 29** **D-60311 Frankfurt am Main** **Germany**
Postal address	**Postfach 16 03 19** **D-60066 Frankfurt am Main** **Germany**
Telephone	**+49 69 1344 0**
Internet	**http://www.ecb.int**
Fax	**+49 69 1344 6000**
Telex	**411 144 ecb d**

ISSN 1561-0810

Contents

Abstract

In order to assess the importance of monetary and financial developments for key macroeconomic variables in the euro area a money demand system for M3 is estimated adopting a structural cointegrating VAR approach. While maintaining a good statistical representation of the data, long-run relationships are based on economic theory. By using generalised response profiles the dynamics of the money demand system is investigated without any further identifying assumptions. Error bounds of the profiles are derived using bootstrap simulations.

JEL classification: C32, E41.
Keywords: Money demand, Fisher hypothesis, Term structure, Structural cointegrated VAR, response profiles.

1 Introduction

There is a large body of empirical literature on the estimation of money demand equations and on testing key arbitrage propositions in economic theory like the Fisher parity (linking interest rates and inflation) and the expectations hypothesis of the term structure of interest rates (linking long and short-term interest rates). However, a joint incorporation and testing of these relationships within multivariate time series models has been undertaken only recently.

By focusing on the monetary and financial sector of the economy, using euro area data from 1980 Q1 to 1999 Q3, this paper investigates how key long-run relationships among monetary and financial variables such as M3 and interest rates can be used to model the historical behaviour of variables that are of interest for the policy maker, in particular inflation and income growth. Among these long-run relationships, a stable demand function for real M3 plays a central role. Money demand in the euro area and in European Union countries has already been analysed by several authors (e.g. Coenen and Vega (1999), Fagan and Henry (1999), and Fase and Winder(1999)). These studies essentially offer single equation approaches to money demand. In contrast to this, we argue that the demand for euro area (real) M3 should be modelled within a system of equations similar to the ones suggested by Lütkepohl and Wolters (1999) for Germany, Hubrich and Vlaar (2000) for the euro area and Vlaar and Schuberth (1999) for 14 EU countries.

The system presented in this paper comprises three long-run relationships suggested by economic theory: (i) a demand for money function; (ii) a term structure equation and (iii) an equation related to the Fisher hypothesis. We argue that these relationships cannot be reduced into a single long-run money demand function and find evidence that reducing the system to a single money demand equation would incur in a loss of information.

In this study we follow the structural cointegration approach to macroeconometric modelling recently proposed by Pesaran and Smith (1998) and Garratt, Lee, Pesaran and Shin (1999a, 1999b). Thereby, while maintaining a good statistical representation of the data, the focus is on developing a macroeconometric model, where the structure of long-run relationships imposed on the model is obtained from economic theory, leaving the short-run dynamics of the model to be determined by the data. Thus, and in contrast to the studies by Coenen and Vega (1999), Hubrich and Vlaar (2000) or Vlaar and Schuberth (1999) we do not attempt to identify structural shocks by imposing restrictions on the covariance matrix of the innovation processes.

The following main findings emerge from this study. Firstly, deviations from the equilibrium mapped out by the three long-run relationships play a vital role in terms of explaining the dynamics of inflation, income, money and interest rates. Secondly, our findings suggest that there are no major distortions in the stability of the long-run money demand relationship with the advent of Stage Three of Economic and Monetary Union (EMU). Thirdly, the reference value for M3 growth announced in December 1998 and confirmed in December 1999 by the ECB can be derived from the steady state growth rates of real M3 and GDP implied by the model and the ECB's definition of price stability.

The remainder of this study contains two main parts. In the first part (section 2) the economic theory underlying the specification of the system is presented. Data description and analysis is presented in section 3. The econometric specification, estimation and testing of the model, including analysis of parameter stability is presented in section 4. Section 5 elaborates on how the concept of generalised impulse-response functions can be used to illustrate the dynamics in multivariate time series models and applies it to the money demand system. The main conclusions are presented in the final section.

2 The economics of the model

In this section the economic contents of the money demand system specified in this study are presented. The purpose of this is twofold. First, it serves to motivate the long-run relationships identified in the system. Second, it shows that shocks to the system equations cannot be easily identified with variable specific structural shocks. It should be stressed that no attempt is made to write down or estimate a fully specified structural model of the euro area economy.

The modelling strategy begins with an explicit statement of the long-run relationships between the variables in the model obtained from macroeconomic theory and approximated by log-linear equations. Short-run deviations from equilibrium are embedded within an otherwise unrestricted VAR model, which incorporates the structural long-run relationships as its steady-state solution.

The long-run relationships included in our model are relatively uncontroversial, as they appear in most theoretical and applied models of monetary economies, and can be motivated in different ways, either derived from explicit microfoundations or postulated as macroeconomic aggregate relationships. Our focus though is mainly on arbitrage conditions and standard portfolio theory. The model is closely related to the one presented in Garratt, Lee, Pesaran and Shin (1999a).

2.1 The core macroeconomic model

2.1.1 The Fisher inflation parity

The Fisher inflation parity (FH henceforth) can be seen as capturing the equilibrium outcome of the arbitrage process between holding bonds and investing in capital assets. The real rate of return on capital is given by

$$1+\rho_{t+1}=(1+\rho)\exp(\eta_{\rho,t+1}) \tag{1}$$

where $\eta_{\rho,t}$ is a stationary process with normalisation $E_t\left(\exp(\eta_{\rho,t+1})\right)=1$; $E_t\left(\cdot\right)$ is the expectation operator conditional on information available at time t. The FH can be expressed as:

$$(1 + R_t) = (1 + \rho_{t+1}) \left(1 + \frac{E_t\left(P_{t+1}\right) - P_t}{P_t}\right) \exp(\eta_{fh,t+1}) \tag{2}$$

where $(1 + R_t)$ is the gross nominal return on holding a long-term bond over one period (from t to $t + 1$), $\eta_{fh,t}$, is a risk premium assumed to follow a stationary process, and $\frac{E_t(P_{t+1})-P_t}{P_t}$, is expected, one period ahead inflation with

$$E_t\left(P_{t+1}\right) = P_{t+1} \exp(\eta_{pe,t+1}). \tag{3}$$

In (3), expectation errors, $\eta_{pe,t+1}$, are assumed to be uncorrelated and with $E_t\left(\exp(\eta_{pe,t+1})\right) = 1$. Combining (2), (3) and (1) we get, in terms of observable variables:

$$(1 + R_t) = (1 + \rho) \left(1 + \frac{P_{t+1} - P_t}{P_t}\right) \exp(\eta_{fh,t+1} + \eta_{pe,t+1} + \eta_{\rho,t+1}) \tag{4}$$

When the tax system is not indexed after-tax real rates of return will be more relevant for the saving and portfolio decisions of economic agents. If nominal income is subject to taxes, for a given pre-tax real return the after-tax real return is decreasing in the rate of inflation. In the steady-state nominal interest rates thus have to rise more than proportionately with an increase in inflation. The FH should be adjusted for tax effects taking into account that in the steady-state (in terms of observable variables):

$$\frac{\partial(1 + R_t)}{\partial\left(1 + \frac{P_{t+1}-P_t}{P_t}\right)} = \varphi \tag{5}$$

where $\varphi = \frac{(1+\rho)}{(1-\tau)} \geq 1$ and τ is the marginal tax rate (see Walsh (1998, p. 173)).

2.1.2 Money demand

A long-run money demand function for a broad monetary aggregate like M3 can be derived within a portfolio balance approach. The long-run solvency constraint of the private sector is given by

$$\frac{L_{t+1}}{Y_t} = \mu \exp(\eta_{ly,t+1}), \tag{6}$$

where $\mu > 0$ and $\eta_{ly,t+1}$ is a stationary process, so that the private sector asset/liability position measured as the ratio of total financial assets, L_{t+1}, to the nominal income level, Y_t, is stationary. Stocks are measured at the beginning of the period to which they are indexed.

The desired level of M3 in the stock of financial assets held by the private sector is given by

$$\frac{M_{t+1}}{L_{t+1}} = F\left(\frac{Y_t}{P_t}, \rho_{b,t+1}, \rho_{m,t+1}\right) \exp(\eta_{m,t+1}) \tag{7}$$

where $\rho_{b,t+1} = \frac{(1+R_t)}{\left(1+\frac{E_t(P_{t+1})-P_t}{P_t}\right)} - 1$, and $\rho_{m,t+1} = \frac{(1+O_t)}{\left(1+\frac{E_t(P_{t+1})-P_t}{P_t}\right)} - 1$ are, respectively, the expected real rates of return on domestic long-term bonds and M3; $(1+O_t)$ is the gross own rate of return on M3; $\eta_{m,t+1}$ is a stationary process which captures the effects of various factors that contribute to the short-run deviations of the ratio of M3 to total financial assets from its long-run determinants. The asset demand function can be written as:

$$\frac{M_{t+1}}{L_{t+1}} = \digamma\left(\frac{Y_t}{P_t}, R_t - O_t\right)\exp(\eta_{m,t+1}) \tag{8}$$

where the expected real returns were replaced by the nominal interest rate differential. Combining (6) with (8), gives

$$\frac{M_{t+1}}{Y_t} = \mu\digamma\left(\frac{Y_t}{P_t}, R_t - O_t\right)\exp(\eta_{m,t+1} + \eta_{ly,t+1}) \tag{9}$$

Hence, the inflation rate is cancelled from the portfolio balance equation.

2.1.3 The term structure of interest rates

The inclusion of a short–term interest rate equation in the model might be interpreted as reflecting an underlying monetary policy reaction function. However, there was no single unified monetary authority in the countries now participating in Stage Three of EMU, and given the diversity of inflation experiences in the participating countries, reflecting the varying degrees of their respective central banks' credibility and monetary policy strategies, there should be no simple equation (or rule) describing the euro area aggregate behaviour. Therefore, whereas the short-term interest rate should depend on all variables in the macroeconomy, shocks to the short-term interest rate equation cannot be identified in a simple way with ”pure” monetary policy innovations. One way of modelling how short-term interest rate developments affect the macroeconomy is through the slope of the yield curve.

The expectations hypothesis. According to the (local) expectations theory of the term structure of interest rates (EHTS, henceforth), the one period expected returns on all securities must be equal. The EHTS can be expressed in logarithmic form as:

$$l_t = \frac{1}{n}\sum_{j=0}^{n-1} E_t\left(s_{t+j}\right) + \phi_l, \tag{10}$$

where, $l_t = \ln\left(1+R_t\right)$; l_t, is expressed as an average of expected one period log yields, $E_t\left(s_{t+j}\right)$; and ϕ_l is a possibly time-invariant but maturity dependent term premium; n is the maturity of the bond.

Subtracting s_t from both sides of (10) we get:

$$l_t - s_t = \frac{1}{n} \sum_{j=0}^{n-1} E_t \left(s_{t+j} - s_t \right) + \phi_l. \tag{11}$$

If s_t is a non-stationary, $I(1)$, variable then $\sum_{j=0}^{n-1} E_t \left(s_{t+j} - s_t \right)$ is stationary. Then, if l_t is also a non-stationary, $I(1)$, variable the EHTS implies that the spread, $l_t - s_t$, is a stationary $I(0)$ variable, that is, the short- and the long-term interest rates must cointegrate with cointegrating vector $\begin{pmatrix} -1 & 1 \end{pmatrix}$.

Consider a steady-state characterized by $E_t \left(s_{t+j} - s_t \right) = 0$. Then,

$$l_t - s_t - \phi_l = \eta_{ehts,t+1} \tag{12}$$

where, $\eta_{ehts,t+1} = \frac{1}{n} \sum_{j=0}^{n-1} (E_t \left(s_{t+j} - s_t \right) - \left(s_{t+j} - s_t \right))$, are innovations to the short-term interest rate process with $E_t(\eta_{ehts,t+1}) = 0$.

2.1.4 Summary of the log–linear approximation of the model

A log-linear approximation of (4) and (9) is needed for estimation purposes

$$l_t = \widetilde{r} + \varphi \pi_{t+1} + \varepsilon_{fh,t+1} \tag{13}$$

$$(m_{t+1} - p_t) = \ln \mu + \beta_y y_t - \beta_l (l_t - o_t) + \varepsilon_{mp,t+1}, \tag{14}$$

where $y_t = \ln(\frac{Y_t}{P_t})$, $(m_{t+1} - p_t) = \ln(\frac{M_{t+1}}{P_t})$, $l_t = \ln(1 + R_t)$, $o_t = \ln(1 + O_t)$, $\pi_{t+1} = \ln \left(1 + \frac{P_{t+1} - P_t}{P_t} \right)$, $\widetilde{r} = \ln(1 + \rho) + E(\eta_{fh})$; $\tilde{r}$ is the sum of the long–term real interest rate with the risk premium. The risk premium is $E(\eta_{fh})$ not necessarily equal to zero; $\varepsilon_{fh,t+1}$, and $\varepsilon_{mp,t+1}$, are innovations which are related to the structural innovations as follows:

$$\begin{aligned} \varepsilon_{fh,t+1} &= (\eta_{fh,t+1} + \eta_{pe,t+1} + \eta_{\rho,t+1}) - (E(\eta_{fh} + ln(1 + \rho))), & (15) \\ \varepsilon_{mp,t+1} &= \eta_{m,t+1} + \eta_{ly,t+1}. & (16) \end{aligned}$$

As Garratt, Lee, Pesaran and Shin (1999b) point out it is not always possible to identify structural innovations from the reduced form disturbances. From this it is evident that structural shocks cannot easily be identified with variable specific shocks.

3 Description of the data

3.1 The construction of euro area aggregates

In this study quarterly data from 1980Q1 through 1999Q3 are used. As a measure of M3 quarterly averages of the month-end stocks of M3 are used (Source: ECB, in millions of euro, seasonally adjusted).[1] Until 1997Q3 M3 data are based on stocks; from 1997Q4 on flow statistics. Nominal and real GDP until 1994Q4 is calculated based on ESA79 system of national accounts. From 1995Q1 the series is extended using ESA95 quarter-over-quarter growth rates. Nominal GDP is in millions of euro and has been seasonally adjusted and converted to euro via the irrevocable fixed conversion rates of 31 December 1998. The real and nominal GDP series are used to construct the GDP deflator. Short-term rates are 3-month money market interest rates and long-term interest rates are 10 year government bond yields or close substitutes. From 1999 onwards the EURIBOR is used as 3-month money market rate. Interest rates are measured as averages of the respective euro-11 interest rates using GDP weights at purchasing power exchange rates in 1995. Except interest rates, all data are in logs. In the analysis interest rates have been divided by 400 to facilitate the assessment of relationships between interest rates and quarter-over-quarter growth rates in the variables. The data can be found in Appendix A. The underlying national series are taken from the macroeconomic database provided by the BIS.

3.2 The yield on alternative financial assets: the role of the own rate and money market interest rates

In order to capture how the demand for real M3 is affected by yields of alternative financial assets it is crucial to find an appropriate measure comparing the own yield of M3 with that of alternative financial instruments ($R_t - O_t$). A broad monetary aggregate like M3 comprises not only currency in circulation (about 7%) but also a number of components that are remunerated. A possible approach to measure the opportunity costs of holding M3 is to use the spread between long- and short-term interest rates as in Coenen and Vega (1999). Thereby the short–term rate can be thought of as approximating the own rate of return on M3.

In fact, the own rate on M3 and the short-term market rate appear to exhibit similar trend behaviour as illustrated in Figure 1. However, it is also evident that not only the levels but also the dynamics of the two series are quite different. Therefore it is not obvious that the short-term interest rate provides a reliable approximation for the own rate of M3.[2]

The problems with using the short-term money market interest rate as a proxy for the own rate of M3 is more apparent when the differential between the long-term interest rate and the own rate of M3 is compared with the market spread (long-term minus short-term market interest rates). As Figure 2 suggests the stochastic

---

[1] The main components of M3 are currency in circulation and overnight deposits (M1), other short-term deposits (M2-M1: deposits with an agreed maturity of up to two years; deposits redeemable at notice up to three months) and marketable instruments (M3-M2: repurchase agreements; debt securities issued with a maturity of up to two years; money market fund shares/units and money market paper).

[2] The own rate series used in Figure 1 through Figure 3 was constructed from German, French, Italian, Spanish and Dutch interest rates aggregated using ECU conversion rates. In terms of GDP ratios, these data capture more than 80% of the euro area.

properties of these measures are quite different. In Figure 2 the differential between the short-term interest rate and the rate of return on M3 is also shown to further emphasise the problem.

It appears that movements in the market spread only gradually pass through to what is the "true" opportunity cost measure, indicating that the spread comprising the own rate adjusts to movements in the market spread in an imperfect and sluggish manner. However, due to the low volatility of the own rate of M3 there is a strong resemblance between the dynamics of the long-term interest rate and the spread constructed using the own rate. Figure 3 illustrates that the dynamics of the spread of the long-term interest rate against the own rate of M3 is almost fully captured by the dynamics of the long-term interest rate. This suggests that the long-term interest rate may be a better measure of opportunity costs than the market spread. The exclusion of the own rate has the advantage of reducing the complexity of the model. The incorporation of an opportunity cost measure constructed from long-term rates and the own rate as a separate variable would drastically impair the empirical analysis of how short-term rates (the policy instrument of the monetary authority), long-term rates, inflation, money and income are related to each other.

3.3 Time series properties of the data

Standard unit root tests confirm the results found in the money demand studies quoted in section 1. The null of non-stationarity of real M3 ($(m-p)_t$), inflation (π_t), the short-term interest rate (s_t), the long-term interest rate (l_t), and real GDP (y_t) cannot be rejected.[3]

A critical perspective on the reported unit root tests should be taken at this stage. The stability-oriented monetary policy by the Eurosystem can be expected to be reflected in the stochastic properties of the data namely of inflation, nominal and real short– and long– term interest rates. The nominal variables are likely to become mean reverting $I(0)$ processes. The others will possibly remain stationary processes although reverting to lower means. Thus, if a shift in the level of the (measured) real short- and long-term interest rate occurs, this would lead to non-rejection of non-stationarity in real interest rates when using conventional ADF tests.

It should be noted that the euro-area short term interest rate displays significant volatility around periods of ERM realignments, namely in 1982/83 and in 1993 (see Figure 4). The problem with aggregating euro area short-term interest rates when modelling the demand for money at the euro area level is that portfolio shifts away from currencies that were expected to devalue in favour of currencies that were expected to appreciate cancel out when aggregating M3. However, the increase in volatility of short–term interest rates due to foreign exchange pressures does not cancel out when aggregating. This introduces an artificial distortion in the data possibly creating "outliers" in the equation for short–term interest rates.

---

[3] In order to save space the results are not presented here. They are available from the authors upon request.

4 Model specification, estimation and testing

4.1 The structure of the model

Following the economic model presented in section 2 the stationary combinations of the $I(1)$ variables $(m-p)_t$, π_{t+1}, l_t, s_t and y_t can be written as follows[4]

$$\varepsilon_t = \beta^{'} z_{t-1} - a_0 \tag{17}$$

where

$$z_t = \begin{pmatrix} (m-p)_t & \pi_{t+1} & l_t & s_t & y_t \end{pmatrix}'$$

$$a_0 = \begin{pmatrix} \tilde{r} & ln(\mu) & \phi_l \end{pmatrix}'$$

$$\beta' = \begin{pmatrix} 0 & -\varphi & 1 & 0 & 0 \\ 1 & 0 & \beta_l & 0 & -\beta_y \\ 0 & 0 & 1 & -1 & 0 \end{pmatrix}$$

$$\varepsilon_t = \begin{pmatrix} \varepsilon_{fh,t} & \varepsilon_{mp,t} & \varepsilon_{ehts,t} \end{pmatrix}'.$$

The vector ε_t is embodied in an otherwise unrestricted VAR system in Δz_t:

$$\Delta z_t = b_0 - \alpha\varepsilon_t + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + u_t, \tag{18}$$

where b_0 and u_t are $(n \times 1)$ vectors of fixed intercepts and serially uncorrelated shocks, respectively and α is a $(n \times r)$ matrix of error-correction coefficients, and $\{\Gamma_i, i = 1, 2, ..., p-1\}$ are $(n \times n)$ matrices of short-run coefficients. Furthermore, $E(u_t) = 0$ and $E(u_t u_t') = \Sigma$. In our case $n = 5$ and $r = 3$. Using (17), we have

$$\Delta z_t = b_0 + \alpha a_0 - \alpha\beta' z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + u_t. \tag{19}$$

We consider two cases:

(i) The intercept is restricted to the long-run model (cointegration space): $b_0 = 0$. It means that there are no linear trends in the levels of the data and first-differenced series have a zero mean. The error correction term becomes $(a_0 - \beta' z_{t-1})$.

(ii) The intercept in the cointegration vectors is cancelled by the intercept in the short-run model: $\alpha a_0 = 0$. It means that there are linear trends in the levels of the data and first-differenced series have a non-zero mean. The error correction term becomes $\beta' z_{t-1}$.

---

[4] In the estimation π_t is used instead of π_{t+1}.

Economic theory suggests that in the steady state first differences in short- and long-term interest rates and in inflation, should have zero unconditional means whereas the first differences in real M3 and real GDP should have non-zero means. In fact, it seems implausible for interest rates (or inflation) to exhibit deterministic trends, but real GDP and, possibly, real balances should normally have a trend. Thus, whereas Model (i) seems to be more appropriate for the first three variables Model (ii) seems to be appropriate for the last two.

The null hypothesis that there are at most r cointegrating vectors, and thus $n - r$ unit roots, is tested using the trace test statistic presented and tabulated in Johansen and Juselius (1990). The two models were estimated and the results are presented in Table 2 from the most restrictive alternative ($r = 0$ and Model (i)) through to the least restrictive alternative ($r = n - 1$ and Model (ii)).[5] The test procedure suggested by Johansen (1992) is to move through from the most restrictive model and at each stage to compare the trace test statistic to its critical value and only stop the first time the null hypothesis is not rejected. The first time the null is not rejected is indicated in bold. Accordingly, the procedure suggests that we should accept that there are three cointegration vectors ($r = 3$) and that there are deterministic trends in the levels of the data (Model (ii)).

Testing for cointegration relationships and identifying assumptions has to be carried out within a correctly specified system.[6] Model adequacy tests applied to the residual processes of the unrestricted system show that there is only a minor problem with normality in the short-term interest rate equation, due to excess kurtosis (Tables 3 and 4).

4.2 Identification of long-run relationships

Identification of the cointegration space requires imposing $r(r-1)$ linear independent restrictions after arbitrary normalisation of each vector in β. Identification of the money demand function is achieved by excluding inflation and the short-term interest rate from the first cointegrating vector; identification of the second cointegrating vector is achieved by excluding real balances, GDP and the short-term interest rate; and identification of the third cointegrating vector is achieved by excluding inflation, GDP and real balances from the third cointegrating vector. These six restrictions exactly identify the system. The exclusion of real output from the second and the third cointegrating vectors and the homogeneity restriction in the EHTS are three over-identifying restrictions that play a crucial role in testing the economic theory. The estimates of the restricted cointegration vectors are reported in Table 6.[7] The three over-identifying restrictions are not rejected and thus we

---

[5] The estimation and testing of the model was carried out in PCFiml 9.0 (Doornik and Hendry (1997)).

[6] The VECM has two lags selected by standard information criteria like Akaike's information criterion.

[7] Note that the second cointegrating vector is normalised in π_t and not in l_t as in (13). Thus the coefficient displayed in the table is $\frac{1}{\varphi}$.

may conclude that the theoretical assumptions underlying our specification are not rejected by the data (see Table 5).

We tested for two additional over-identifying restrictions that, although not playing a determinant role in testing the economic theory, are interesting in its own right. The first is unitary income elasticity of money demand which, if not rejected, would allow rewriting the money demand function as a velocity equation. The second is homogeneity in the Fisher relation. Both over-identifying restrictions are rejected (see Table 5). Therefore our identified and over-identified cointegrating vectors are those displayed in Table 6.

Rejection of homogeneity in the Fisher relation can be attributed to different factors. One reason alluded in the text is that tax effects imply that the coefficient of the long-term rate (normalising the vector in inflation) should be greater than -1. A back-of-the-envelope calculation can be made to check whether the estimated coefficient is reasonable. Consider $\rho = 0.95$ which corresponds to a real interest rate of $5\%[1/(1.05)]$. It follows that $(1-\tau) = 0.67/0.95 = 0.70 => \tau = 0.3$ which seems to be a plausible estimate for an euro area marginal tax rate, although on the upper side. Nevertheless, our estimate is in line with the findings of Mishkin (1992) for US data, where it is also shown that the coefficient of inflation in the Fisher relation may take different values, for purely statistical reasons, depending on the variability of the level of inflation in relation to the variability of the real interest rate.[8]

The estimated long-run income elasticity of money demand is 1.33, which suggests that wealth may be an important determinant of the demand for real M3 in the euro area (see Fase and Winder (1999)). The interest rate semi-elasticity of money demand is -1.61. It should be emphasized that under stationarity of the interest rate spread, equilibrium short- and long- term interest rate semielasticities are not individually identified. Essentially the same money demand equation would be obtained if the long-term rate instead of the short-term rate were excluded from the money demand function. Our choice is motivated by economic theory (portfolio balance), as is the exclusion of inflation from the money demand equation as opposed to e.g. Hubrich and Vlaar (2000).

4.3 Weak exogeneity

Each of the r non-zero columns of $\hat{\alpha}$ contains information about which cointegration vector enters which short-run equation and on the speed of the short-run response to disequilibrium. If all entries in row i of α_{ij}, $i = 1, \ldots, n$, $j = 1, \ldots, r$ are zero, the cointegration vectors in β do not enter the equation determining Δz_{it}. This means that when estimating the parameters of the model there is no loss of information from not modelling the determinants of Δz_{it}; thus this variable is weakly

---

[8] The rejection of homogeneity in the Fisher relation may also be due to “peso problems”, that is, systematic overprediction of inflation by market participants. Another reason could be a time–varying risk premium which could be dependent on the level or on the variability of inflation. A comparison and assessment of these competing explanations is, however, beyond the scope of this paper.

exogenous to the system and can enter on the right-hand side of the VECM.

Weak exogeneity tests were carried out by firstly testing the joint exclusion of all cointegration vectors from each equation; and secondly, by testing for the exclusion of each cointegration vector individually from each equation. In doing so the long–run relationships $\beta' z_{t-1}$ have been kept fixed. According to the tests reported in Table 7 weak exogeneity is rejected for all variables included in the analysis. The main conclusions are as follows:

(i) The vector representing deviations from equilibrium real M3 (monetary overhang) enters the equation for changes in real M3 and the short-term interest rate. Due to the inclusion of an intercept in the equation for changes in inflation it is difficult to assess the role of the monetary overhang. The inclusion of the intercept implies that low-frequency movements in inflation are generated by an independent time trend. However, if inflation is regarded as monetary phenomenon, low-frequency movements in inflation should rather be linked to the trend in money. Due to multicollinearity it is difficult to distinguish, on statistical grounds, which one should enter the inflation equation. Since the inclusion of both improved the forecasting performance of the model, both were kept.

(ii) The vector representing deviations from the (adjusted) Fisher inflation parity enters the equation for changes in inflation and changes in long-term interest rates. This is in line with the Fisher hypothesis (see Engsted (1995) and Shiller and Siegel (1997)).

(iii) The slope of the yield curve enters the equation for changes in real GDP, confirming previous results on the leading indicator properties of the slope of the yield curve for future output growth (see Estrella and Mishkin (1997)); and also the equation for changes in the short-term interest rate which is in line with the EHTS (see Engsted and Tangaard (1994)).

In Tables 10 through 14 the estimates of a parsimonious model are shown where the short run dynamics is simplified such that only coefficients with t-ratios above 1 (in absolute value) are left in the model.[9] Two features are worth mentioning. Firstly, the positive and statistically significant relation between changes in the short-term interest rate and changes in inflation (Table 11). This should be interpreted as a short-term Fisher effect. Secondly, the positive and statistically significant relation between changes in real balances and GDP growth which suggests a role of real balances independent of the interest rate channel in the transmission mechanism of monetary policy in the euro area (Table 14).

---

[9] According to tests of overidentifying restrictions the parsimonious representation is not rejected by the data.

4.4 Recursive estimates of long-run relationships

For the purposes of this study the stability of the detected relationships over recent years is of utmost importance. For that reason model coefficients have been estimated recursively as well as a number of diagnostic test statistics computed using the sample range 1994Q1 to 1999Q3. The results suggest that no major breaks can be observed, in particular since the start of Stage Three of EMU in 1999 Q1. This is evident from recursive estimates of all model coefficients, the trace test statistic, the log-likelihood and one-step-ahead out-of-sample forecasts. In order to save space we focus only on the results for the long-run money demand coefficients. The remaining results are available from the authors upon request.

Figure 6 shows the time paths of the parameters in the first cointegration vector, the money demand function. Over the recent past the money demand relationship has remained stable. In addition Figure 7 shows the recursive residuals of the VECM. On the right hand side the panel at the bottom displays a recursive Chow test showing that we cannot detect a break over the last 5 years.

5 Generalised impulse response functions and persistence profiles

5.1 In search of the macroeconomic time series facts:

identification problems

There is a wide range of empirical studies dealing with the identification and transmission of monetary policy. Identifying monetary policy is not only desirable in order to assess its stance compared to what it was under similar macroeconomic conditions, it is also necessary to evaluate alternative theories of the monetary transmission mechanism and the quantitative effects of policy changes on various macroeconomic variables. These judgements must be based on objective means of determining the direction and size of changes in the policy stance. The most important strand of literature is thereby based on multivariate time series models that identify statistical innovations in monetary aggregates or short–term interest rates with monetary policy actions (Bernanke and Blinder (1992), Bernanke and Mihov(1995), Christiano and Eichenbaum (1992), Shapiro (1994), Sims (1980), 1992)). While focusing on a good statistical representation of the data, the objective of using vector autoregressions originally pursued in Sims (1980) was to detect stylised or "macroeconomic time series facts" about the behaviour of an economy using minimal assumptions about the underlying structure of the economy.

Consider the underlying n-dimensional cointegrated *VAR* of lag order p in terms of the levels of the variables. Its first order Markov-representation corresponding to (18) would be

$$Z_t = AZ_{t-1} + U_t \tag{20}$$

with

$$A = \begin{pmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I_n & 0 & \cdots & 0 & 0 \\ \vdots & & \ddots & & \vdots \\ 0 & 0 & \cdots & I_n & 0 \end{pmatrix}, \quad Z_t = \begin{pmatrix} z_t \\ z_{t-1} \\ \vdots \\ z_{t-p+1} \end{pmatrix}, \quad U_t = \begin{pmatrix} u_t \\ 0 \\ \vdots \\ 0 \end{pmatrix},$$

where A is referred to as companion matrix and where, for simplicity, in (19) $b_0, a_0 = 0$. Equation (18) would be derived using

$$\begin{aligned} \Gamma_i &= -(I_n \quad - A_1 - \cdots - A_i) \\ \Pi &= (I_n \quad - A_1 \quad - \cdots - A_p). \end{aligned}$$

In multiple time series analysis, impulse response analysis is a conventional tool of assessing how the variables in the system interact with each other over time. The concept can basically be thought of as tracing out how the variables will deviate from the path predicted by the model if there is a forecast error with respect to one specific equation at time t. Unforeseen movements in one variable are referred to as shocks and the state of the economy at time $t+m$ as responses. The response sequences are implied by the transfer function representation of (20). From $Z_t = (I_{np} - AL)^{-1}U_t$ (where L denotes the lag-operator, so that $L^i Z_t = Z_{t-i}$, $i = 1, 2, \ldots$), the transfer function representation is given by

$$Z_t = (I_{np} + AL + A^2L^2 + \cdots + A^iL^i + \cdots)U_t.$$

Hence, the response of z_t at time m to a shock of size δ (δ denotes a unit size shock in variable $i = 1, \ldots, n$) in u_t at time t ($m = 0, 1, 2, \ldots$) is given by

$$E_{t-1}(z_{t+m}|u_t = \delta) - E_{t-1}(z_{t+m}) = JA^mJ', \tag{21}$$

where $J = (I_n \quad 0_{n\times(pn-n)})$; JA^mJ' is equal to the upper left hand $(n \times n)$ block of the companion matrix A raised to power m.

However, unless the error covariance matrix Σ is a diagonal matrix, the shocks in u_t will not occur independent from each other. In the money demand system presented here there are some significant contemporaneous correlations among the shocks, so that forecast errors cannot be attributed to one equation alone (Table15). The conventional practice in the VAR literature is therefore to impose $n(n-1)/2$ restrictions on the elements of matrix T in

$$\Sigma = TDT',$$

where $D = E(v_tv_t')$ is the diagonal covariance matrix of orthogonalised innovations, and letting the remaining $(n(n+1)/2)$ open. The aim of this is to identify variable specific shocks. The resulting responses to orthogonalised responses is given by $E_{t-1}(z_{t+m}|u_t = \delta) - E_{t-1}(z_t) = TJA^mJ'$. The number of exactly identifying restrictions increases tremendously with the dimension of the process.

Thereby Sims (1980) adopted a Wold-ordering scheme, resulting in a triangular shape of T, whereas Bernanke (1986) used a more generic approach. The approach followed in Blanchard and Quah (1989) imposes zero restrictions on the long-run effect of structural shocks of particular endogenous variables. King, Plosser, Stock and Watson (1991) take into account that in correspondence with the cointegration rank the number of innovations with permanent effects is equal to the number of common trends.

This has several drawbacks. It is well known that the resultant shape of impulse responses will heavily depend on the choice of structure imposed on the system (Lütkepohl (1992, Chapter 2)). The imposed structure is always to a large extent arbitrary. There may also be more shocks hitting the economic system under investigation than actually identified, as it may be the case with the model presented in section 2. Consequently, it is difficult to identify the shocks hitting the system. The different types of shock are based on their respective statistical properties. Therefore, neither the shocks nor the long-run relationships are identified using an economic model. The experience with VARs over the last decades shows that the results are often inconsistent with what might be presumed from traditional monetary theory. These phenomena termed “liquidity puzzle” or “price puzzle” are usually explained by the failure to identify autonomous actions of the central bank, so that the effects are contaminated by non–policy components as argued in Sims (1992). Neither would the approach provide a theoretically neutral way of statistically summarising the dynamics of the system. In particular, the response functions will fail to reveal how the variables have been interacting with each other over time.

5.2 Detecting the true historical pattern: a non-structural approach to dynamic analysis

5.2.1 Generalised response profiles

In consideration of the difficulties surrounding the identification of shocks Pesaran and Shin (1996, 1998) have suggested a theoretically neutral way of deriving impulse responses that takes into account the information on the correlation of errors contained in Σ. This concept is suitable to unambigously detect the dynamics among the variables as it is implied by a specific VAR. To stress the difference with structural VARs responses are refered to as generalised impulse responses or, persistence or time profiles of responses respectively. In equivalence to Pesaran and Shin (1996, 1998) it can be argued that given the information on the correlation structure a one standard error "shock" of size $\sqrt{\sigma_{jj}}$ in equation *j* will actually occur within a vector of errors. Let R denote the matrix of correlations implied by the structure of Σ:

$$R = \begin{pmatrix} \rho_{11} & \rho_{12} & \cdots & \rho_{1n} \\ \rho_{21} & \rho_{22} & & \vdots \\ \vdots & & \ddots & \vdots \\ \rho_{n1} & \cdots & \cdots & \rho_{nn} \end{pmatrix}.$$

Due to this correlation structure, a one standard error innovation in the jth equation will then be equivalent to errors in equations $j = 1, \ldots, n$ of the size

$$E_{t-1}(z_t | u_t = e_j) - E_{t-1}(z_t) = e_j = \\ (\rho_{1j}\sqrt{\sigma_{jj}} \quad \cdots \quad \rho_{2j}\sqrt{\sigma_{jj}} \quad \cdots \quad \rho_{nj}\sqrt{\sigma_{jj}})',$$

which is equal to

$$e_j = (\sigma_{1j}/\sqrt{\sigma_{jj}} \quad \cdots \quad \sigma_{2j}/\sqrt{\sigma_{jj}} \quad \cdots \quad \sigma_{nj}/\sqrt{\sigma_{jj}})'.$$

Hence, the $(n \times 1)$ vector e_j summarises how the model fails to forecast all the variables if there is a one standard error innovation in the jth equation. This can also be regarded as the contemporaneous response of the variables in response to a shock $\sqrt{\sigma_{jj}}$. Since there are possibly n such typical shocks, and therefore n e_j-vectors, the contemporaneous responses can be collected in the $(n \times n)$ matrix

$$\mathcal{E} = (e_1 \quad \cdots \quad e_j \quad \cdots \quad e_n).$$

Thereby, the ith row of matrix $\mathcal{E}$ reflects the contemporaneous error in variable i in response to one standard error innovations in all $j = 1, \ldots, n$ variables of the VAR system.

In equivalence to Pesaran and Shin (1996, 1998) and as extension to (21) the sequence of generalised impulse responses can thus be calculated as:

$$\Psi^g(m) = E_{t-1}(z_{t+m} | u_t = e_j) - E_{t-1}(z_{t+m}) = JA^m J'\mathcal{E}. \qquad (22)$$

This measures the effect of a one standard error shock to the jth equations at time t on expected values of the variables at time $t + m$.

It should be noted that the response profiles derived in this way are not conveying information about economic causation among the variables. The exercise can be thought of as tracing out how the observation of a forecast error in one equation of the system would lead to revisions in the forecast path of all model variables. However, it is impossible to draw conclusions about structural relationships that are causing these empirical regularities.

5.2.2 Persistence profiles

As an alternative way of assessing the speed of convergence, Pesaran and Shin (1996), suggest to compute 'persistence profiles' of cointegration relationships, i.e. the time profile of responses of the cointegrating relationships to a 'system wide shock'. Thereby a system wide shock is calculated as a joint unitary shock to the cointegrating relationships, again taking into account the correlation structure in the innovations.

$$\begin{aligned} \Xi(m) = {} & [diag^{-1}(\beta'\Sigma\beta)^{-1/2}]' \\ & [(\beta' J A^m J')\Sigma(\beta' J A^m J')'][diag^{-1}(\beta'\Sigma\beta)^{-1/2}], \end{aligned} \tag{23}$$

where $\Xi(m)$ is of dimension $(r \times r)$.[10] The profile $\Xi(m)$ provides information on the speed with which the effect of system-wide shocks on the cointegration relation $\beta' z_t$ will disappear. Again, the resultant time profile is unique and does not require assumptions about the nature of shocks hitting the system.

5.2.3 Statistical inference for generalised response profiles

The pure shape of impulse response functions is not fully informative of whether a detected reaction path is also meaningful in a statistical sense. It has therefore become common practice also to display error bands around the resultant sequences to gain a closer insight into the duration and size of a specific reaction. The asymptotic distribution of generalised response profiles has been investigated in Pesaran and Shin (1996, 1998) by drawing on the analysis of cointegrated VARs adopted in Lütkepohl and Reimers (1992).

Given the size of the sample period at hand it appears to be more robust to rely on the actual small sample distribution rather than asymptotic results. In order to do so, we simulate the small sample distribution of response and persistence profiles by generating large numbers of artificial observations from the actual data set and the estimated residuals. This amounts to producing confidence bands in a non-parametric way. A more detailed description of the procedure can be found in Annex B.

---

[10] The operator $diag^{-1}(\beta'\Sigma\beta)$ is writing the diagonal elements of $(\beta'\Sigma\beta)$ into a diagonal matrix of the same dimension and $(\cdot)^{-1/2}$ refers to an elementwise operation.

5.3 Speed of adjustment to equilibrium and dynamic interaction among the variables

5.3.1 Persistence profiles

The persistence profiles illustrate how quickly the long-run relationships will be re-established if the system is hit by a system wide shock (Figure 8). To obtain a simple summary of the persistence profile it is helpful to look at the ’half-life’ measure describing the time horizon over which the profile falls to $\frac{1}{2}$. Figure 8 shows that whereas the Fisher parity needs just one quarter to get half-way back to its equilibrium, this takes 7 quarters for money demand and 11 quarters for the yield spread. Moreover, within just 2 quarters the Fisher parity can be expected to have fully converged to equilibrium again. This suggests that changes in inflation expectations rapidly feed into long-term interest rate movements. Changes in inflation expectations are quickly reflected in long-term rates, but other variables need more time to adjust. Long-term rates adjust much quicker than short-term rates, because these are smoothed by central banks. So, if long-term rates go up this may lead to a steepening of the spread, which is prevailing longer than deviations from the Fisher parity.

5.3.2 Generalised response profiles

The M3 VECM implies a specific pattern of how money, inflation, income and interest rates interact with each other over time. In this section, the pattern of interaction is illustrated in a neutral way drawing on the concept of generalised impulse responses. The sequences are computed using the parsimonous model specification presented in section 4.

Consider a forecast error in one equation of the system. Generalised impulse response analysis can be thought of as tracing out the implications of that forecast error in terms of revisions in forecasts of all variables included in the model. Let us consider the response profiles of the variables to some forecast errors.

Suppose that for some reason GDP growth is above, by one standard error, what the model would have predicted. No structural interpretation of this deviation is given. At the bottom panel in Figure 9 we can see that this would imply a persistent upward revision in the rate of growth of real M3; at the bottom panels in Figures 10 to 12 we see that this would also be accompanied by upward persistent revisions in the forecasts of the paths for inflation, short- and long-term interest rates.

Suppose now that, for some reason, short-term interest rates are above, by one standard error, what the model would have predicted. Again no structural interpretation of this deviation is given and, in particular, we do not identify this shock with a “pure” monetary policy surprise. At the left hand side in the middle panel in Figure 9 we can see that this would imply a persistent downward revision in the rate of growth of real M3; and at the left hand side in the midle panel in Figure 13 we can see that this would also imply a persistent downward revision in the rate of growth of GDP. In contrast by looking at Figures 10 and 12 (left hand side in the midle panels) we can see that upward revisons in forecasts of inflation and long-term interest rates would be implied.

Suppose now a one standard (forecast) error in the inflation equation. By looking at the right hand side in the upper panels in Figures 9, 11, 12 and 13 we can see that this would lead to upward and persistent revisons in forecasts of interest rates (short- and long-term) but would not imply upward persistent revisons in the forecasts of GDP growth and real M3. Whilst avoiding structural interpretations it seems interesting to note that this result would be consistent with the long-run neutrality of inflation. Inflation and interest rates have very similar response profiles. This may be attributed to the way inflation and long-term rates are tied to inflation expectations via the Fisher parity.

Finally, consider a one standard error, forecast error in the real balances equation. By looking at the left hand side in the uper panel in Figure 13 we can see that this would lead to persistent upward revisons in forecasts of GDP growth. In the equivalent panels in Figures 10, 11, and 12 we can see that this would also lead to upward revisons in forecasts of inflation and interest rates (short- and long-term) but less persistent.

6 Conclusions

A demand function for real M3 in the euro area was estimated using a structural cointegrated VAR approach. The system comprises three long run relationships suggested by economic theory: (i) a demand for money function linking real M3 to long-term interest rates with semi-elasticity -1.6 and a scale variable measured by real GDP with elasticity 1.3; (ii) a term structure equation and (iii) an equation related to the Fisher hypothesis. There is evidence that over the last few years these relationships have been stable and that these relationships cannot be integrated into a single money dmenad equation.

There are two major implications of the results. The first is that a straightforward derivation of the reference value for M3 growth can be obtained within a money demand framework. The reference value for monetary growth announced by the ECB in December 1998 of $4\frac{1}{2}\%$ can be derived by multiplying the income elasticity of money demand by the steady state growth rate of real GDP (2.25%) implied by the model and considering the ECB's definition of price stability (an increase in the Harmonised Index of Consumer Prices below 2% over the medium-term).

Above all, the model illustrates how monetary and financial variables can be used to model the time series behaviour of key macroeconomic variables. Short-run dynamics as well as deviations from the equilibrium mapped out by the three long-run relationships play a vital role in terms of explaining the dynamics of inflation, income, money and interest rates.

References

Bernanke, B. S., 1986, Alternative explanations of the money income correlation, Carnegie-Rochester Conference Series on Public Policy, 25, 49–100.

Bernanke, B.S., Blinder, A. S., 1992, The Federal Funds rate and the channels of monetary transmission, American Economic Review, 82, 901–921.

Bernanke, B.S., Mihov, I., 1995, Measuring monetary policy, NBER Working Paper, No.5145.

Blanchard, O., D. Quah, 1989, The dynamic effects of aggregate demand and aggregate supply disturbances, American Economic Review, 79, 653–658.

Christiano, L.J., Eichenbaum, M., 1992, Identification and the liquidity effect of a monetary policy shock, in: A. Cukierman, L.Z. Hercowitz, and L. Leiderman, eds., Business cycles, growth and political economy, MIT Press, Cambridge MA, 335-370.

Coenen, G., Vega, J.L., 1999, The demand for M3 in the Euro Area, Working Paper No. 6, ECB, September.

Doornik, J., Hendry, D., 1997, Modelling Dynamic Systems Using PcFiml 9.0 for Windows, International Thomson Business Press, London.

Efron, B., Tibshirani, R., 1993, An Introduction to the Bootstrap, Chapman & Hall, New York.

Engsted, T., 1995, Does the long-term interest rate predict future inflation? A multi-country analysis, Review of Economics and Statistics, 77, 42-54.

Engsted, T., Tangaard, C., 1994, Cointegration and the US term structure, Journal of Banking and Finance, 18, 167-181.

Estrella, A., Mishkin, F., 1997, The predictive power of the term structure of interest rates in Europe and the United States: Implications for the European Central Bank, European Economic Review, 41, 1375-1401.

Fagan, G. and Henry, J., 1999, Long-run money demand in the EU: Evidence for area-wide aggregates, in: Lütkepohl, H., Wolters, J. (Eds.), Money demand in Europe, Physica-Verlag, Heidelberg, 217-240.

Fase, M.M.G. and Winder, C.C.A., 1999, Wealth and the demand for money in the European Union, in: Lütkepohl, H., Wolters, J. (Eds.), Money demand in Europe, Physica-Verlag, Heidelberg, 241-258.

Garratt, A., Lee, K., Pesaran, M.H., Shin, Y., 1999a, A Long Run Structural Macroeconometric Model of the UK, DAE Working Paper No. 9812, University of Cambridge (revised version October 1999).

Garratt, A., Lee, K., Pesaran, M.H., Shin, Y., 1999b, The Structural Cointegrating VAR Approach to Macroeconometric Modelling, Holly, S., Weale, M. (Eds.) Econometric Modelling: Techniques and Applications, Cambridge University Press, Cambridge (forthcoming).

Hubrich, K.S.E.M., Vlaar, P.J.G., 2000, Germany and the euro area: differences in the transmission process of monetary policy, Research Memorandum No. 613, De Nederlandsche Bank.

Johansen, S., 1992, Determination of cointegration rank in the presence of a linear trend, Oxford Bulletin of Economics and Statistics, 54, 383-397.

Johansen, S., Juselius, K., 1990, Maximum likelihood estimation and inference on cointegration - with application to the demand for money, Oxford Bulletin of Economics and Statistics, 52, 169-210.

King, R.G., Plosser, C. I., Stock, J., Watson, M., 1991, Stochastic trends and economic fluctuations, American Economic Review, 81, 819–40.

Lütkepohl, H., Wolters, J., 1999, A money demand system for M3 in the Unified Germany, in: Lütkepohl, H., Wolters, J. (Eds.), Money demand in Europe, Physica Verlag, Heidelberg, 105-120.

Lütkepohl, H. and Reimers, E., 1991, Impulse response analysis of cointegrated systems, Journal of Economic Dynamics and Control, 16, 53–78.

Lütkepohl, H., 1993, Introduction to Multiple Time Series Analysis, 2nd edition, Springer Verlag, Berlin.

Mishkin, F., 1992, Is the Fisher effect for real?, Journal of Monetary Economics, 30, 195-215.

Mussa, M., 1981, Sticky prices and disequilibrium adjustment in a rational model of the inflationary process, American Economic Review, 71 (5), 1020-1027.

Pesaran, M. H., Shin, Y., 1996, Cointegration and speed of convergence to equilibrium, Journal of Econometrics, 71, 117-143.

Pesaran, M.H., Shin, Y., 1998, Generalized impulse response analysis in linear multivariate models, Economics Letters, 58, 17-29.

Pesaran, M. H., Smith, R., 1998, Structural analysis of cointegrating VARs, Journal of Economic Surveys, 12, 471-505.

Shapiro, M.D., 1994, Federal Reserve policy: causes and effect, in: Mankiw, N.G., ed., Monetary Policy, NBER Studies in Business Cycles, 29, 307–334.

Shiller, R., Siegel, J. , 1977, The Gibson Paradox and historical movements in real interest rates, Journal of Political Economy, 83, No. 5, 891-907.

Sims, Ch. A., 1980, Macroeconomics and Reality, Econometrica, 48(1), 1-48.

Sims, Ch. A., 1992, Interpreting the macroeconomic time series facts, European Economic Review, 36, 975–1000.

Vlaar, P.J.G., Schuberth, H., 1999, Monetary transmission mechanism and controllability of money in Europe: a structural vector error correction approach, DNB Staff Reports, No. 36, De Nederlandsche Bank.

Walsh, C. E., 1998, Monetary Theory and Policy, The MIT Press, London.

Zellner, A.,1962 , An Efficient Method of Estimating Seemingly Unrelated Regressions, and Tests for Aggregation Bias, Journal of the American Statistical Association, 57, 348-368.

Appendix A: Data

Table 1: Data used in this study

Date	Real GDP	Real M3	Short-term rates	Long-term rates	Price level	Nominal M3
Q1-80	4.288841916	4.123191475	12.6073	12.0586	3.862330534	3.380351824
Q2-80	4.282180016	4.12128346	13.0987	12.1	3.884563418	3.400676693
Q3-80	4.27931941	4.121246892	12.1323	12.1493	3.905163533	3.421240239
Q4-80	4.278252495	4.130510024	12.5659	12.7719	3.921107615	3.446447453
Q1-81	4.280139858	4.135217774	13.3685	13.3851	3.941041856	3.471089444
Q2-81	4.286862774	4.144236054	15.4768	14.5276	3.959227151	3.498293018
Q3-81	4.288361505	4.141473759	16.0814	15.1481	3.981612499	3.517916071
Q4-81	4.28917673	4.139549782	15.3532	15.0485	4.006645676	3.541025272
Q1-82	4.293740949	4.147793217	14.2551	14.7183	4.027732782	3.570355814
Q2-82	4.294614283	4.158159458	14.3021	14.4717	4.044741067	3.59773034
Q3-82	4.289891691	4.170091798	13.2518	14.1672	4.060206776	3.625128388
Q4-82	4.290651518	4.178620154	12.4914	13.6262	4.075910698	3.649360666
Q1-83	4.296750972	4.181750526	11.7569	13.0919	4.097567696	3.674148035
Q2-83	4.304788682	4.186808271	11.6631	13.0041	4.112402204	3.694040289
Q3-83	4.306835987	4.191261992	12.0108	13.0685	4.129216088	3.715307894
Q4-83	4.315801443	4.197640254	12.0027	13.0481	4.144305469	3.736775538
Q1-84	4.326580134	4.198964622	11.289	12.5627	4.160035544	3.75382998
Q2-84	4.319326579	4.208290937	10.7457	12.4518	4.169730289	3.77285104
Q3-84	4.330282622	4.219306943	10.3164	12.0737	4.182025715	3.796162472
Q4-84	4.334519203	4.227214723	10.0348	11.2666	4.193987765	3.816032303
Q1-85	4.337152333	4.241187256	9.7691	10.7307	4.204001336	3.840018406
Q2-85	4.346936389	4.247515363	9.859	10.6427	4.214956186	3.857301363
Q3-85	4.355860438	4.248028302	9.2446	10.525	4.229324072	3.872182189
Q4-85	4.362438291	4.250800757	8.5533	10.1486	4.240837424	3.886467995
Q1-86	4.361418781	4.253644263	8.6425	9.7215	4.255286415	3.903760492
Q2-86	4.373612873	4.256308793	7.9197	8.5608	4.26600252	3.917141127
Q3-86	4.38142783	4.265554438	7.6429	8.3173	4.274682208	3.93506646
Q4-86	4.387090702	4.279713099	7.755	8.3288	4.280457534	3.955000447
Q1-87	4.379373128	4.292246821	7.9576	8.3212	4.287483785	3.97456042
Q2-87	4.397012108	4.306402547	8.2222	8.5937	4.295971618	3.997203979
Q3-87	4.405375201	4.32109553	8.3153	9.3246	4.299939025	4.01586437
Q4-87	4.417613615	4.33072621	8.2922	9.4027	4.309551367	4.035107391
Q1-88	4.424885633	4.340485773	7.345	8.7883	4.315877484	4.051193071
Q2-88	4.432748945	4.354503746	7.1716	8.7446	4.325285634	4.074619194
Q3-88	4.444605935	4.368214253	7.9025	8.8772	4.332743161	4.095787228
Q4-88	4.456207195	4.377938876	8.3787	8.8243	4.342916715	4.115685405
Q1-89	4.467135794	4.389665296	9.4119	9.2805	4.352458782	4.136953892
Q2-89	4.473080834	4.404693487	9.5814	9.5134	4.360353459	4.15987676
Q3-89	4.479585188	4.419672175	9.991	9.554	4.369838915	4.184340905
Q4-89	4.492153769	4.426899433	10.9651	10.0772	4.382446546	4.204175794
Q1-90	4.50680281	4.441359065	11.1133	10.8164	4.392290035	4.228478914
Q2-90	4.511261007	4.443457754	10.5127	10.8217	4.404458156	4.242745724
Q3-90	4.519209876	4.453852244	10.4338	10.9262	4.414867666	4.263549724
Q4-90	4.526524537	4.469474466	10.9485	11.0256	4.421155998	4.285460277
Q1-91	4.53516717	4.476455741	11.0022	10.6443	4.433669868	4.304955423
Q2-91	4.539027783	4.476187129	10.3842	10.143	4.449376824	4.320393768

Continued on next page

Data used in this study – continued

Date	Real GDP	Real M3	Short-term rates	long-term rates	Price level	nominal M3
Q3-91	4.541384236	4.484064474	10.4375	10.2273	4.461287113	4.340181401
Q4-91	4.546776899	4.492153102	10.6618	9.943	4.473820412	4.360803328
Q1-92	4.556368193	4.497907442	10.7846	9.6001	4.483063567	4.375800823
Q2-92	4.554315505	4.512172416	10.9207	9.7234	4.492301555	4.399303785
Q3-92	4.552867533	4.522548955	11.8637	10.0962	4.502212337	4.419591106
Q4-92	4.548560573	4.531759525	11.3343	9.666	4.510637504	4.437226843
Q1-93	4.539630323	4.536829787	10.5987	9.0229	4.520359295	4.452018896
Q2-93	4.540592472	4.5433931	9.0188	8.6406	4.530411079	4.468633992
Q3-93	4.544352982	4.549125057	8.078	7.6029	4.535335532	4.479290402
Q4-93	4.548426707	4.55850595	7.3775	6.9519	4.542779756	4.49611552
Q1-94	4.556409217	4.564830914	6.8069	7.0077	4.549904803	4.509565531
Q2-94	4.56598501	4.566573527	6.3365	7.9531	4.55461767	4.516021011
Q3-94	4.573405292	4.567466424	6.3556	8.8068	4.559947899	4.522244137
Q4-94	4.58200073	4.565303592	6.4874	9.2086	4.566279658	4.526413064
Q1-95	4.587369032	4.567058144	6.9451	9.3333	4.571773679	4.533661637
Q2-95	4.592057356	4.569427644	7.1453	8.9521	4.579481027	4.543738485
Q3-95	4.59291632	4.575988722	6.6897	8.5586	4.587215969	4.558034505
Q4-95	4.595212977	4.588216674	6.4954	8.1315	4.591083432	4.57412992
Q1-96	4.597121435	4.600229782	5.626	7.681	4.597142047	4.592201642
Q2-96	4.603254816	4.605039369	5.132	7.5372	4.600542495	4.600411678
Q3-96	4.608716597	4.610132713	4.9969	7.2707	4.604822125	4.609784653
Q4-96	4.611527213	4.614932213	4.581	6.4615	4.608331185	4.618093212
Q1-97	4.612058502	4.622213614	4.4326	6.1877	4.612080256	4.629123685
Q2-97	4.624635513	4.629132918	4.3209	6.1912	4.616319797	4.640282529
Q3-97	4.631362077	4.637004033	4.3162	5.8245	4.620424249	4.652258096
Q4-97	4.639850493	4.643333511	4.4261	5.6599	4.624179361	4.662342686
Q1-98	4.647009176	4.651129068	4.1909	5.1127	4.629123013	4.675081895
Q2-98	4.652291643	4.66149935	4.0442	5.008	4.632815508	4.689144672
Q3-98	4.656912808	4.66661086	3.9272	4.551	4.636511864	4.697952538
Q4-98	4.658988582	4.674045765	3.6149	4.1524	4.639269152	4.70814473
Q1-99	4.664205571	4.690136453	3.0899	3.9742	4.643328797	4.728295064
Q2-99	4.66997981	4.702881795	2.6334	4.2265	4.644225501	4.74193711
Q3-99	4.679938763	4.714280494	2.699	5.0614	4.646622062	4.755732371

Source: BIS, ECB

Appendix B: Simulating the distribution of response profiles

This bootstrapping exercise can be carried out in a similar manner as in the case of the *AR*(1) model treated by Efron and Tibshirani (1993). The simulation design can be described as follows:

1. The residuals $\tilde{e}_t$ needed for the simulation are calculated subject to the estimated VECM coefficients.
2. Using a random number generator B bootstrap samples of size T,

   $$\{\tilde{e}_t^{*1}, \tilde{e}_t^{*2}, \ldots, \tilde{e}_t^{*b}, \ldots, \tilde{e}_t^{*B}\}$$

   $t = 1, ..., T$, are drawn with replacement from $\tilde{e}_t$. Given the parameters and the structure of the model, these are used to simulate Δz_t^{*b} and $(\beta' z_t)^{*b}$. This ensures that the long-run relationships and the corresponding number of unit roots are always imposed on the simulated data. In the bootstrap exercises conducted by Garratt, Lee, Pesaran and Shin (1999a) and Pesaran and Shin (1996), 5,000 to 10,000 replications have been employed to simulate the persistence profile of the cointegration relationships and the distribution of other test statistics under investigation. However, for the purposes of this study 600 replications have proofed to be sufficient.
3. For each bootstrap sample the structural VECM was re-estimated by treating the system as a Seemingly Unrelated Regression (SUR) problem as in Zellner (1962). As in the case of maximum likelihood estimation the method is fully exploiting the information content in the error variance-covariance matrix. With the actual data, the SUR estimates produced exactly the same results as the Maximum Likelihood estimates of the system. The choice of using SURE was, however, mainly motivated by the fact that Maximum Likelihood methods generally involve convergence problems that cannot be dealt with in an automated manner, as required in this bootstrap exercise.
4. Given the estimated structural VECMs for each bootstrap sample, the sequence of persistence and response profiles was calculated from the corresponding VAR representation, giving $\widehat{\Psi}(m)^{CI,*b}$ and $\widehat{\Xi}(m)^{*b}$ for $b = 1, ..., B$.
5. From these sequences confidence bounds can be constructed based on the α and $(1-\alpha)$ percentiles of the empirical distribution of the bootstrap estimates $\widehat{\Psi}(m)^{CI,*b}$ and $\widehat{\Xi}(m)^{*b}$

The algorithm has the advantage of avoiding all parametric assumptions. Using draws from the actual data set results in carrying out the bootstrap non-parametrically. It is not necessary to rely on asymptotic theory. The simulation approach is the same as the one adopted in Garratt, Lee, Pesaran and Shin (1999a) with the exception that the system is estimated using SURE instead of OLS.

Appendix C: Tables

Table 2: Trace test

$\lambda_{trace} = -T \sum_{i=r+1}^{n} log(1-\hat{\lambda}_i)$ and $r = 0, 1, \ldots, n-2, n-1$.

H_0	r	$n-r$	Model (i)	Model(ii)
Trace test and critical value	0	5	122.7** (76.1)	95.71** (68.5)
	1	4	72.97** (53.1)	59.26* (47.2)
	2	3	43.35** (34.9)	29.79* (29.7)
	3	2	22.77* (20.0)	**13.59 (15.4)**
	4	1	6.60 (9.2)	0.021 (3.8)

**Denotes rejection with $\alpha = 1\%$, * with $\alpha = 5\%$

Table 3: Model adequacy tests - Model (ii)

Single equation tests					
Portmanteau 9 lags	9.921	2.447	3.781	15.83	4.44
AR 1-5 $F(5,60)$	1.033	0.232	0.60	1.67	0.89
(p-value)	(0.401)	(0.947)	(0.697)	(0.156)	(0.49)
Normality Chi^2	0.27	5.33	**10.95****	3.54	5.85
(p-value)	(0.87)	(0.07)	**(0.0042)**	(0.173)	(0.054)
ARCH (4) $F(5,57)$	1.777	0.843	2.2	0.27	1.17
(p-value)	(0.15)	(0.5)	(0.08)	(0.89)	(0.33)
Chi^2 $F(20,44)$	1.09	0.84	0.96	0.78	1.02
(p-value)	(0.39)	(0.65)	(0.52)	(0.72)	(0.45)

**Denotes rejection with $\alpha = 1\%$, * with $\alpha = 5\%$

Table 4: Multivariate tests

Vector portmanteau 9 lags	168.48
Vector AR 1-5 F(125,182)	1.275 (0.0673)
Vector normality Chi^2(10)	24.683 (0.0060) **
Vector Xi^2 F(300,405)	0.84179 (0.9435)

**Denotes rejection with $\alpha = 1\%$, * with $\alpha = 5\%$

Table 5: Testing restrictions on β

Testing zero restrictions in cointegration space: LR-test, rank=3: Chi^2(3) = 1.4763 [0.6877]
Unit income elasticity LR-test, rank=3: Chi^2 (4)= 17.2 [0.0018]**
Homogeneity in the Fisher hypothesis: LR-test, rank=3: Chi^2(4) = 15.547 [0.0037]**
**Denotes rejection with $\alpha = 1\%$, * with $\alpha = 5\%$

Table 6: Estimates of the restricted cointegration vectors

β'				
$(m-p)$	π	l	s	y
1	0	1.608	0	-1.3305
0	1	-0.6710	0	0
0	0	1	-1	0
Standard errors				
$(m-p)$	π	l	s	y
0	0	0.001569	0	0.030532
0	0	0.049482	0	0
0	0	0	0	0

Table 7: Tests for weak exogeneity

Weak Exogeneity				
		CI-ERB	CI-FH	CI-EHTS
Δ (m-p)	18.111 [0.0060] ***	14.453 [0.0060] ***	1.5301 [0.8213]	1.4856 [0.8292]
Δ p	21.067 [0.0018] ***	1.9782 [0.7398]	14.948 [0.0048] ***	2.0645 [0.7239]
Δ l	11.819 [0.0661] *	1.7081 [0.7892]	9.5428 [0.0489] **	1.5169 [0.8236]
Δ s	16 [0.0138] **	6.3847[0.1722]	4.8065 [0.3077]	6.7789 [0.1480]
Δ y	11.335 [0.0786] *	3.0502[0.5495]	3.6719[0.4522]	10.064 [0.0394] **
Test distribution:	Chi^2(6)	Chi^2(4)	Chi^2(4)	Chi^2(4)
	CI-ERB and CI-EHTS	CI-FH and CI-ERB	CI-EHTS and CI-FH	
Δ s	14.53 [0.0126] *	12.153 [0.0328] *	7.429 [0.1906]	
Test distribution:	Chi^2(5)			
*** Rejection at the 1% level – ** Rejection at the 5% level – * Rejection at the 10% level				

Table 8: Restricted VECM

Vector portmanteau 9 lags	179.12	
Vector AR 1-5 F(125,201)	1.0174	(0.4526)
Vector normality Chi^2(10)	17.644	(0.0613)
Vector Xi^2 F(375,426)	0.91547	(0.8101)

Table 9: Restricted VECM

$\Delta(m-p)$	Portmanteau 9 lags	10.859	
$\Delta\pi$	Portmanteau 9 lags	2.524	
Δl	Portmanteau 9 lags	20.565	
Δs	Portmanteau 9 lags	9.7933	
Δy	Portmanteau 9 lags	4.1778	
$\Delta(m-p)$	Normality Chi^2(2)	0.86788	(0.6480)
$\Delta\pi$	Normality Chi^2(2)	3.8956	(0.1426)
Δl	Normality Chi^2(2)	0.21961	(0.8960)
Δs	Normality Chi^2(2)	13.589	(0.0011)**
Δy	Normality Chi^2(2)	3.3374	(0.1885)
$\Delta(m-p)$	ARCH 4 F(4, 53)	2.0789	(0.0966)
$\Delta\pi$	ARCH 4 F(4, 53)	1.2906	(0.2855)
Δl	ARCH 4 F(4, 53)	0.48122	(0.7494)
Δs	ARCH 4 F(4, 53)	0.99945	(0.4161)
Δy	ARCH 4 F(4, 53)	1.8496	(0.1331)
$\Delta(m-p)$	Xi^2 F(25, 35)	0.91918	(0.5810)
$\Delta\pi$	Xi^2 F(25, 35)	0.54436	(0.9418)
Δl	Xi^2 F(25, 35)	0.97348	(0.5204)
Δs	Xi^2 F(25, 35)	0.97042	(0.5238)
Δy	Xi^2 F(25, 35)	0.70476	(0.8173)

**Denotes rejection with $\alpha = 1\%$, * with $\alpha = 5\%$

Table 10: Restricted VECM

Equation for $\Delta(m-p)_t$

Variable	Coeff.	Std. Error	t-value	t-prob
$\Delta(m-p)_{t-1}$	0.48143	0.079579	6.05	0
Δl_{t-1}	-0.98817	0.40112	-2.464	0.0162
Δs_{t-1}	-0.38481	0.34969	-1.1	0.2749
Δy_{t-1}	-0.18294	0.068986	-2.652	0.0099
CI-ERB$_{t-1}$	-0.14443	0.028085	-5.143	0
Constant	-0.21206	0.042109	-5.036	0

Table 11: Restricted VECM

Equation for $\Delta\pi_t$

Variable	Coeff.	Std. Error	t-value	t-prob
$\Delta\pi_{t-1}$	-0.21679	0.089678	-2.417	0.0182
Δs_{t-1}	0.50805	0.18523	2.743	0.0077
CI-ERB$_{t-1}$	0.017804	0.017774	1.002	0.3199
CI-FH$_{t-1}$	-0.50824	0.10824	-4.695	0
Constant	0.023474	0.026922	0.872	0.3862

Table 12: Restricted VECM

Equation for Δl_t				
Variable	Coeff.	Std. Error	t-value	t-prob
$\Delta(m-p)_{t-1}$	0.03433	0.02391	1.436	0.1554
Δl_{t-1}	0.58591	0.093732	6.251	0
CI-FH$_{t-1}$	0.10012	0.037355	2.68	0.0091
Constant	0.00026941	0.00026988	0.998	0.3215

Table 13: Restricted VECM

Equation for Δs_t				
Variable	Coeff.	Std. Error	t-value	t-prob
$\Delta(m-p)_{t-1}$	0.038641	0.030173	1.281	0.2045
Δl_{t-1}	0.28358	0.14749	1.923	0.0585
Δs_{t-1}	0.26623	0.10732	2.481	0.0155
Δy_{t-1}	-0.039086	0.024097	-1.622	0.1092
CI-ERB$_{t-1}$	-0.031161	0.0081601	-3.819	0.0003
CI-EHTS$_{t-1}$	0.10884	0.047125	2.31	0.0238
Constant	-0.047179	0.012233	-3.857	0.0003

Table 14: Restricted VECM

Equation for Δy_t				
Variable	Coeff.	Std. Error	t-value	t-prob
$\Delta(m-p)_{t-1}$	0.33266	0.12197	2.728	0.008
$\Delta\pi_{t-1}$	0.54435	0.19787	2.751	0.0075
CI-EHTS$_{t-1}$	0.64831	0.20526	3.159	0.0023
Constant	0.0018033	0.0011689	1.543	0.1273

Table 15: Correlation of residuals

	$\Delta(m-p)_t$	$\Delta\pi_t$	Δl_t	Δs_t	Δy_t
$\Delta(m-p)_{t-1}$	1	·	·	·	·
$\Delta\pi_{t-1}$	-0.487	1	·	·	·
Δl_{t-1}	0.319	0.004	1	·	·
Δs_{t-1}	0.156	-0.011	0.596	1	·
Δy_{t-1}	0.091	0.183	0.187	0.171	1

Figure 1

Rate of return on M3 (OR) and short-term interest rate(s)

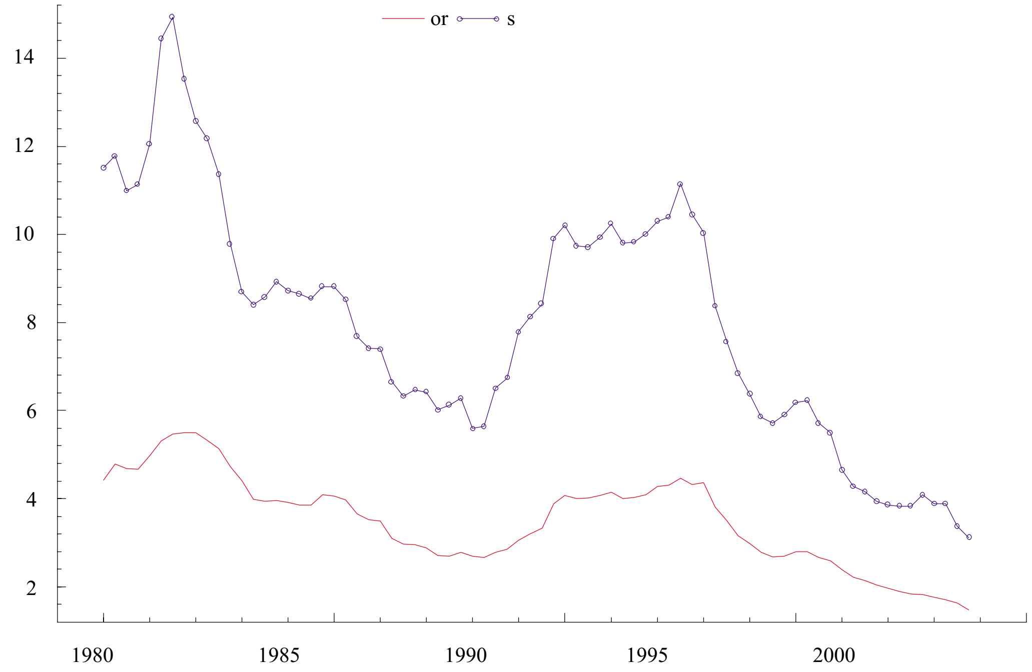


Figure 2

Spreads between the long-term interest rate and the short term interest rate (Market spread), the long-term interest rate and the rate of return on M3 (IRL-ORM3) and between the short-term interest rate and the rate of return on M3 (IRS-ORM3)

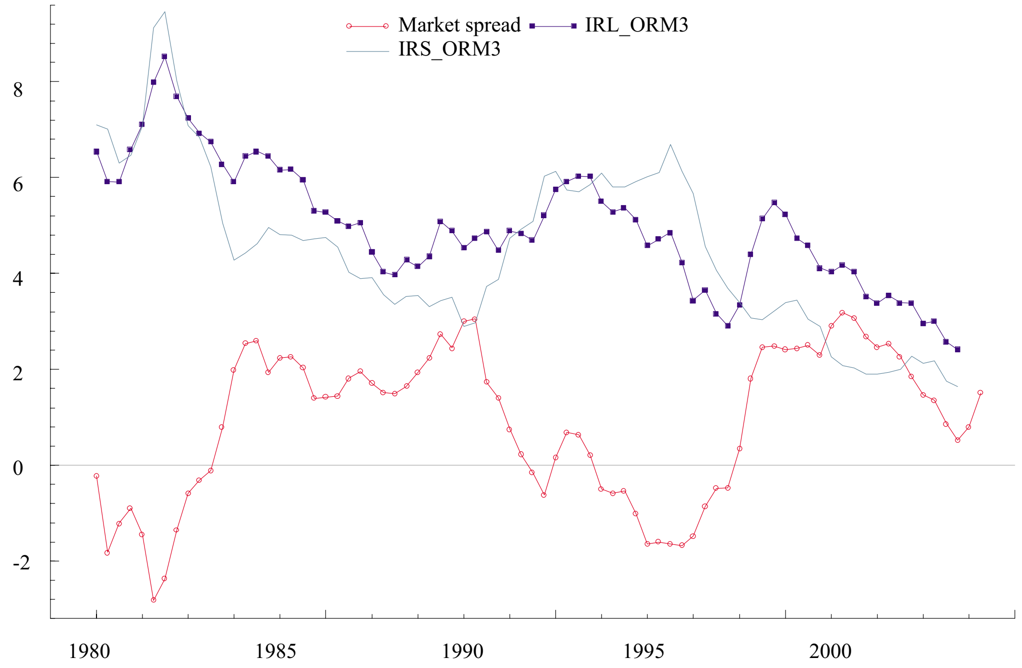


Figure 3

The long-term interest rate (l) and the spread between the long-term interest rate and the rate of return on M3 (IRL_ORM3)

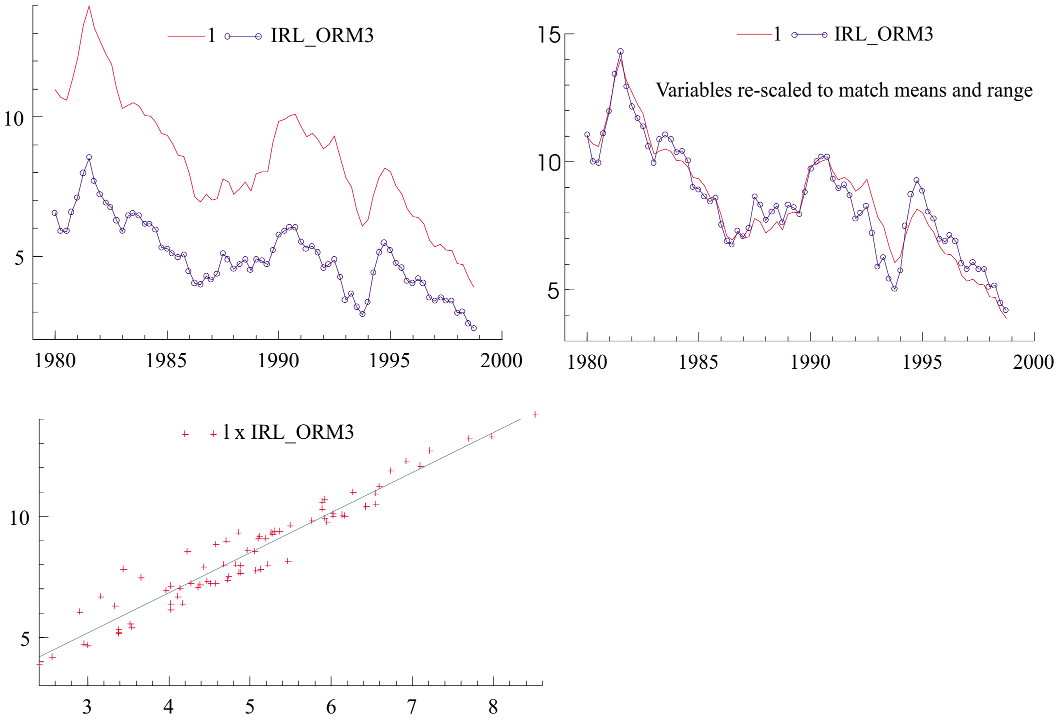


Figure 4

Conditional volatility of the short-term interest rate

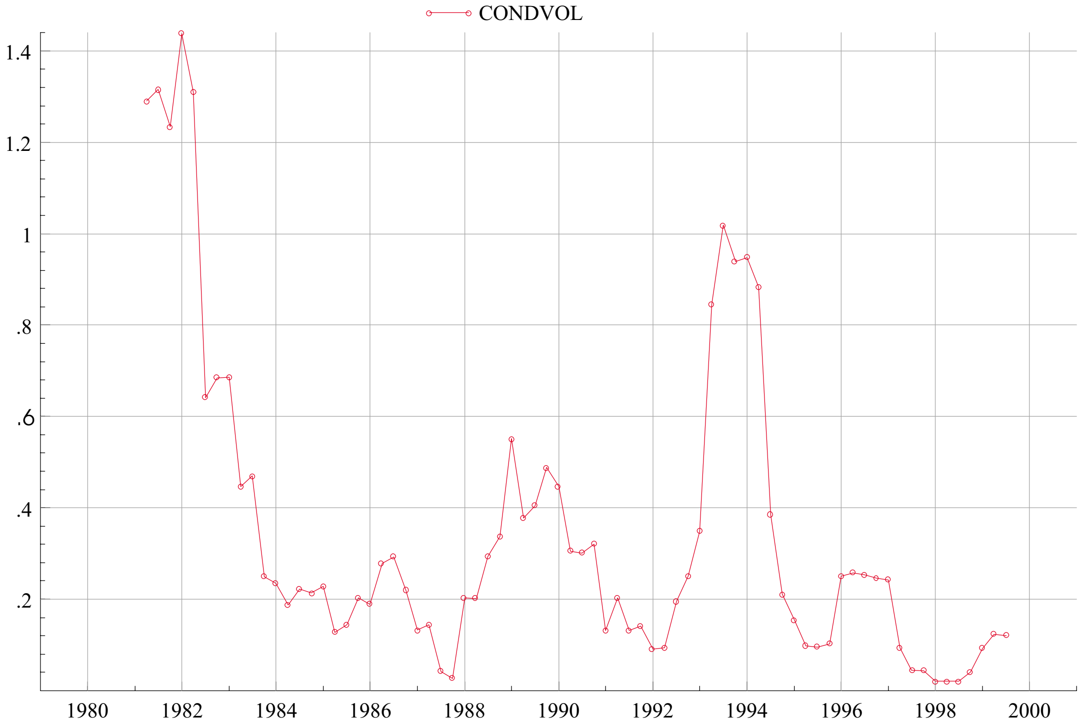


Figure 5

Plot of the restricted cointegrating relations

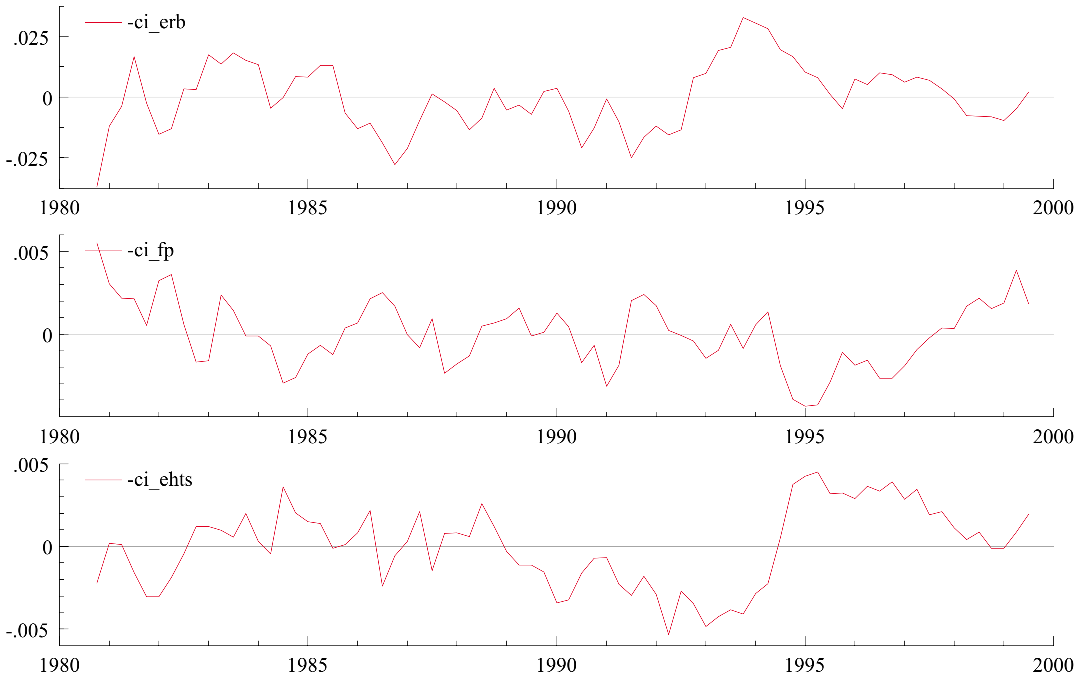


Figure 6

Recursive estimates of long-run coefficients in the money demand equation

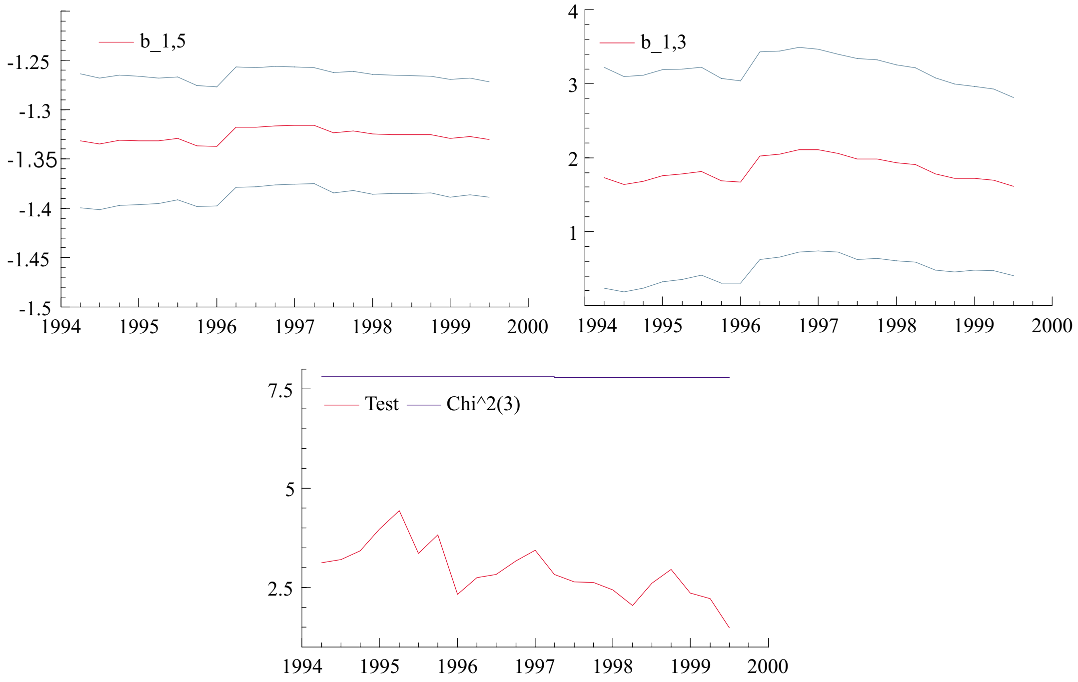


Figure 7

Recursive residuals of the restricted short-run VECM

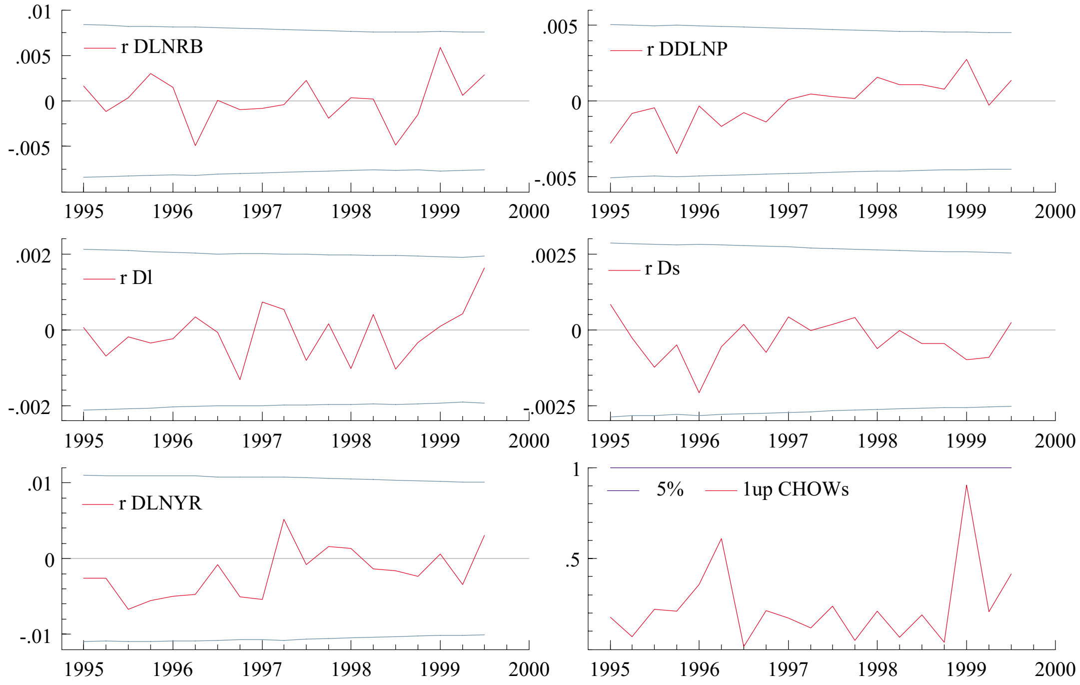
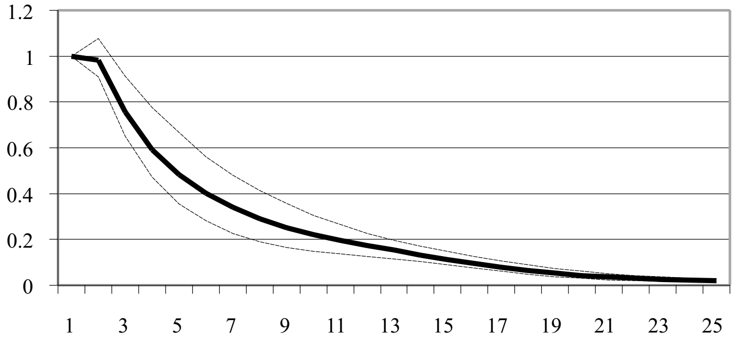


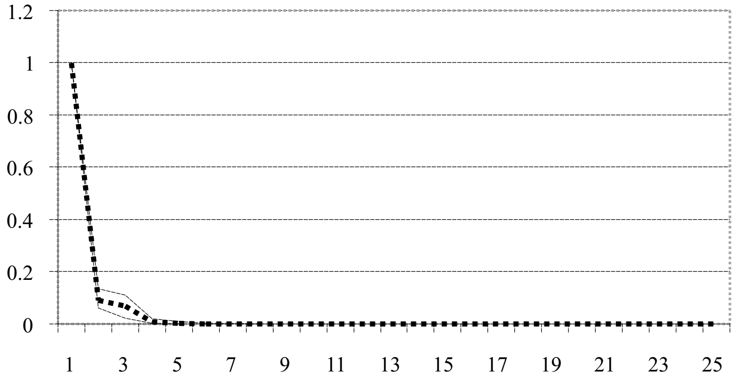
Figure 8

Persistence profiles in response to area wide shock

Persistence profile of money demand relationship



Persistence profile of Fisher parity



Persistence profile of yield spread

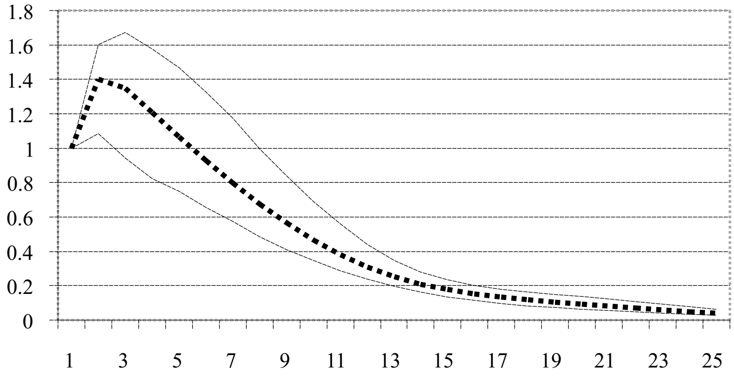
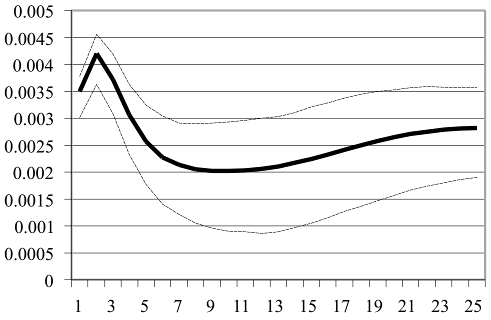
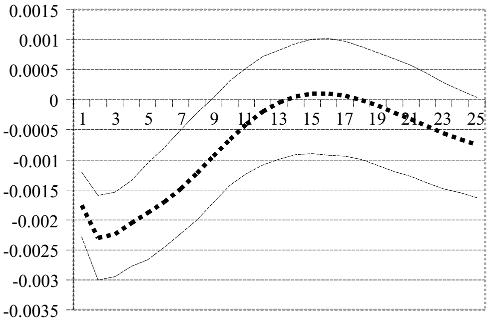
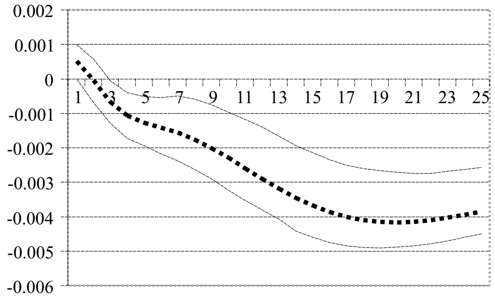


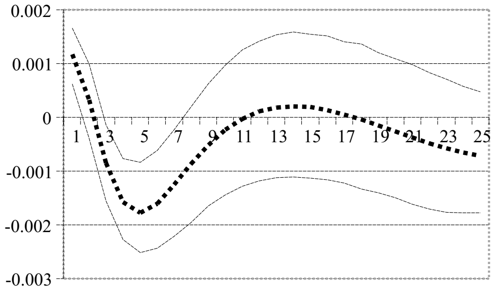
Figure 9

Generalised response profiles of real M3


Response profile: real M3 to real M3


Response profile: real M3 to inflation


Response profile: real M3 to short term rates


Response profile: real M3 to long term rate

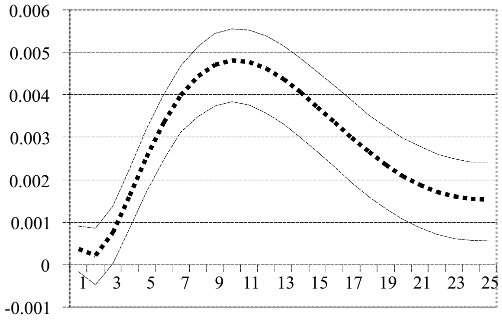
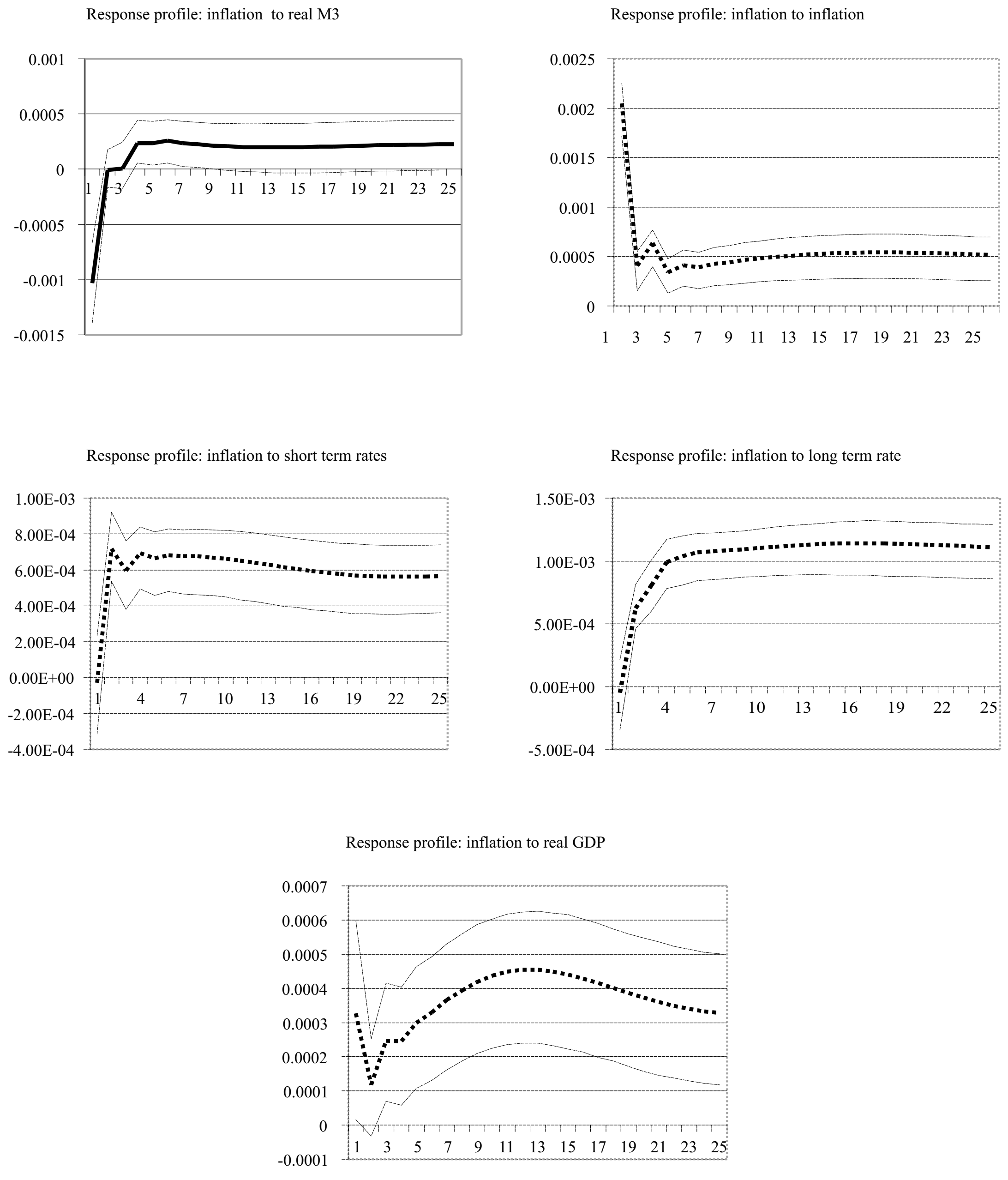

Response profile: real M3 to real GDP

Figure 10

Generalised response profile of inflation



Response profile: inflation to real M3

Response profile: inflation to inflation

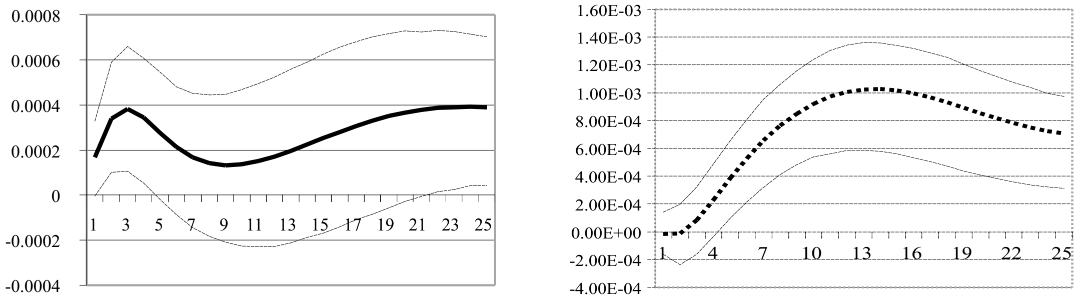
Response profile: inflation to short term rates

Response profile: inflation to long term rate

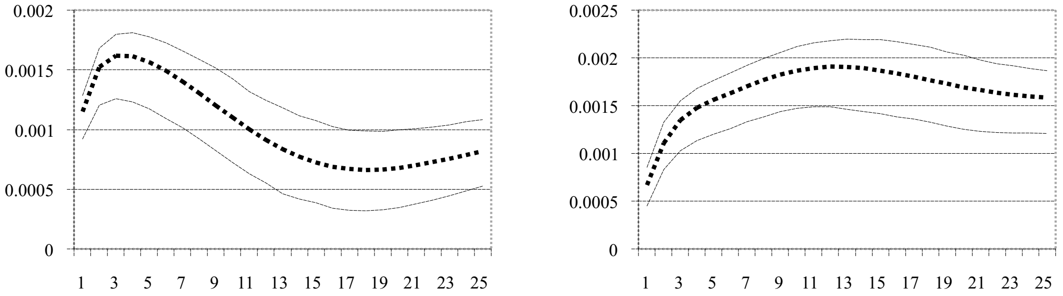
Response profile: inflation to real GDP

Figure 11

Generalised response profile of short-term rates


Response profile: short term rates to real M3

Response profile: short term rates to inflation


Response profile: short term rates to short term rates

Response profile: short term rates to long term rate

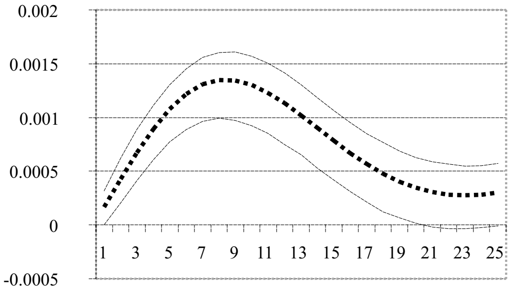
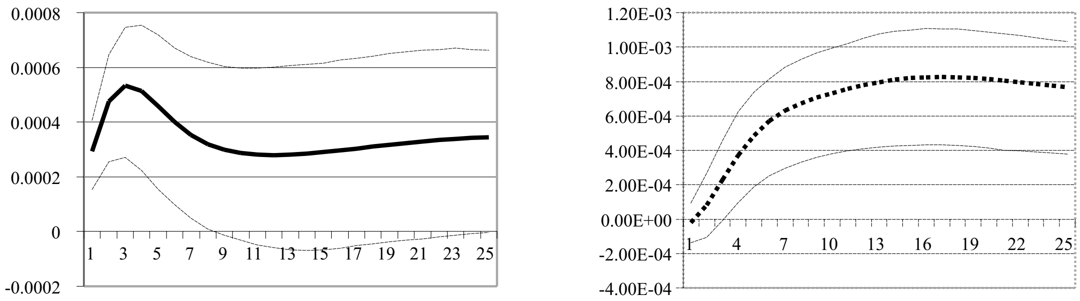

Response profile: short term rate to real GDP

Figure 12

Generalised response profile of long-term rates

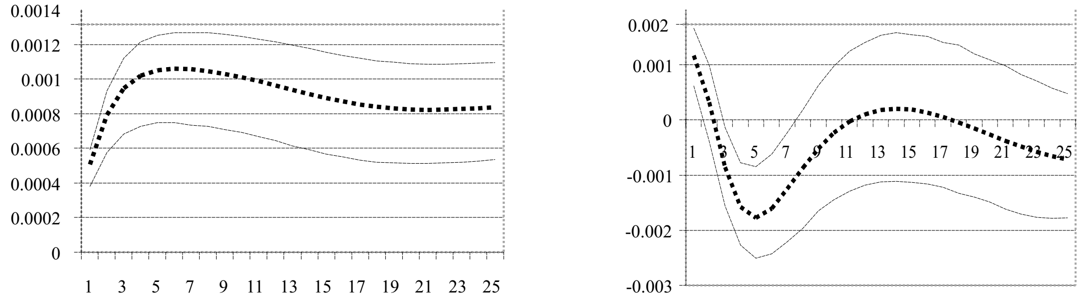
Response profile: long term rate to real M3

Response profile: long term rate to inflation



Response profile: long term rate to short term rates

Response profile: long term rate to long term rate



Response profile: long term rate to real GDP

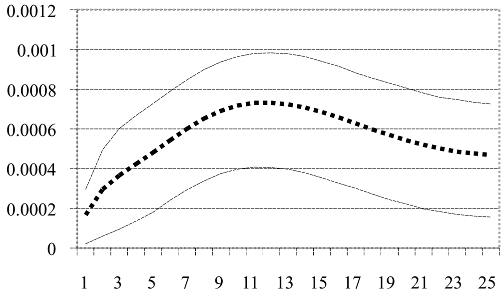
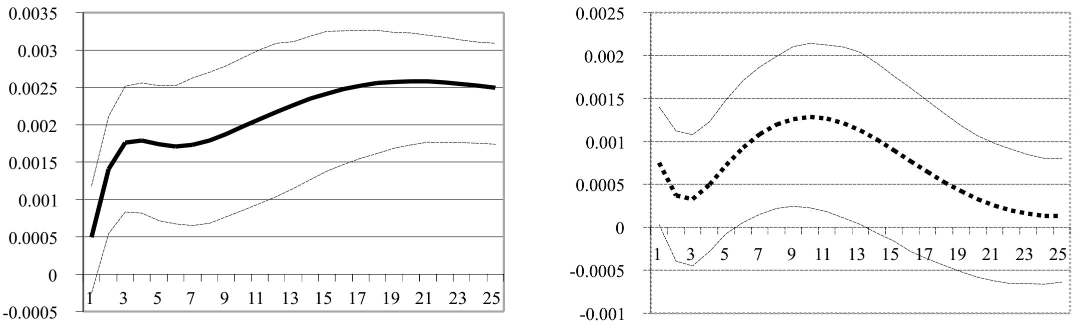
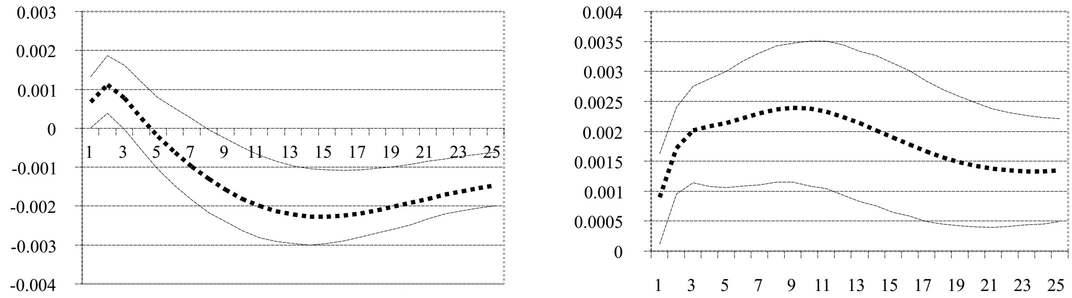


Figure 13

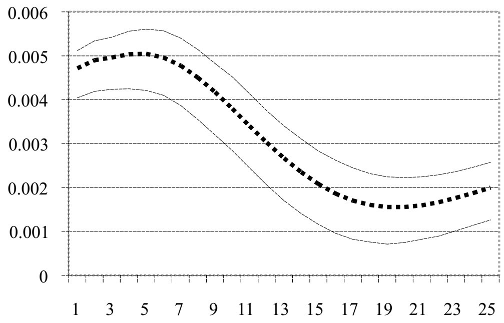
Generalised response profile of GDP


Response profile: real GDP to real M3

Response profile: real GDP to inflation


Response profile: real GDP to short term rates

Response profile: real GDP to long term rate


Response profile: real GDP to real GDP

European Central Bank Working Paper Series

1 “A global hazard index for the world foreign exchange markets” by V. Brousseau and F. Scacciavillani, May 1999.

2 “What does the single monetary policy do? A SVAR benchmark for the European Central Bank” by C. Monticelli and O. Tristani, May 1999.

3 “Fiscal policy effectiveness and neutrality results in a non-Ricardian world” by C. Detken, May 1999.

4 “From the ERM to the euro: new evidence on economic and policy convergence among EU countries” by I. Angeloni and L. Dedola, May 1999.

5 “Core inflation: a review of some conceptual issues” by M. Wynne, May 1999.

6 “The demand for M3 in the euro area” by G. Coenen and J.-L. Vega, September 1999.

7 “A cross-country comparison of market structures in European banking” by O. de Bandt and E. P. Davis, September 1999.

8 “Inflation zone targeting” by A. Orphanides and V. Wieland, October 1999.

9 “Asymptotic confidence bands for the estimated autocovariance and autocorrelation functions of vector autoregressive models” by G. Coenen, January 2000.

10 “On the effectiveness of sterilized foreign exchange intervention” by R. Fatum, February 2000.

11 “Is the yield curve a useful information variable for the Eurosystem?” by J. M. Berk and P. van Bergeijk, February 2000.

12 “Indicator variables for optimal policy” by L. E. O. Svensson and M. Woodford, February 2000.

13 “Monetary policy with uncertain parameters” by U. Söderström, February 2000.

14 “Assessing nominal income rules for monetary policy with model and data uncertainty” by G. D. Rudebusch, February 2000.

15 “The quest for prosperity without inflation” by Athanasios Orphanides, March 2000.

16 “Estimating the implied distribution of the future short term interest rate using the Longstaff-Schwartz model” by Peter Hördahl, March 2000.

17 “Alternative measures of the NAIRU in the euro area: estimates and assessment” by Silvia Fabiani and Ricardo Mestre, March 2000.

18 “House prices and the macroeconomy in Europe: Results from a structural VAR analysis” by Matteo Iacoviello, April 2000.

19 “The euro and international capital markets” by Carsten Detken and Philipp Hartmann, April 2000.

20 “Convergence of fiscal policies in the euro area” by O. de Bandt and F. P. Mongelli, May 2000.

21 “Firm size and monetary policy transmission: evidence from German business survey data” by M. Ehrmann, May 2000.

22 “Regulating access to international large value payment systems” by C. Holthausen and T. Rønde, June 2000.

23 “Escaping Nash inflation” by I-K. Cho and T. J. Sargent, June 2000.

24 “What horizon for price stability” by F. Smets, July 2000.

25 “Caution and conservatism in the making of monetary policy” by P. Schellekens, July 2000.

26 “Which kind of transparency? On the need for clarity in monetary policy-making” by B. Winkler, August 2000.

27 “This is what the US leading indicators lead” by M. Camacho and G. Perez-Quiros, August 2000.

28 “Learning, uncertainty and central bank activism in an economy with strategic interactions” by M. Ellison and N. Valla, August 2000.

29 “The sources of unemployment fluctuations: an empirical application to the Italian case” by S. Fabiani, A. Locarno, G. Oneto and P. Sestito, September 2000.

30 “A small estimated euro area model with rational expectations and nominal rigidities” by G. Coenen and V. Wieland, September 2000.

31 “The disappearing tax base: is foreign direct investment eroding corporate income taxes?” by R. Gropp and K. Kostial, September 2000.

32 “Can indeterminacy explain the short-run non-neutrality of money?” by F. De Fiore, September 2000.

33 “The information content of M3 for future inflation” by C. Trecroci and J. L. Vega, October 2000.

34 “Capital market development, corporate governance and the credibility of exchange rate pegs” by O. Castrén and T. Takalo, October 2000.

35 "Systemic risk: A survey" by O. De Bandt and P. Hartmann, Novermber 2000.

36 "Measuring Core Inflation in the euro area" by C. Morana, November 2000.

37 "Business Fixed Investment: Evidence of a financial accelerator in Europe" by P. Vermeulen, November 2000.

38 "The optimal inflation tax when taxes are costly to collect" by F. De Fiore, November 2000.

39 "A money demand system for euro area M3" by C. Brand and N. Cassola, November 2000.