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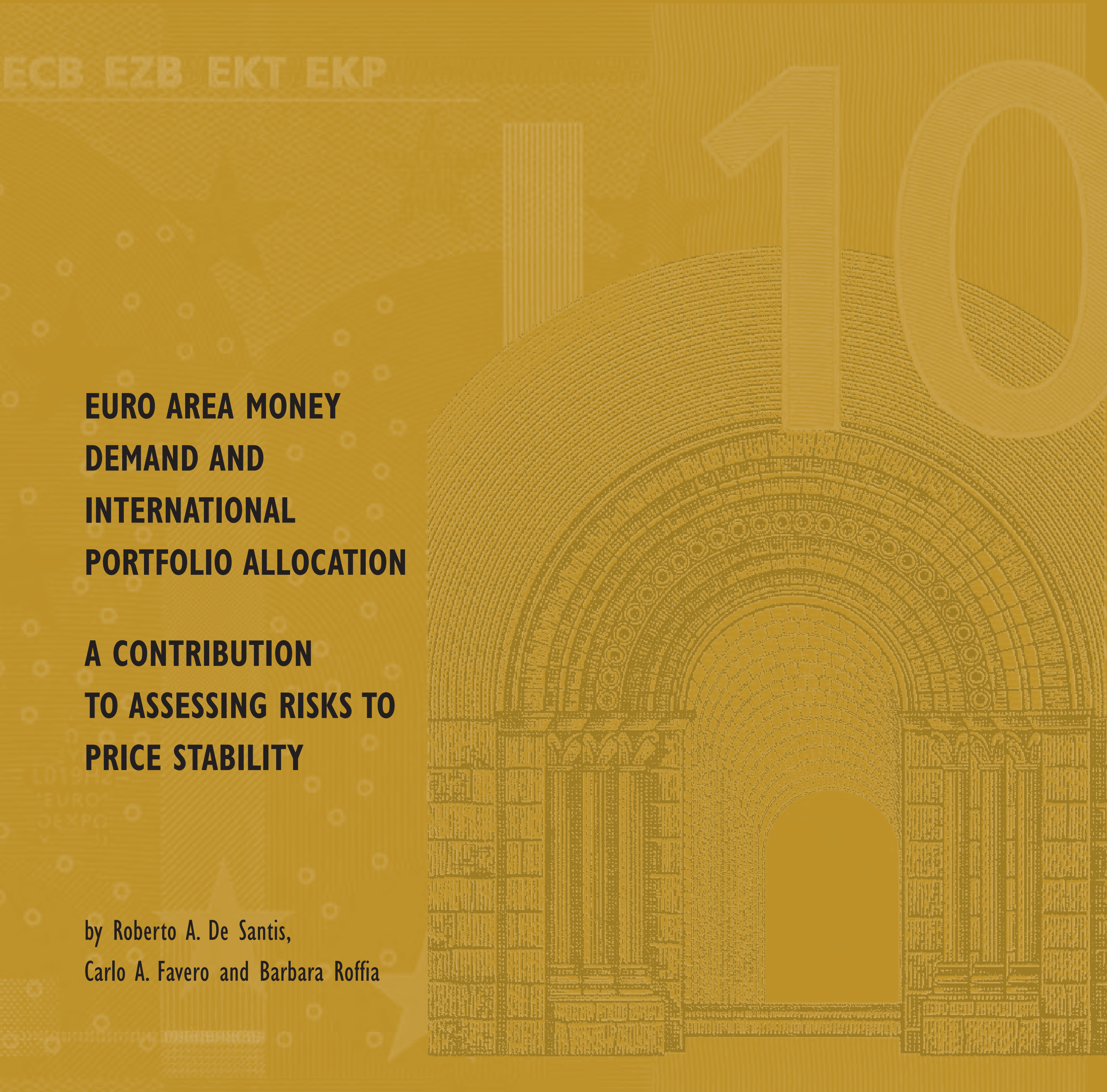

EURO AREA MONEY DEMAND AND INTERNATIONAL PORTFOLIO ALLOCATION

A CONTRIBUTION TO ASSESSING RISKS TO PRICE STABILITY

by Roberto A. De Santis,
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by Roberto A. De Santis[2], Carlo A. Favero[3]
and Barbara Roffia[4]

In 2008 all ECB publications feature a motif taken from the €10 banknote.

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CONTENTS

Abstract

The long-run relationship between money and prices in the euro area embedded in traditional money demand models with income and interest rates broke down after 2001. We develop a money demand model where investors hold a diversified portfolio with money, domestic and foreign stocks and long-term bonds in which, in addition to the classical wealth effect, a size and an international portfolio allocation effects also arise. The estimated model identifies three cointegrating vectors stable over the sample 1980-2007: a long-run money demand, which depends on income and all risky assets' returns, and two equilibria for the euro area and the US financial markets. Steady state equilibrium of nominal M3 growth is estimated to be about 7% in 2007 with large standard errors mainly due to uncertainty in asset prices. The gap between actual euro area M3 growth and model-based fitted or predicted values helps forecast euro area inflation.

Keywords: Euro area money demand, inflation forecasts, monetary policy, portfolio allocation
JEL classification: E41, E44, E52, G11, G15

Non-Technical Summary

The analysis of the risks to price stability in the euro area is organised on the basis of two complementary analytical perspectives, widely known as the two pillars: (1) the "economic analysis", which identifies short to medium-term risks to price stability, with a focus on real activity and financial conditions in the economy, and (2) the "monetary analysis", which focuses on a longer-term horizon exploiting the long-run link between money and prices. To provide a benchmark for the assessment of monetary developments, the ECB announced a reference value for the broad monetary aggregate nominal M3 growth. This reference value refers to the rate of annual growth of nominal M3 that is deemed to be compatible with price stability over the medium term and it has been set to $4\frac{1}{2}$ per cent per annum.

Since the start of Stage Three of Economic and Monetary Union (EMU) in 1999, euro area consumer price inflation has been very close to 2 percent, with very little volatility, while M3 growth has been almost always above its reference value (i.e. average annual M3 growth was 7.3 percent over the period 2000 Q1 - 2007 Q3), actually diverging from it rather than converging to it. As a consequence, average annual real M3 growth over the period 2000 Q1 - 2007 Q3 amounted to 4.9 percent, thus diverging from its 3.2 percent average value over the sample 1981-1999. The behaviour of these time-series raises naturally a question on the nature and the validity of the long-run link between money and prices in the euro area.

In this paper, we show that the long-run relationship between money and prices in the euro area embedded in traditional money demand equations (with determinants being represented by income and interest rates) broke down after 1999 and that M3 grew at a much higher pace than that predicted by these models. However, the relevant question is not if traditional money demand models broke down, but why they did. Is it possible to reconstruct a stable money demand by including variables omitted in the traditional specifications? Moreover, do the implied equilibria deliver a stable relation between inflation and M3 growth exploitable to predict inflation and to allow the real time assessment of risks to price stability?

We present evidence that cross-border portfolio flows can help explain recent monetary developments in the euro area. To model the link between euro area M3 and international portfolio flows, a simple Tobin portfolio model of asset choice in an open economy is developed, where wealth-owners hold a diversified portfolio consisting of money and domestic and foreign risky assets (stocks and bonds).

On the basis of this stylised model, in the long run money balances are a positive function of:

1. domestic real disposable wealth, since money is held as part of a wealth

portfolio (i.e. *wealth effect*). In the empirical analysis, income is used as an (imperfect) proxy for wealth (noting that this improves comparability with earlier models of M3 demand, such as Calza et al. (2001));

2. the ratio of foreign residents' wealth to that of euro residents (i.e. *size effect*). If the attractiveness of non-monetary assets increases, foreign demand for these assets will crowd out euro area demand simply because euro area wealth is smaller than foreign wealth. The resulting purchases of assets from euro area residents by foreigners imply a rise in euro area M3;

3. the differential between risk-adjusted excess returns expected by foreign and domestic agents on the same asset (i.e. *international portfolio allocation effect*). In a closed economy, any attempt to shift out of money into non-monetary assets (e.g. when the risk-adjusted excess returns on assets rise) will simply transfer money from the purchaser to the seller of the asset, leaving the aggregate stock of money unchanged. In an open economy, transactions between money holders and foreigners (not part of the money holding sector) can result in changes in aggregate M3 holdings.

This paper presents an econometric model that attempts to quantify the implications of these international portfolio flows for monetary developments in the euro area. The model thus characterises money demand as part of a broader portfolio allocation problem, where the returns on domestic and foreign risky assets, as well as the own return on holding M3, influence money holdings. This portfolio approach thus relates monetary developments to asset price dynamics, here in an international context, offering a link to the growing literature on asset prices and money/credit. The theoretical model is used to identify the properties of the long-run equilibrium and the data are let free to determine the short-run dynamics of the empirical model.

The resulting system is stable over the period 1980-2007 and is characterised by three cointegrating vectors: (i) a new specification for the euro area money demand with euro area and US price-earnings ratios and bonds yields; (ii) the equilibrium between price-earnings ratio, 10-year bond yields and the own rate of money in the euro area; (iii) the equilibrium between price-earnings ratio and 10-year bond yields in the United States (known as the FED model). The system is compatible with the long-run money demand specification of the theoretical model.

On the basis of this model set-up, two main observations are worth making.

(i) Given that asset prices are volatile, this introduces some volatility in the residuals of the money demand, although, at the same time, they exhibit a fast reversion to the mean. While confirming the underlying relationship between money and a small number of macroeconomic variables, this model suggests that asset price developments are an important determinant of monetary developments.

(ii) There are linkages between money and asset price developments which run in both directions, so that disequilibria in any of the three markets encompassed by the model – M3 and euro area/US asset markets – trigger corrective responses in all markets. Thus, this portfolio approach relates monetary developments to asset price dynamics in an international context, offering a link to the growing literature on asset prices and money.

Given the new framework, the resulting model-based steady state annual nominal M3 growth compatible with price stability is estimated at 7.1% in 2007. However, the confidence intervals surrounding money path derived from the model simulations are large, as stock prices are more volatile than output and interest rates.

In accordance with the theoretical model, a fall in euro area and/or US equity price-earnings ratios relative to their respective long-term bond yields leads to net portfolio inflows into the euro area and, therefore, to an increase in euro area M3 growth. This is exactly what happened after the sharp decline in equity prices in October 1987 and March 2001.

We also found that a measure of excess M3 growth, namely the gap between actual euro area M3 growth and M3 growth predicted by the model, is statistically significant in forecasting euro area HICP inflation. As a rule of thumb, an excess of actual real M3 growth beyond that simulated by the DFR model of 1 percentage point leads to an increase of HICP inflation 6 quarters ahead of about 13 basis points.

Finally, given that asset prices are timely available, the real-time assessment of inflationary risks is feasible by comparing actual money growth with model-based simulated values.

1 Introduction

Price stability in the euro area has been defined on 13 October 1998 by the Governing Council of the ECB as "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2 per cent. Price stability has to be maintained over the medium term". Lately, on 8 May 2003, following an evaluation of its monetary policy strategy, the Governing Council clarified that price stability corresponds to maintaining HICP inflation rate in the euro area "below but close to 2 per cent" over the medium term (ECB, 2004a). The assessment by the Governing Council of the risks to price stability is organised on the basis of two complementary analytical perspectives, widely known as the two pillars: (1) the "economic analysis", which identifies short to medium-term risks to price stability, with a focus on real activity and financial conditions in the economy, and (2) the "monetary analysis", which focuses on a longer-term horizon exploiting the long-run link between money and prices. To provide a benchmark for the assessment of monetary developments, the ECB announced a reference value for the annual growth rate of nominal broad monetary aggregate M3. This reference value refers to the rate of annual growth of M3 that is deemed to be compatible with price stability over the medium term and it has been set equal to $4\frac{1}{2}$ per cent per annum.

Figures 1 reports the HICP annual inflation and nominal M3 annual growth over the sample 1981-2007. The evidence shows that, while inflation has been very close to 2% with very little volatility since 1999, annual M3 growth has been almost always above the reference value (i.e. average annual M3 growth was 7.3% over the period 2000 Q1 - 2007 Q3), actually diverging rather than converging to it. As a consequence, average annual real money growth over the period 2000 Q1 - 2007 Q3 amounted to 4.9% higher than its 3.2% average value over the sample 1981-1999. The behaviour of nominal M3 growth and inflation raises a question on the nature and validity of the long-run link between money and prices, whose stability is a prerequisite for using monetary aggregates in the conduct of monetary policy.

Numerous studies have estimated the money demand for the euro area, showing that the demand for broad money (M3) in the euro area used to exhibit a stable relationship with goods prices, economic activity, interest rates, domestic equity and house prices.[1] However, evidence of parameter instability is pervasive, when the

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[1] See, for example, Coenen and Vega (1999), Brand and Cassola (2000), Calza et al. (2001), Funke (2001), Cassola and Morana (2002), Golinelli and Pastorello (2002), Kontolemis (2002), Bruggeman et al. (2003), Gerlach and Svensson (2003), Artis and Beyer (2004), Greiber and Lembke (2005), Avouyi-Dovi et al. (2006), Carstensen (2006), and Dreger and Wolters (2006).

estimation sample goes beyond 2004 Q4.[2]

The most strongly investigated and robust specification up to 2001, which has also been widely used in the context of the monetary analysis carried out at the ECB (see ECB, 2004b), is the one proposed by Calza, Gerdesmeier and Levy (2001) (henceforth denoted as CGL). Therefore, it is natural to start off from the CGL modelling approach.

CGL contributed to the debate on the stability of euro area money demand by proposing a traditional long-run cointegrating relationship based on a careful specification of the opportunity cost of holding money. They show that the equilibrium money demand delivered by the data as a cointegrating vector over the sample 1980 Q1 - 1999 Q4 takes the following specification (standard errors are reported in parenthesis below their respective coefficients in all equations of this paper):

$$m_t - p_t = \beta_0 + \underset{(0.04)}{1.34} y_t - \underset{(0.25)}{0.83} \left(i_t^{ST} - i_t^{OWN} \right)$$

where m_t denotes M3, p_t is the GDP deflator, y_t is the real GDP with all these variables being measured in logarithms. $\left(i_t^{ST} - i_t^{OWN} \right)$ represents the opportunity cost of holding money defined as the difference between the short-term market interest rates, i_t^{ST}, and the own rate of return on M3, i_t^{OWN}. In this specification, euro area interest rates are constructed using GDP weights to aggregate data from member countries. The long-run equilibrium relationship is the unique cointegrating vector emerging from the application of the Johansen (1995) procedure to a VAR in levels for the three variables of interest.

We have replicated these results by using the same definition of the variables, with the only difference that we employ for the interest rates M3 weights rather than GDP weights given the availability of these new series (see Bruggeman et al. 2003). We obtain the following unique cointegrating relation over the sample 1980 Q1 - 1999 Q4:

$$m_t - p_t = \beta_0 + \underset{(0.04)}{1.34} y_t - \underset{(0.30)}{0.76} \left(i_t^{ST} - i_t^{OWN} \right).$$

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[2] An alternative approach is used by Greiber and Setzer (2007). They augment a standard money demand function with variables representing developments in the housing sector, such as property prices and property wealth. They find a positive stable relationship with either property prices or property wealth for the euro area over the period 1980 Q1-2006 Q4. The drawback of this model is that it considers gross wealth (rather than net wealth) in addition to real GDP and the long-term interest rate. Most importantly, we have estimated the Greiber and Setzer's model using latest ECB housing wealth data up to 2007 Q3 and it turns out that money is weakly exogenous and the system is not stable.

We use the estimated coefficients to construct the disequilibrium in money demand over the sample 1980 Q1 - 2007 Q3 measured by $m_t - p_t - \beta_0 - 1.34 y_t + 0.76 \left(i_t^{ST} - i_t^{OWN} \right)$ and we project real M3 growth out-of-sample from 2000 Q1 to 2007 Q3. Specifically, the model has been estimated up to 1999 Q4 and then the forecasts up to 2007 Q3 are obtained by stochastic dynamic simulation with 4-period ahead horizon.

The results reported in Figures 2 and 3 clearly illustrate the failure of the CGL model. Over the period 2000-2007, the deviation of real money from its long-run equilibrium identified and estimated over the sample 1980-1999 does not show any sign of mean reversion (see Figure 2). In fact, the null hypothesis of the existence of no cointegrating vector cannot be rejected when the Johansen procedure is implemented on the trivariate VAR for $\left(m_t - p_t, y_t, i_t^{ST} - i_t^{OWN} \right)$ over the sample 1980-2007. Moreover, the simulated out-of-sample annual growth of real M3 fails clearly to match the pattern of the observed data. Indeed, the model forecasts of real money growth go in the opposite direction with respect to the actual pattern (see Figure 3).

We can conclude that the long-run relationship between money and prices embedded in the existing money demand models for the euro area broke down after 2001 and that M3 grew at a much higher pace than that predicted by these models. However, the relevant question is not if traditional money demand models broke down, but why they did.[3]

The failure of the traditional money demand specification for the euro area is clearly related to the upward trend in annual (nominal and real) M3 growth that has occurred since 2001. Over this period, M3 developments have been strongly linked to the positive trend in capital flows in non-Monetary Financial Institutions (MFI) portfolio investment, as these two variables are tightly correlated (see Figure 4).

Four key periods can be identified when looking at the net flows in cross-border portfolio investment in the euro area since 2001. Up to mid-2003, in an environment of heightened financial market and geopolitical uncertainty and in search of safer returns,[4] the euro area money-holding sector reallocated its portfolio from domestic

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[3] Several studies have confirmed that there is a strong relationship between monetary growth and inflation at low frequencies. In other words, the relationship between money and prices is stronger between the trend-like developments than at frequencies influenced by business cycle fluctuations (Assenmacher-Wesche and Gerlach, 2007; Kugler and Kaufmann, 2005).

[4] This period coincided with the strong decline in the stock market indices during 2001 worldwide, the terrorist attacks on 11 September 2001, the accounting scandals in the US in 2002, the subsequent geopolitical uncertainties in the Middle East and the war in Iraq. The period 2001-2003 was, therefore, characterised by an extraordinary preference for liquid and safe financial assets by euro area residents.

and foreign equity holdings into domestic money holdings. The resulting portfolio shifts affected monetary dynamics, as argued by the ECB on several occasions.[5] Subsequently, from the summer of 2003 to mid-2004, net portfolio inflows have gradually declined amid expectations of capital losses as a result of a sharp rise in long-term bond yields in summer 2003 and probably because of weak economic growth in the euro area relative to developments in the rest of the world. The third period from mid-2004 to mid-2006 recorded a rebound with a strong rise in net inflows in portfolio investment associated with an increase in net purchases of euro area equity securities by non-residents. Finally, when looking at the most recent period from mid-2006 up to 2007 Q3, large net portfolio inflows occurred, driving up MFI net external assets mostly as a result of stronger investment by foreigners into the euro area. The positive economic outlook in favour of the euro area relative to the United States might have favoured the reallocation of the international portfolio towards euro area assets.

Overall, the anecdotal evidence suggests that transactions in cross-border portfolio investment have had an important role in driving monetary dynamics in the euro area in the past few years. Therefore, the analysis of cross-border portfolio transactions may shed some light on why monetary developments at times cannot be fully explained by traditional money demand determinants, such as output and interest rates.

Against this background, the aim of this paper is to analyse the role of international portfolio allocation on the euro area money demand, both from the theoretical and the empirical point of view. Specifically, is it possible to reconstruct a stable money demand by including variables (e.g. explaining portfolio flows) omitted in the traditional specifications? Moreover, do the implied equilibria deliver a stable relation between inflation and money growth exploitable to predict inflation and to allow the real time assessment of risks to price stability?

The rest of the paper is organized as follows. Section 2 constructs a Tobin's portfolio model of asset choice in an open economy, where wealth-owners hold a diversified portfolio with money, domestic and foreign risky assets. Different beliefs about Sharpe ratios by domestic and foreign investors and the amount of disposable wealth to be invested by foreign agents relative to domestic agents are sources of cross-border portfolio allocation, which ultimately affects monetary aggregates. Section 3 estimates a new empirical specification for money demand in the euro area within a system, where Sharpe ratios are assumed to be a function of the disequilibria between

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[5] See, for instance, Box 2 entitled "External capital flows and domestic monetary dynamics in the euro area" in the February 2005 issue of the ECB Monthly Bulletin and Box 2 entitled "Recent developments in MFI net external assets" in the July 2005 issue of the ECB Monthly Bulletin.

equity and bond markets in the euro area and the United States. Section 4 computes the model-based steady state money growth and investigates the role of excess money growth on HICP inflation over k-quarters ahead. Section 5 presents some robustness checks using preliminary estimates of euro area net financial and housing wealth. Finally, Section 6 concludes.

2 Money demand and international portfolio allocation

This section proposes a simple model of international portfolio allocation, which may help understand the link between money demand and net portfolio flows in the euro area.

Assume that the world consists of two countries, h (home) and f (foreign), where firms are pure endowment streams that generate homogenous nonstorable country-specific goods *à la* Lucas (1982) with the stochastic realizations $Y_{j,t}$ $(j = h, f)$. Moreover, we assume that the two countries issue fixed income securities whose coupon payments, C_j, are fixed in nominal terms. The current real state of the system is completely described by $(Y_{j,t} + C_j/P_{j,t}) = \zeta_{j,t}\,(Y_{j,t-1} + C_j/P_{j,t-1})\,\epsilon_{j,t}$, where $P_{j,t}$ is the price of good j and $\epsilon_{j,t}$ is lognormal.

Money, $M_{j,t}$, is used to buy goods and risky assets, such as domestic and foreign stocks and long-term bonds. Currency substitution is ruled out.[6] $\epsilon_{j,t}$ is revealed before trading occurs, so agents can allocate their portfolio between cash and other assets at the start of each period.

Each firm issues one perfectly divisible share of stock, e, and of perpetuity bond, b. The stock and the bond are traded in competitive markets such that $Z^{r}_{h,t} + Z^{r^*}_{h,t} = 1$ and $Z^{r}_{f,t} + Z^{r^*}_{f,t} = 1$, where $Z^{r}_{j,t}$ and $Z^{r^*}_{j,t}$ denote asset r $(= e, b)$ issued in country j and held at home and abroad (with asterisk), respectively. The firms pay out all of their output $Y_{j,t}Z^{e}_{j,t-1}$ priced at $P_{j,t}$ as dividends to shareholders, which together with the coupon on bonds, $C_j Z^{b}_{j,t-1}$, and interests on deposits, $i_{h,t-1}M_{h,t-1}$, form the sole sources of support for individuals. Therefore, the representative consumer in country

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[6] This is a plausible assumption given that the outstanding amount of deposits of euro area residents in foreign currency only amount to about 4% of all currencies.

j brings into period t wealth equal to

$$\begin{aligned} W_{h,t} = & \left(P_{h,t}Y_{h,t} + Q^e_{h,t}\right) Z^e_{h,t-1} + \left(P_{f,t}Y_{f,t} + Q^e_{f,t}\right) S_t Z^e_{f,t-1} \\ & + \left(C_h + Q^b_{h,t}\right) Z^b_{h,t-1} + \left(C_f + Q^b_{f,t}\right) S_t Z^b_{f,t-1} + \left(1 + i_{h,t-1}\right) M_{h,t-1}, \end{aligned}$$

$$\begin{aligned} W_{f,t} = & \left(P_{h,t}Y_{h,t} + Q^e_{h,t}\right) Z^{e^*}_{h,t-1}/S_t + \left(P_{f,t}Y_{f,t} + Q^e_{f,t}\right) Z^{e^*}_{f,t-1} \\ & + \left(C_h + Q^b_{h,t}\right) Z^{b^*}_{h,t-1}/S_t + \left(C_f + Q^b_{f,t}\right) Z^{b^*}_{f,t-1} + \left(1 + i_{f,t-1}\right) M_{f,t-1}, \end{aligned}$$

where $i_{j,t}$ is the own rate of return on money, $Q^e_{j,t}$ denotes the ex-dividend stock market price, $Q^b_{j,t}$ denotes the ex-coupon bond market price and S_t is the exchange rate expressed as the price of country h currency in terms of country f currency.

In turn, nominal wealth is used to buy goods and is allocated between money, domestic stocks and bonds and foreign stocks and bonds:

$$\begin{aligned} W_{h,t} = & M_{h,t} + Q^e_{h,t}Z^e_{h,t} + Q^e_{f,t}S_tZ^e_{f,t} + Q^b_{h,t}Z^b_{h,t} + Q^b_{f,t}S_tZ^b_{f,t} \\ & + P_{h,t}X_{h,t} + P_{f,t}S_tX_{f,t}, \\ W_{f,t} = & M_{f,t} + Q^e_{f,t}Z^{e^*}_{f,t} + Q^e_{h,t}Z^{e^*}_{h,t}/S_t + Q^e_{f,t}Z^{e^*}_{f,t} + Q^b_{h,t}Z^{b^*}_{h,t}/S_t \\ & + P_{f,t}X^*_{f,t} + P_{h,t}X^*_{h,t}/S_t. \end{aligned} \tag{1}$$

where $X_{j,t}$, and $X^*_{j,t}$ denote respectively goods consumed at home and abroad. The goods market equilibrium implies $Y_{h,t} + C_h/P_{h,t} = X_{h,t} + X^*_{h,t}$ and $Y_{f,t} + C_f/P_{f,t} = X_{f,t} + X^*_{f,t}$.

Given the opportunity cost of holding money, consumers acquire the exact amount of cash required to finance the current-period consumption plan. Under the hypothesis of a constant consumption-wealth ratio (b_j),[7] (1) can be re-written as

$$\begin{aligned} M_{h,t} &= \left(1 - b_h\right) W_{h,t} \left(1 - \lambda'\alpha_t\right), \\ M_{f,t} &= \left(1 - b_f\right) W_{f,t} \left(1 - \lambda'\alpha^*_t\right), \\ \lambda' &= \begin{bmatrix} 1 & 1 & 1 & 1 \end{bmatrix} \\ \alpha_t &= \begin{bmatrix} \alpha^e_{h,t} \\ \alpha^e_{f,t} \\ \alpha^b_{h,t} \\ \alpha^b_{f,t} \end{bmatrix}, \alpha^*_t = \begin{bmatrix} \alpha^{e^*}_{h,t} \\ \alpha^{e^*}_{f,t} \\ \alpha^{b^*}_{h,t} \\ \alpha^{b^*}_{f,t} \end{bmatrix} \end{aligned} \tag{2}$$

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[7] This hypothesis is supported by a recent work of Skudelny (2008), who finds a cointegrating relationship between euro area consumption and wealth. This hypothesis is also supported by the influential work of Lettau and Ludvigson (2001), who find a cointegrating relationship between US consumption and wealth and that fluctuations in aggregate consumption-wealth ratio can help predicting stock returns. To be consistent, one should assume b_j stationary. For simplicity, we assume b_j constant, given that the stationarity assumption would not have any implication in the empirics.

where $\alpha_t = \mathbf{Q}_t\mathbf{S}_t\mathbf{Z}_t/\left(1-b_h\right)W_{h,t}$ and $\alpha_t^*{=}\mathbf{Q}_t^*\mathbf{S}_t^*\mathbf{Z}_t^*/\left(1-b_f\right)W_{f,t}$ denote the vector of portfolio weights by domestic and foreign investors, $\mathbf{S}_t = \begin{bmatrix} 1 & S_t \end{bmatrix}$ and $\mathbf{S}_t^* = \begin{bmatrix} S_t^{-1} & 1 \end{bmatrix}$.

The relationship between investors' money demand and portfolio weights is negative. Given the assets' aggregate supply, decisions on the portfolio weights by domestic and foreign investors generate international portfolio flows that ultimately affect money growth.

The purchase of foreign risky assets ($Z_{f,t}^r$ for the domestic agent, $Z_{h,t}^{r^*}$ for the foreign agent) or the re-purchase of home assets held abroad ($Z_{h,t}^{r^*}$ for the domestic agent, $Z_{f,t}^r$ for the foreign agent) is paid through the reduction of current consumption such that the balance of payments is in equilibrium:

$$\begin{aligned}&\left[Q_{f,t}^e Z_{f,t}^e - \left(P_{f,t}Y_{f,t} + Q_{f,t}^e\right) Z_{f,t-1}^e\right] S_t - \left[Q_{h,t}^e Z_{h,t}^{e^*} - \left(P_{h,t}Y_{h,t} + Q_{h,t}^e\right) Z_{h,t-1}^{e^*}\right] \\ &\quad + \left[Q_{f,t}^b Z_{f,t}^b - \left(C_f + Q_{f,t}^b\right) Z_{f,t-1}^b\right] S_t - \left[Q_{h,t}^b Z_{h,t}^{b^*} - \left(C_h + Q_{h,t}^b\right) Z_{h,t-1}^{b^*}\right] \\ &\qquad = P_{h,t}X_{h,t}^* - P_{f,t}S_tX_{f,t}.\end{aligned}$$

To simplify the notation we develop the problem that the domestic household faces. Let us assume a time-separable utility function, which is a bounded, continuously differentiable, strictly increasing and strictly concave over X_h and X_f. In period t, subject to the intertemporal budget constraint, each domestic agent wishes to maximise

$$E_t\left\{\sum_{\tau=0}^{\infty}\beta^\tau u\left(X_{h,t+\tau}, X_{f,t+\tau}\right)\right\}, \qquad\qquad 0<\beta<1,$$

where E_t is the expectations operator conditional on information available at t.

The associated Euler equations are the following

$$\begin{array}{lc} X_{h,t} & u'\left(X_{h,t}\right) = \gamma_t \\ X_{f,t} & u'\left(X_{f,t}\right)/u'\left(X_{h,t}\right) = P_{f,t}S_t/P_{h,t} \\ Z_{h,t}^r: & E_t\left\{m_{t+1}\left(1+r_{h,t+1}^r\right)/\left(1+\pi_{h,t+1}\right)\right\} = 1 \\ Z_{f,t}^r: & E_t\left\{m_{t+1}\left(1+r_{f,t+1}^r\right)\left(1+s_{t+1}\right)/\left(1+\pi_{h,t+1}\right)\right\} = 1 \\ M_{h,t}: & E_t\left\{m_{t+1}\left(1+i_{h,t}\right)/\left(1+\pi_{h,t+1}\right)\right\} = 1 \end{array} \tag{3}$$

where $m_{t+1} = \beta\gamma_{t+1}/\gamma_t$ is the stochastic discount factor, $\left(1+\pi_{h,t+1}\right) = P_{t+1}^h/P_t^h$ is the gross consumer price inflation rate in country h, $\left(1+r_{j,t+1}^e\right) = \left(P_{j,t+1}Y_{j,t+1} + Q_{j,t+1}^e\right)/Q_{j,t}^e$ is the local currency gross total return on stock j, $\left(1+r_{j,t+1}^b\right) = \left(C_j + Q_{j,t+1}^b\right)/Q_{j,t}^b$ is the local currency gross total return on bond j and $\left(1+s_{t+1}\right) = S_{t+1}/S_t$ is the gross appreciation of the foreign currency. γ is the Lagrange multiplier.

The first expression in (3) is the standard equality between marginal utility of consumption and marginal utility of wealth. The second expression is the standard relationship between marginal utility ratios and relative prices. The remaining three expressions are the familiar conditions for asset pricing. Along the optimal path, the marginal cost (in terms of today's utility) from reducing wealth slightly (γ_t) must equal the utility value of carrying the wealth forward one period $\beta\left(\gamma_{t+1}\right)$, earning $\left(1+r^r_{h,t+1}\right)/\left(1+\pi_{h,t+1}\right)$ if investing in domestic assets r, $\left(1+r^r_{f,t+1}\right)(1+s_{t+1})/\left(1+\pi_{h,t+1}\right)$ if investing in foreign assets r and $\left(1+i_{h,t}\right)/\left(1+\pi_{h,t+1}\right)$ if holding domestic money.

Assume that expected inflation at time $t+1$ is known at time t, then the asset pricing equations can be used to derive asset returns as follows

$$\begin{gathered}E_t\left\{1+r^r_{h,t+1}\right\}=\left(1+i_{h,t}\right)E_t\left\{rp^r_{h,t+1}\right\},\\ E_t\left\{\left(1+r^r_{f,t+1}\right)\left(1+s_{t+1}\right)\right\}=\left(1+i_{h,t}\right)E_t\left\{rp^r_{f,t+1}\right\},\end{gathered}\tag{4}$$

where the risk premia on domestic and foreign assets are respectively equal to $rp^r_{h,t+1}=1-cov_t\left\{m_{t+1},\frac{\left(1+r^r_{h,t+1}\right)}{\left(1+\pi_{h,t+1}\right)}\right\}$ and $rp^r_{f,t+1}=1-cov_t\left\{m_{t+1},\frac{\left(1+r^r_{f,t+1}\right)\left(1+s_{t+1}\right)}{\left(1+\pi_{h,t+1}\right)}\right\}$.

To solve analytically for the portfolio weights, let us assume that the utility function is of the form $u\left(X_{h,t},X_{f,t}\right)=\left(X^{1-\eta}_{h,t}X^{\eta}_{f,t}\right)^{1-\delta_h}/1-\delta_h$, where δ_h is the coefficient of relative risk aversion and $0<\eta<1$ is the expenditure share of the foreign country's good in the consumption basket of the domestic household.

If asset returns and aggregate consumption are jointly log-normal, then $\log E_t\left(\mathbf{rp}_{t+1}\right)=\delta_h\alpha_t\mathbf{\Sigma}_{t+1}$, where $\mathbf{\Sigma}_{t+1}$ is the expected conditional variance-covariance matrix of returns (Campbell and Viceira, 2002). As a result, (4) can be solved for the optimal portfolio allocation:

$$\alpha_t=\frac{1}{\delta_h}\mathbf{\Sigma}^{-1}_{t+1}\left(E_t\widetilde{\mathbf{r}}_{t+1}-\mathbf{i}_{_{h,t}}+\widetilde{\sigma}^2_{t+1}/2\right),\tag{5}$$

where $\widetilde{\mathbf{r}}_{t+1}$ and $\widetilde{\sigma}_{t+1}$ denote the vector of expected returns and conditional variance of returns evaluated in the domestic currency.

Foreign agents face the same portfolio choice with the resulting optimal portfolio outcome:

$$\alpha^*_t=\frac{1}{\delta_f}\mathbf{\Sigma}^{*-1}_{t+1}\left(E^*_t\widetilde{\mathbf{r}}_{t+1}-\mathbf{i}_{f,t}+\widetilde{\sigma}^{*2}_{t+1}/2\right).\tag{6}$$

Portfolio allocation and expectations by foreign agents are denoted with a star. Namely, we assume that the fundamental equation for consumption-based asset pricing holds for any asset using the beliefs and consumption of any agent (Anderson et al., 2005; Shefrin, 2005).

In a closed economy, the relationship between money demand and the domestic assets' Sharpe ratio is negative. In an open economy, such relationship depends, *inter alias*, also on the Sharpe ratio expected by foreign investors on the same asset. To address the issue more formally, we need to assess the impact of optimal portfolio allocation by domestic and foreign investors on cross-border holdings.

Given that $\alpha_t = \mathbf{Q}_t \mathbf{S}_t \mathbf{Z}_t / (1 - b_h) W_{h,t}$ and $\alpha_t^* = \mathbf{Q}_t^* \mathbf{S}_t^* \mathbf{Z}_t^* / (1 - b_f) W_{f,t}$, by making use of (5) and (6), the value of each asset held abroad minus the value of the same asset held at home can be determined as:

$$\begin{aligned} &\mathbf{Q}_t \left(\mathbf{Z}_t^* - \mathbf{Z}_t\right) = (1 - b_h) W_{h,t} \times \\ &\left[\frac{1}{\delta_f} \phi_t \boldsymbol{\Sigma}_{t+1}^{*-1} \left(E_t^* \widetilde{\mathbf{r}}_{t+1} - \mathbf{i}_{f,t} + \widetilde{\sigma}_{t+1}^{*2}/2\right) - \frac{1}{\delta_h} \boldsymbol{\Sigma}_{t+1}^{-1} \left(E_t \widetilde{\mathbf{r}}_{t+1} - \mathbf{i}_{h,t} + \widetilde{\sigma}_{t+1}^{2}/2\right)\right], \end{aligned} \tag{7}$$

where $\phi_t = (1 - b_f) S_t W_{f,t}^* / (1 - b_h) W_{h,t}$.

As a result, different portfolio allocations across agents, which is an equilibrium outcome, arises for three main reasons:

(i) disagreement (heterogeneous beliefs) by utility maximizing agents in the two countries about the expected rate of change of output in each of the two economies. The home country would record net international portfolio inflows if, *ceteris paribus*, $\boldsymbol{\Sigma}_{t+1}^{*-1} \left(E_t^* \widetilde{\mathbf{r}}_{t+1} - \mathbf{i}_{f,t} + \widetilde{\sigma}_{t+1}^{*2}/2\right)$ is greater than $\boldsymbol{\Sigma}_{t+1}^{-1} \left(E_t \widetilde{\mathbf{r}}_{t+1} - \mathbf{i}_{h,t} + \widetilde{\sigma}_{t+1}^{2}/2\right)$. In this case, $\mathbf{Z}_t^* - \mathbf{Z}_t > 0$, which implies a portfolio shift towards home assets through the sale of domestic assets to foreign investors and a portfolio shift away from foreign assets through a decrease in the holding of foreign assets;

(ii) the higher δ_j, namely the more risk adverse the consumer, the lower the stochastic discount factor and the higher the expected excess returns ought to be in order for the agent to hold domestic and foreign risky assets. The home country would hold a relatively reduced number of risky assets to finance his current consumption if, *ceteris paribus*, $\delta_h > \delta_f$;

(iii) the difference in disposable wealth between the two economies. The home country would record net portfolio inflows if, *ceteris paribus*, its wealth is relatively smaller or its average propensity to consume is relatively larger, $\phi_t > 1$.

If, for simplification, we assume that $\delta_h = \delta_f = \delta$, then variations in portfolio holdings mainly depend on differences in disposable wealth and Sharpe ratios.

Given (7) and the exogenous supply of stocks and bonds, we can determine $Q_{h,t}^r Z_{h,t}^r + Q_{f,t}^r S_t Z_{f,t}^r$, which substituted into (2) yields

$$
\begin{array}{rlcc}
M_{h,t} = & \left(1-b_h\right) W_{h,t}\times & \Rightarrow & \text{wealth effect} \\
 & \left\{1+\lambda' \left[\left(\phi_t \mathbf{\Phi}^{*}_{t+1} - \mathbf{\Phi}_{t+1}\right)\right] /2\delta\right\} & \Rightarrow & \text{size and portfolio allocation effects} \\
 & \text{-}\Pi_t/2 & \Rightarrow & \text{firms' valuation effect}
\end{array}
\tag{8}
$$

where $\mathbf{\Phi}_{t+1} = \mathbf{E}_t \left[\mathbf{\Sigma}^{-1}_{t+1} \left(\widetilde{\mathbf{r}}_{t+1} - i_t + \widetilde{\sigma}^{2}_{t+1}/2\right)\right]$, $\mathbf{\Phi}^{*}_{t+1} = \mathbf{E}^{*}_t \left[\Sigma^{-1}_{t+1} \left(\widetilde{\mathbf{r}}_{t+1} - i_t + \widetilde{\sigma}^{*2}_{t+1}/2\right)\right]$ and Π_t is the aggregate asset value of domestic and foreign firms.

In the long run, money balances are a positive function of wealth, of the relative disposable wealth between foreign and domestic agents and of the differentials between Sharpe ratios expected by foreign and domestic agents, while they are a negative function of half of firms' aggregate asset value.

Money is a store of value and as such it serves as an alternative to holding other assets (i.e. *wealth effect*).

If the attractiveness of non-monetary assets increases, foreign demand for these assets will crowd out euro area demand simply because euro area wealth is smaller than foreign wealth. The resulting purchases of assets from euro area residents by foreigners imply a rise in euro area M3 (i.e. *size effect*).

If the Sharpe ratio on domestic asset rises, then the opportunity cost of holding money increases. In a closed economy, any attempt to shift out of money into non-monetary assets will simply transfer money from the purchaser to the seller of the asset, leaving the aggregate stock of money unchanged. However, the classical domestic substitution effect would still arise if the transaction occurs between the money-holding sector and the MFI sector or central government. In the latter case, when asset prices rise, if the wealth effect does not outweigh the domestic substitution effect, the demand for money declines. In an open economy, in addition, there is a foreign substitution effect to be taken into account. If the Sharpe ratio on domestic and/or foreign asset rises, foreign investors are also willing to buy domestic and/or foreign assets from domestic agents (i.e. *international portfolio allocation effect*).

Thus, the portfolio model does not yield unambiguous predictions about the effect of an increase in Sharpe ratios on the demand for money. So long as the size and the foreign substitution effects outweigh the domestic substitution effect, i.e. $\phi_t \mathbf{\Phi}^{*}_t > \mathbf{\Phi}_t$, then an expected rise in domestic Sharpe ratios will increase the demand for money in the economy as a whole.

If the law of one price would hold for both consumer and asset prices, and domestic and foreign agents would have the same intertemporal utility function, and share the same forward-looking expectations regarding the dividend process, then the equilibrium would be symmetric: $\alpha_t = \alpha^{*}_t$. In this case each agent owns half of domestic firm, half of the foreign firm and half of the issued bonds. This equilibrium corresponds to Lucas (1982) equilibrium in the sense that it guarantees complete insurance of idiosyncratic risks. But also in this case, the portfolio allocation effect is not nil unless $\phi_t = 1$, namely if countries have the same disposable wealth. In a symmetric world, portfolio flows are nil and $M_t = (1-b)\,W_t - V_t$, where V_t is the aggregate asset value of the symmetric firm.

All in all, if $\phi_t \mathbf{\Phi}_t^* > \mathbf{\Phi}_t$ ($\phi_t \mathbf{\Phi}_t^* < \mathbf{\Phi}_t$), foreign investors would hold a higher (lower) number of domestic and foreign stocks implying higher (lower) real domestic money balances.

Thus far, we studied the theoretical properties of a model with international portfolio allocation; however, our ultimate goal is to empirically model its role on euro area money demand.

3 A new specification of the euro area money demand

Our focus of interest is to study the long-run relationship between money and prices. The relevant empirical question at this stage is which specification to adopt for the long-run analysis in the light of the theoretical model that we have proposed in the previous section. The theoretical model suggests that portfolio shares for all assets, including money, depend on Sharpe ratios of domestic and foreign assets. The problem of having a proxy for the Sharpe ratios expected by agents is solved by applying an extended version of the so-called “FED model” (see Lander et al., 1997; Koivu et al., 2005) to euro area and US assets given the strong link between price/earnings ratios and bond yields in both economic regions (see Figure 5).[8] This simple model

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[8] This regularity was used as an input by Alan Greenspan in a famous speech on market’s irrational exuberance in December 1996 (http://www.federalreserve.gov/boarddocs/speeches/1996/19961205.htm). This approach has been criticised mainly because in theory the dividend/earnings yield is a real variable, while bond yield is function of expected inflation (Asness, 2003). Campbell and Vuolteenaho (2004) argue that the market suffers from inflation illusion as they found a positive relationship between growth in real earnings and expected inflation. Thomas and Zhang (2007) challenge the Campbell and Vuolteenaho’s results, as the relationship becomes negative when looking at the period after the second world war or when proxing expected inflation with 10-year bond yield. Thomas and Zhang (2007) also find that nominal earnings growth are largely unrelated to expected inflation. Therefore, they argue that earnings yields are “nominal” rather than “real”, as also found by Boucher (2006). Similar conclusions are suggested by Bekaert and Engstrom (2008). They find that both bond and equity yields comove strongly and positively with expected inflation.

sometimes is used by practitioners to form expectations about excess returns.

3.1 From theory to a cointegrated VAR

The extended version of the FED model is best understood by considering the dynamic dividend growth model of Campbell and Shiller (1988) and the n-period coupon bond yield model of Shiller (1979). Using a loglinear approximation to the returns on the stock market, we can express the log of the stock price-dividend ratio $q^e_{j,t} - d_{j,t} = \log(Q^e_{j,t}/P_{j,t}Y_{j,t})$ as a linear function of the future discounted dividend growth, $\Delta d_{j,t+1+\tau}$, and of future returns, $Er^e_{j,t+1} = i_{h,t} + \xi^e_{j,t+1}$:

$$q^e_{j,t} - d_{j,t} = \frac{k^e_j}{1-\rho^e_j} + E_t\left[\sum_{\tau=0}^{\infty} \rho_j^{e^\tau} \left(\Delta d_{j,t+1+\tau} - r^e_{j,t+1+\tau}\right)\right], \tag{9}$$

where $\xi^e_{j,t+1} = \log E_t\left(\widetilde{rp}^e_{j,t+1}\right) - \widetilde{\sigma}^{e^2}_{j,t+1}/2$, $k^e_j = -\log\left(\rho^e_j\right) - \left(1-\rho^e_j\right)\log\left(1/\rho^e_j - 1\right)$, $\rho^e_j = 1/\left(1+\exp\left\{\overline{d_j - q^e_j}\right\}\right)$, and $\overline{d_j - q^e_j}$ is the steady-state level of the dividend-price ratio.

Similarly, a loglinear model for coupon bonds implies that the log price of an n-period coupon bond, $q^b_{j,t} = \log(Q^b_{j,t})$, is a linear function of coupon payments, $c_j = \log(C_j)$, and the future returns on the bond, $Er^b_{j,n-\tau,t+1+\tau} = i_{h,t} + \xi^b_{j,n-\tau,t+1}$:

$$q^b_{j,nt} = \sum_{\tau=0}^{n-1} \rho_j^{b^\tau}\left(k^b_j + \left(1-\rho^b_j\right)c_j - r^b_{j,n-\tau,t+1+\tau}\right), \tag{10}$$

where $\xi^b_{j,n-\tau,t+1} = \log E_t\left(\widetilde{rp}^b_{j,t+1}\right) - \widetilde{\sigma}^{b^2}_{j,t+1}/2$, $k^b_j = -\log\left(\rho^b_j\right) - \left(1-\rho^b_j\right)\log\left(1/\rho^b_j - 1\right)$, $\rho^b_j = 1/\left(1+\exp\left\{\overline{c_j - q^b_j}\right\}\right)$, and $\overline{c_j - q^b_j}$ is the steady-state level of the coupon-price ratio.

Shiller (1979) shows that (10) implies that the n-period coupon bond yield satisfies $R_{j,nt} \approx \left(\left(1-\rho^b_j\right)/\left(1-\rho_j^{b^n}\right)\right)\sum_{\tau=0}^{n-1}\rho_j^{b^\tau} r^b_{j,n-\tau,t+1+\tau}$. If n is sufficiently large such that the steady-state levels of the dividend-price ratio and of the coupon-price ratio are equal and $\rho_j^{b^n} = 0$, then $\rho^e_j = \rho^b_j = \rho_j$ and

$$R_{j,nt} \approx \left(1-\rho_j\right)E_t\sum_{\tau=0}^{\infty}\rho_j^\tau r^e_{j,t+1+\tau} - \left(1-\rho_j\right)\Omega_{j,t}, \tag{11}$$

where $\Omega_{j,t} = \sum_{\tau=0}^{\infty}\rho_j^\tau \xi^e_{j,t+1+\tau} - \sum_{\tau=0}^{n-1}\rho_j^\tau \xi^b_{j,n-\tau,t+1+\tau}$.

Assuming a stationary relation between the dividend- and earnings-yield and stationary dividend growth (see Appendix B), (11) into (9) yields the equilibrium level for the (log of) stock market price, $\widehat{q}^{e}_{j,t}$, to be a function of the (log of) earnings, $e_{j,t}$, the long-term coupon bond yield and the risk premia differential:

$$\widehat{q}^{e}_{j,t} = \frac{1}{1-\rho_j}\left[k_j + g_{j,t} + (1-\rho_j)\,\psi_{j,t}\right] + e_{j,t} - \frac{1}{1-\rho_j}\left(R_{j,t} + \Omega_{j,t}\right) \tag{12}$$

where $g_{j,t}$ is the growth rate in dividends and $\psi_{j,t}$ the expected payout ratio.

Under the hypothesis of constancy of the variance-covariance matrix of returns, the dynamics of stock and bond prices are such that they adjust to fulfil (12), so that the following empirical model for stock and bond returns can be adopted:

$$\Phi^{r}_{j,t+1} = \kappa^{r}_{j,0} - \kappa^{r}_{j,1}\left(q^{e}_{j,t} - \widehat{q}^{e}_{j,t}\right) + u^{r}_{j,t+1}, \tag{13}$$

where $\kappa^{r}_{j,1}$ is the speed of adjustment to the equilibrium expected earnings yields consistent with bond yields and the risk premium as thought by the domestic agent, and $u^{r}_{j,t+1}$ is the unforecastable part of the Sharpe ratios.

Similarly, the foreign agent will adopt the following empirical model

$$\Phi^{r^*}_{j,t+1} = \kappa^{r}_{j,0} - \kappa^{r^*}_{j,1}\left(q^{e}_{j,t} - \widehat{q}^{e}_{j,t}\right) + u^{r^*}_{j,t+1}, \tag{14}$$

where $\kappa^{r^*}_{j,1}$ is the speed of adjustment of asset prices to the equilibrium expected earnings yields consistent with bond yields and the risk premium as thought by the foreign agent.

$\kappa^{r}_{j,0}$ can be interpreted as the fundamental component of the Sharpe ratios while the remainder is the heterogeneity component, which depends on agents' expectations about consumption growth and which, ultimately, determines the direction of the portfolio flows. Investors reallocate assets in response to the disequilibrium $\left(q^{e}_{j,t} - \widehat{q}^{e}_{j,t}\right)$ causing stock and bond prices to move in the direction that reduces the disequilibrium or, alternatively, interest rates and risk premia change such that the equilibrium is restored.

Inserting (12), (13), and (14) into (8) and assuming stationarity of disposable wealth across countries (see Appendix B) and of the difference between equity and bond premia, the stock of money can be rewritten as follows

$$\begin{aligned} M_{h,t} = \quad & (1-b_h)\,W_{h,t}\sum_{r=e,b}\;\sum_{j=h,f}\left[\chi^{r}_{j,t} - \left(\phi_t\kappa^{r^*}_{1} - \kappa^{r}_{1}\right)\left(q^{e}_{j,t} - e_{j,t} + \beta_j R_{j,t}\right)\right]/2\delta \\ & + (1-b_h)\,W_{h,t} \text{ - } \Pi_t/2 + \varepsilon^{m}_{h,t+1} \end{aligned} \tag{15}$$

where $\chi^{r}_{j,t} = (\phi_t - 1)\,\kappa^{r}_{j,0} + \left(\phi_t\kappa^{r^*}_{j,1} - \kappa^{r}_{j,1}\right)\left[k_j + g_{j,t} + (1-\rho_j)\,\psi_{j,t} - \Omega_{j,t}\right]/\left(1-\rho_j\right)$ and ϕ_t are time-varying but stationary and $\varepsilon^{m}_{h,t+1} = \sum_{r=e,b}\sum_{j=h,f}\left(\phi_t u^{r^*}_{j,t+1} - u^{r}_{j,t+1}\right)$.

In the light of the above derivation, the main omitted variables in traditional money demand models are domestic and foreign risky asset prices, as the importance of wealth and the valuation effect can be captured by traditional scale variables such as income. Indeed, in order to have an empirical model comparable with the existing CGL specification and given the quality of the euro area net wealth measure (see Skudelny, 2008), we use output rather than wealth as a scale variable.[9]

In order to analyse simultaneously the long-run equilibria for money demand and domestic and foreign asset markets, the multivariate cointegrating space is based on the specification of the following VAR in levels:

$$\begin{aligned} \mathbf{X}_t &= \mathbf{A}(L)\mathbf{X}_{t-1} + v_t \\ \mathbf{X}'_t &= \left[\begin{array}{cccccccc} m_t - p_t & y_t & i_t^{OWN} & q_t^{EA} - e_t^{EA} & R_t^{EA} & q_t^{US} - e_t^{US} & R_t^{US} \end{array} \right] \end{aligned} \tag{16}$$

In terms of variable candidates to determine the long-run money demand, we augment the set considered by CGL with the determinants of stocks and bonds Sharpe ratios in the euro area and US markets, given the role of US assets in the world economy.

The specification strategy is close in spirit to the "long-run structural modelling approach" proposed by Pesaran and Shin (2002) (see also Garratt et al., 2006), in which empirical models are constructed on the belief that economic theory is most informative about the long-run relationships between the relevant variables while no restrictions are imposed on the short-run dynamics of the model except for the inevitable choice of the lag length for the adopted VAR specification.

In the light of the results on the importance of using the opportunity cost of holding money as a determinant of money demand, it could be argued that we still omit from our system the spread between the short-term interest rates and the own rate of return on M3, $\left(i_t^{ST} - i_t^{OWN}\right)$. This variable is omitted because i_t^{OWN} and $\left(i_t^{ST} - i_t^{OWN}\right)$ present a clear long-run comovement, with i_t^{OWN} being approximately equal to $0.5 i_t^{ST}$ (see Figure 6 and Appendix A).

Moreover, it could be argued that we omit the foreign short-term interest rate to capture the cross-border investment in short-term debt instruments. Such instruments have a smaller role in international portfolio allocation. In fact, at end of 2006, non-MFI euro area holdings of foreign money market instruments amounted to 2.1% of total non-MFI euro area portfolio investment abroad. Yet, we tried to include in the long-run specification also the US short-term interest rate, but it turned to be

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[9] Based on euro area estimates of financial and housing wealth on an annual basis, some robustness checks are presented in Section 5.

that the Likelihood Ratio test for over-identifying restrictions is rejected.

3.2 The data set

We make use of historical series of quarterly data for the euro area and the United States over the period 1980 Q1 to 2007 Q3. All variables are measured as end-of-period and seasonally adjusted whenever it applies.

As regards the euro area, the real M3 holdings are calculated as the nominal broad monetary aggregate M3 deflated by the GDP deflator.[10] The real GDP series is based on euro area countries national series aggregated using the irrevocably fixed exchange rates (see Appendix A for details).

With regard to the financial variables, the short-term interest rate for the euro area is a weighted average (based on money weights) of the national three-month interbank interest rates up to end of 1998, and then Euribor afterwards. Similarly, the long-term interest rate is constructed as a weighted average of the yields on the national ten-year government bonds or their closest substitutes. The own rate of return on M3 is calculated using the national contributions to M3 as weights. For the United States, the long-term interest rate also corresponds to the yields on the ten-year US Treasury notes and bonds or their closest substitutes. The price earning-ratio for the euro area and the United States are calculated as being derived by dividing the total market value by the total earnings and refer to the DataStream stock market index.

Except for the interest rates, all variables are expressed in logarithms. Appendix A contains a detailed description of the construction and sources of the variables used in the study.

We also verified the assumptions underlying the theoretical model and the results are reported in Appendix B. Overall, the assumptions are supported by the data.

3.3 The empirical model

The treatment of the deterministic component in the cointegrating space must reflect the nature of the time series considered in the analysis. The system (16), hereafter referred to as DFR, differs from the traditional cointegrating space adopted for money demand analysis in that it includes returns on asset prices. It seems natural to rule

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[10] The use of the GDP deflator as price index to derive real money balances is consistent with the use of real GDP. The choice of real GDP and the GDP deflator as the scale and price variables in the money demand function is standard in existing empirical work.

out the presence of a deterministic trend in equilibrium long-run returns to investment in the bond and stock markets. The application of the Johansen test for the joint hypothesis of both the rank order and the deterministic component confirms this notion. In absence of a deterministic trend, the cointegration test allows to reject the null of the existence of at most two cointegrating vectors and it does not reject the null of existence of at most three cointegrating vectors (see Table 1). Interestingly, the statistical evidence on the number of cointegrating vectors is robust when we re-estimate the baseline VAR over the sample 1980-1999 used in CGL (see Table 2). Thus, the intercept is restricted to the cointegrating space. Having said this, we have also tested out that all the results presented in the following sections are generally robust to the introduction of a deterministic trend in the system.

Restrictions are needed to identify the three cointegrating relations. We consider alternative paths to identification. First, we set the restrictions in such a way that the first cointegrating relation identifies a standard money demand with output and interest rates, the second cointegrating relation captures the FED model for the euro area and the third cointegrating relations captures the FED model for the United States. The three relevant cointegrating vectors are specified as follows:

$$\begin{aligned} m_t - p_t &= \beta_{10} + \beta_{12} y_t + \beta_{13} i_t^{OWN} \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \beta_{25} R_t^{EA} \\ q_t^{US} - e_t^{US} &= \beta_{30} + \beta_{37} R_t^{US}. \end{aligned}$$

The over-identifying restrictions for this long-run structure are overwhelmingly rejected with the Likelihood Ratio test for over-identifying restrictions (rank = 3) being distributed as χ_8^2 with 8 degree of freedom equal to 29.81 with a tail probability of 0.0002.[11]

Second, in the light of this rejection, we consider a more general structure directly

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[11] We have also extended the CGL model (based on the spread between the short-term interest rate and the own rate of return on money) by adding the FED models for the euro area and the United States. However, this alternative identification scheme is highly rejected: the Likelihood Ratio test for over-identifying restrictions (rank = 3) being distributed as χ_8^2 with 8 degree of freedom equal to 30.51 with a tail probability of 0.0002.

related to (12)-(15):

$$\begin{aligned} m_t - p_t &= \beta_{10} + \beta_{12} y_t + \beta_{14}\left(q_t^{EA} - e_t^{EA}\right) \\ &\quad - \beta_{14}\left(q_t^{US} - e_t^{US}\right) + \beta_{15} R_t^{EA} - \beta_{15} R_t^{US} \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \beta_{23} i_t^{OWN} + \beta_{25} R_t^{EA} \\ q_t^{US} - e_t^{US} &= \beta_{30} + \beta_{37} R_t^{US}. \end{aligned}$$

The first cointegrating vector is consistent with the long-run money demand derived in (15). The second and third cointegrating vectors bear a clear relation to an extended version of the FED model for the euro area asset market, which includes the own rate of return on M3, and to the FED model for the US stock market as proposed by Lander et al. (1997). The Likelihood Ratio test for over-identifying restrictions (rank = 3) is χ^2_6=10.83 with a tail probability of 0.0939. Therefore, the theory consistent structure cannot be rejected.

Parameters and standard errors, estimated over the full sample 1980-2007, are as follows:

$$\begin{aligned} m_t - p_t &= \beta_{10} + \underset{(0.046)}{1.84}\, y_t + \underset{(0.035)}{0.38}\left(q_t^{EA} - e_t^{EA}\right) \\ &\quad - \underset{(0.035)}{0.38}\left(q_t^{US} - e_t^{US}\right) + \underset{(0.42)}{1.37} R_t^{EA} - \underset{(0.42)}{1.37} R_t^{US} && (17) \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \underset{(2.92)}{14.11} i_t^{OWN} - \underset{(2.24)}{15.83} R_t^{EA} && (18) \\ q_t^{US} - e_t^{US} &= \beta_{30} - \underset{(2.41)}{18.46} R_t^{US}. && (19) \end{aligned}$$

The results reported in Figure 7 (see also Figure 12) clearly illustrate that our system exhibits a money demand cointegrating vector that is mean reverting or, in other words, stationary.[12] The estimation of the cointegrating space highlights two important features that deserve further comments. First, the output elasticity of money demand is very high. This can be explained if, consistently with a portfolio allocation model of money demand, output is intepreted as a proxy for wealth. We shall explicitly address this issue later in the paper by re-running the cointegration analysis using wealth as a scale variable. Second, there is an asymmetry in the equilibria for asset prices in the euro area and the United States. Specifically, the price-earnings ratio and the long-term yields in the euro area diverge from 2000 onwards. Such di-

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[12] Carstensen (2006) derived a stable money demand using euro area equity prices. The model, however, is no longer stable because to capture the role of net portfolio flows a relative concept for expected asset returns is needed.

vergence is partially captured by the fluctuations of the monetary policy rate, which is reflected in the own rate of return on money.[13]

To be sure that money plays a key role in the system, we follow two strategies. First, we set equal to zero the coefficient on $m_t - p_t$ and normalise to unity the coefficient on y_t. The test rejects strongly the exclusion of money from the above system (χ^2_7=35.72) at 1% significance level. Second, we estimate (17)-(19) and impose restrictions on the adjustment coefficients to asses whether money is weakly exogenous: $\alpha_{11} = \alpha_{12} = \alpha_{13} = 0$. The test rejects such hypothesis (χ^2_9=30.66) at 1% significance level.

Therefore, we can safely argue that Figure 7 represents the residuals from the long-run money demand or the so-called "monetary overhang". The series fluctuates around zero, so that all departures of the actual M3 stock from the long-run money demand implied by the model are "corrected" over time. However, as the model consists of a system, these residuals should be read in the context of the model as a whole, i.e. by taking into account also the potential divergences of earning yields from bond yields, which can occur in the other two asset markets comprising the model. In particular, although the model may explain well the long-run evolution of the stock of M3, this does not exclude that there may be indications of risks to price stability stemming from developments in asset markets.

On the basis of this model set-up, two main observations are worth making.

(i) Given that asset prices are volatile, this introduces some volatility in the residuals of the money demand, although, at the same time, it exhibits a fast reversion to the mean. While confirming the underlying relationship between money and a small number of macroeconomic variables, this model suggests that asset price developments are an important determinant of monetary developments, due to their effect on the velocity of money.

(ii) There are linkages between money and asset price developments which run in both directions, so that disequilibria in any of the three markets encompassed in the model – M3 and euro area/US assets markets – trigger corrective responses in all markets. Thus, this portfolio approach relates monetary developments to asset price dynamics in an international context, offering a link to the growing literature on asset prices and money.

The number of cointegrating vectors (see Table 2) and coefficients' estimates of the cointegrating parameters are robust when the system is estimated over the sample

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[13] In a different context, Manganelli and Wolswijk (2008) have recently hightlighted the importance of monetary policy in determining risk premia in the euro area.

1980-1999:

$$\begin{aligned} m_t - p_t &= \beta_{10} + \underset{(0.069)}{2.02}\, y_t + \underset{(0.057)}{0.49}\, \left(q_t^{EA} - e_t^{EA}\right) \\ &\quad - \underset{(0.057)}{0.49}\, \left(q_t^{US} - e_t^{US}\right) + \underset{(0.546)}{2.12}\, R_t^{EA} - \underset{(0.546)}{2.12}\, R_t^{US} \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \underset{(4.355)}{17.58} i_t^{OWN} - \underset{(3.730)}{19.85} R_t^{EA} \\ q_t^{US} - e_t^{US} &= \beta_{30} - \underset{(6.386)}{29.18} R_t^{US}. \end{aligned}$$

To further investigate the issue of structural stability of our estimates, we apply the recursive analysis and structural stability tests. The results reported in Figures 8a-8c provide evidence for the stability of the parameters determining the long-run solution and for the validity of the identifying restrictions.[14] In particular, the Nyblom test reported in Figure 8a suggests that the system is stable at all possible sample splits, with SupQ(t/T) = 2.968 (p-value = 0.814) and meanQ(t/T) = 1.619 (p-value = 0.680). We then test the stability of the parameters determining the short-run dynamics of the money demand equation using the Chow forecast test. The results reported in Figure 8c show that the null of parameters stability of the short-run coefficients of the money demand cannot be rejected at every possible sample splits. Overall, the cointegrating relation between money and prices estimated within this system does not suffer from the problem of instability characterising the traditional CGL long-run relation over the period 2000 Q1-2007 Q3.

The analysis of the coefficients determining the short-run dynamics suggests that the impact of the three disequilibria is rather pervasive in the system as many variables react to some or all the disequilibria (see Table 3). Given the specification of the long-run properties of the DFR system and the short-run dynamics, Figure 9 illustrates the performance of the model to predict out-of-sample real M3 growth in the euro area after 1999 using a recursive stochastic dynamic simulation with 4-period ahead horizon. The comparison of Figures 3 and 9 shows that the out-of-sample performance of the DFR model is superior to that of the CGL model in predicting the short-run dynamics in the data. In particular, whereas the CGL model predicts a decline in real M3 growth, the DFR predicts a rise, which matches the pattern of the observed data. However, the gap between actual and projected real M3 growth has been rising from 2004 onwards. The results also show that annual M3 growth reached the upper bound of the confidence interval at the end of 2006 pointing towards increased risks for price stability.

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[14] The Nyblom and the Chow forecast tests are made available in the package "Structural VAR" by Warne (2007).

3.4 The impact of asset price shocks on M3 growth

To assess how monetary dynamics are affected by shocks in various markets - and in particular in the financial markets - modelled in our system, we adopt the impulse response analysis approach reporting the impulse responses of real money growth to shocks in the three disequilibrium relationships.

In Figure 10, we show such responses, which are computed by considering the Mellander et al. (1992) representation of a VECM and by implementing Generalized Impulse Response (GIR) analysis (Pesaran and Shin, 1998) to avoid commitment to any identification scheme of structural shocks. The reported results illustrate how the dynamics of real money growth is affected not only by the disequilibrium with respect to long-term money demand (17), but also by the disequilibrium in euro area (18) and US (19) asset markets. This simultaneity, which is consistent with the global nature of the asset allocation problem considered in the theoretical model, makes the task of assessing the risks to price stability signalled by fluctuations in money difficult. Let us emphasise that the sign of the impulse responses are consistent with the theoretical model. If the euro area price/earnings ratio is above the euro area long-term bond yield, Sharpe ratios on euro area assets are expected to decline and, as a consequence of the size and portfolio allocation effects (i.e. euro area agents buy assets from global investors), euro area M3 growth decreases. Similarly, if the US price/earnings ratio is above the US long-term bond yield, euro area M3 growth declines, one interpretation being that risk-adjusted excess returns on US assets are expected to decline, and global investors sell US assets also partly to euro area agents. The impact of shocks in both economic areas last 4-to-5 years and that coming from US financial markets are slightly larger in magnitude.

We complement the GIR analysis with a structural identification of shocks orthogonalized by a Cholesky decomposition. Two alternative assumptions are considered: (*i*) euro area asset markets respond to US markets and not viceversa; (*ii*) US asset markets respond to euro area markets and not viceversa. The impulse responses of money growth to shocks in the disequilibria characterizing financial markets under the two alternative hypotheses are reported in Figure 11. When euro area financial markets respond to US markets (left column of Figure 11), then the impulse responses of M3 growth to euro area asset prices' shocks last 4-to-5 quarters, while the impact of US asset prices' shocks are very similar to those obtained under the GIR analysis. Conversely, under the hypothesis that US financial markets respond to euro area markets (right column of Figure 11), then the impulse responses of money growth to euro area asset prices' shocks are very similar to those obtained under the GIR analysis, while the response to US asset prices' shocks become significant only after 3 quarters.

The short and the long-run dynamics of the system suggest that a decline in price/earnings ratios relative to bond yields in both the euro area and the United States should increase M3 growth. This is consistent with the strengthening of euro area M3 growth after the fall in equity prices in 1987 and 2001 (see Figure 12).

To link the model to the anecdotal evidence provided by Figure 4, we regress various categories of net capital flows (MFI net external assets, net portfolio flows and its two main sub-categories - net debt instruments and net equity flows) both on a quarterly and annual basis on the disequilibria associated with (17), (18) and (19).[15] MFI net external assets are available from 1980 Q1, while net portfolio flows are available only from 1999 Q1 onwards. Table 4 reports the results. The coefficients on the three cointegrating vectors are statistically significant and explain part of the variation in capital flows. This means that capital flows move to re-establish the long-run equilibria between price-earnings ratios and bond yields in both the euro area and the United States.

4 The relationship between money growth and inflation

The aim of this section is twofold: (i) to compute the model-based steady state money growth and the uncertainty surrounding it and (ii) to evaluate the risks to price stability stemming from the gap of actual money growth vis-à-vis the model-based out-of-sample forecasts of money at different period ahead horizons, which we call "excess money growth".

4.1 Model-based steady state money growth

The evidence on the importance of a multivariate cointegration approach to money demand in an open economy, which includes domestic and foreign risky assets, provides an interesting point of view to further evaluate the divergence of M3 growth from its cointegrating equilibrium vis-à-vis the convergence of inflation towards price stability in the euro area.

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[15] The equations include also a dummy variable to capture a large merger and acquisiion that took place in 2000 Q1 and was settled via an exchange of shares, plus an autoregressive term when needed to correct for autocorrelation. We always regress flows between period $t+k$ and period t on disequilibria at time t, to avoid overlapping observations.

Given a cointegrating long-run demand for money, which establishes a relation between real money and a vector of variables $\mathbf{X}$, $m - p = \beta'\mathbf{X}$, a relation between the model-based steady state money growth and price stability is obtained as follows: $\Delta m_s^* = \pi^* + \beta'\Delta\mathbf{X}^*$. Moreover, we construct confidence intervals to assess the uncertainty around Δm_s^*.

Using the identified CVAR

$$
\begin{aligned}
\Delta\mathbf{X}_t &= \mathbf{A}\Delta\mathbf{X}_{t-1} + \alpha\beta'\mathbf{X}_{t-1} + v_t \\
\mathbf{X}_t' &= \begin{bmatrix} m_t - p_t & y_t & i_t^{OWN} & q_t^{EA} - e_t^{EA} & R_t^{EA} & q_t^{US} - e_t^{US} & R_t^{US} \end{bmatrix} \\
\beta' &= \begin{bmatrix} 1 & \beta_{12} & 0 & \beta_{14} & -\beta_{14} & \beta_{16} & -\beta_{16} \\ 0 & 0 & \beta_{23} & 1 & \beta_{25} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & \beta_{37} \end{bmatrix},
\end{aligned}
$$

we simulate the model forward stochastically until it reaches the steady state solution. We then run simulations in each period from 1999 Q4 onwards, after having recursively re-estimated the model by adding one observation at the time. The stochastic simulations deliver steady state values for real money growth along with their standard errors.

The model-based steady-state real money growth shows an upward trend since the end of 2003 and is equal to 5.2 percent in 2007 Q3. Therefore, Δm_s^* amounts to 7.1 percent if we assume $\pi^* = 1.9\%$ to capture the ECB's definition of price stability as "below but close to 2%" (see Figure 13).

The results also allow us to quantify the sizeable uncertainty around Δm_s^*. This depends on the determinants of the cointegrating equilibrium of money, which in our model are much more uncertain than in models without risky assets. To illustrate this point we report in Figure 14 the observed rate of changes of $\Delta\left(i^{ST} - i^{OWN}\right)$, $\Delta\left[\left(q^{EA} - e^{EA}\right) - \left(q^{US} - e^{US}\right)\right]$, and $\Delta\left(R^{EA} - R^{US}\right)$. Clearly, the variability of $\Delta\left[\left(q^{EA} - e^{EA}\right) - \left(q^{US} - e^{US}\right)\right]$ contributes significantly to the uncertainty of the equilibrium money demand.

Overall, the results based on (i) the out-of-sample four period ahead projections of real money growth (see Figure 9) and (ii) the stochastic simulations of steady state equilibrium nominal money growth (see Figure 13) indicate that annual money growth reached the upper bound of the confidence interval in 2007. Both methods suggest increased risks to price stability from 2006 onwards.

4.2 Excess money growth and inflation

The natural question to address is whether money growth in excess of a specific benchmark affects future inflation. To quantify such risks, we conduct a forecast evaluation exercise using three alternative monetary measures: (i) excess M3 growth (a), computed as a difference between actual annual real money growth and its contemporaneous fitted values from the CGL/DFR models; (ii) excess M3 growth (b), computed as a difference between actual annual real money growth and 4-quarters ahead real money growth predicted by the CGL/DFR models at time t for period $t+4$; and (iii) nominal annual M3 growth.[16]

Following the bivariate approach using the methodology proposed by Stock and Watson (1999), euro area inflation takes the following form:

$$\pi_{h,t+k} = a + b\left(L\right)\pi^{q}_{h,t} + c\left(L\right)x_{h,t} + \varepsilon_{h,t+k}, \tag{20}$$

where $\pi_{h,t+k} = 100\left[\left(\frac{P_{h,t+k}}{P_{h,t}}\right)^{4/k} - 1\right]$ is the annualised HICP inflation computed over k-quarters, $\pi^{q}_{h,t}$ is the quarterly inflation rate, $x_{k,t}$ is either excess M3 growth or nominal M3 growth and $b\left(L\right)$ and $c\left(L\right)$ are finite polynomials of order 4 in the lag operator L.

First, the set of equations in (20) is estimated over the entire sample period 1980 Q1 – 2007 Q4 to assess the statistically significance of the coefficients (see first three columns of Table 5). Second, (20) is estimated recursively over the sample 2000 Q1 – 2007 Q4 and the forecasting performance of the alternative equations is compared vis-à-vis a univariate autoregressive model, the random walk model and a constant, set at 1.9% to capture the ECB's definition of price stability as "below but close to 2%" (see last five columns of Table 5).

The statistics used for the forecasting evaluation are the mean squared forecast errors $\left(MSFE^{M} = \frac{1}{T}\sum_{l=1}^{T}\left(\pi_{h,l+k} - \pi^{M}_{h,l+k}\right)^{2}\right)$, where $\pi^{M}_{h,l+k}$ represent the inflation forecasts generated by the various models, and the bias which is equal to $Bias^{M} = \frac{1}{T}\sum_{l=1}^{T}\left(\pi_{h,l+k} - \pi^{M}_{h,,l+k}\right)$. Moreover, we report the standard deviation of the forecast $\left(SDF = \sqrt{\frac{1}{T}\sum_{l=1}^{T}\left(\pi^{M}_{h,l+k} - \frac{1}{T}\pi^{M}_{h,l+k}\right)^{2}}\right)$ and the variance of the errors $\left(MSFE^{M} - Bias^{M^{2}}\right)$.

Table 5 summarises the results based on $k = 6$ (to capture the medium-term

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[16] As an additional measure, we have also used money overhang from the DFR model given by the disequilibria associated to (17), but it turns out to be statistically insignificant.

inflationary developments) and $T = 32$.[17] They suggest that the excess money growth measures generated by the DFR model are both statistically significant, while those obtained using the CGL model are not.

Moreover, the following observations are noteworthy:

1. An excess of M3 growth beyond the DFR model rate of 1 percentage point leads to an increase of HICP inflation of about 13 basis points 6 quarters ahead. The impact of the monetary variable in this bivariate inflation indicator is statistically significant. This implies that at the end of 2007 risks to price stability amounted to about 50 basis points after 6 quarters and 70 basis points after 8 quarters.

2. 1% increase in nominal M3 growth leads to an increase of HICP inflation 6 quarters ahead of about 17 basis points.

3. The best out-of-sample forecasting model of inflation based on a joint assessment of the bias and the MSFE is a simple autoregressive model given that inflation has shown very little volatility since 2000. The second best performing forecasting model is the excess M3 growth (b) based on the DFR model.[18]

5 Robustness check using net wealth

The theoretical model would require the use of net wealth as a scale variable, which has been recently constructed for the euro area using net financial and housing wealth on an annual basis. However, given that the quality of the wealth data is relatively poor due to the various transformations (backcasting, interpolation, different sources) as well as the inherent difficulty in constructing such measure (which ought to include also human capital), we opted for using real GDP.

In this section, to assess the robustness and the validity of the model directly related to (12)-(15), we replace real GDP growth with such a proxy of euro area net wealth (w_t) deriving quarterly series by interpolation. The Likelihood Ratio test for over-identifying restrictions (rank = 3) is χ^2_6=7.97 with a tail probability of 0.2405. Therefore, the theory consistent structure cannot be rejected. Parameters

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[17] The results for alternative values of k (i.e. $k = 4, 6, 12$) do not change qualitatevely. They are available upon request.

[18] We deem it important to mention that the MSFE of the DFR model with a deterministic trend is even lower amounting to 0.1583, i.e. 85.9% of the autoregressive specification's MSFE.

and standard errors, estimated over the sample 1980-2007, are as follows:

$$\begin{aligned} m_t - p_t &= \beta_{10} + 0.87 w_t + \underset{(0.03)}{0.13} \left(q_t^{EA} - e_t^{EA}\right) \\ &\quad - \underset{(0.03)}{0.13} \left(q_t^{US} - e_t^{US}\right) \underset{(0.46)}{-0.64}\, R_t^{EA} + \underset{(0.46)}{0.64} R_t^{US} \qquad (21) \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \underset{(4.74)}{18.19} i_t^{OWN} - \underset{(3.12)}{19.19} R_t^{EA} \qquad (22) \\ q_t^{US} - e_t^{US} &= \beta_{30} - \underset{(2.971)}{22.55} R_t^{US}. \qquad (23) \end{aligned}$$

The results illustrate that the system with net financial and housing wealth is robust, and that the residuals of the cointegrating vectors reported in Figure 15 are closely related to those estimated when using real GDP as a scale variable, suggesting that the latter is a good proxy for net wealth.

The elasticity on real net wealth is 0.87 and it is not statistically different from unity (χ_7^2=8.51). However, the estimated coefficients on bond yields in (21) are not statistically different from zero. Moreover, the coefficients' estimates of the cointegrating parameters are not stable when the system is estimated recursively. For example, over the sample 1980-1999, parameters and standard errors are as follows (χ_6^2=16.40, tail probability=0.0118)

$$\begin{aligned} m_t - p_t &= \beta_{10} + \underset{(0.018)}{0.82}\, w_t - \underset{(0.018)}{0.044} \left(q_t^{EA} - e_t^{EA}\right) \\ &\quad + \underset{(0.018)}{0.044} \left(q_t^{US} - e_t^{US}\right) \underset{(0.180)}{-1.12}\, R_t^{EA} \underset{(0.180)}{+1.12}\, R_t^{US} \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \underset{(4.547)}{1.00}\, i_t^{OWN} - \underset{(2.734)}{5.66}\, R_t^{EA} \\ q_t^{US} - e_t^{US} &= \beta_{30} - \underset{(1.15)}{12.25} R_t^{US}. \end{aligned}$$

Overall, the use of net financial and housing wealth does not improve upon the results presented in the previous section. Moreover, given that the residuals of the cointegrating vectors of the estimated systems (17)-(19) and (21)-(23) move tightly, we can safely suggest that the estimated system with real GDP is to be preferred.

6 Conclusions

The anecdotal evidence shows a strong comovement between net cross-border portfolio flows and M3 growth in the euro area from 2001 onwards, the period in which the traditional money demand based on output and interest rates results to be unstable. This paper presents an econometric model that attempts to quantify the implications of these international portfolio flows on the velocity of money in the euro area via movements in international asset prices, thereby offering a link to the growing literature on asset prices and money.

The key element of this model is the adoption of a portfolio-balance approach to money demand, which is characterised by two main features. First, in order for transactions to have an impact on aggregate M3, a counterpart sector which is not part of the money-holding sector is needed, in the specific being the external (i.e. non-residents) money-holding sector. Second, in order to explain portfolio shifts, we include domestic and foreign asset returns.

The model thus characterises money demand as part of a broader portfolio allocation problem, where the returns on domestic and foreign risky assets, as well as the own return on holding M3, influence money holdings. The theoretical model is used to identify the properties of the long-run equilibrium and the data are let free to determine the short-run dynamics of the empirical model, as suggested by Pesaran and Shin (2002).

The resulting system, compatible with the theoretical model, identifies (i) a new specification for the euro area money demand with euro area and US price-earnings ratios and bonds yields; (ii) the equilibrium between price-earnings ratio, 10-year bond yields and the own rate of money in the euro area; (iii) the equilibrium between price-earnings ratio and 10-year bond yields in the United States (known as the FED model).

Most importantly, we can safely argue that the new euro area money demand in an open economy with euro area and US stocks and bonds is stable. Given the new framework, the resulting model-based steady-state annual nominal M3 growth compatible with price stability is estimated at 7.1% in 2007. However, the confidence intervals surrounding money path derived from the model simulations are large, as stock prices are more volatile than output and interest rates.

In accordance with the theoretical model, a fall in euro area and/or US equity price-earnings ratios relative to their respective long-term bond yields leads to net portfolio inflows into the euro area and, therefore, to an increase in euro area M3 growth. This is exactly what happened after the sharp decline in equity prices in October 1987 and March 2001.

We also found that measures of excess M3 growth, namely the gap between actual real euro area M3 growth and M3 growth fitted or predicted by the model, are statistically significant in forecasting euro area HICP inflation. As a rule of thumb, an excess of M3 growth beyond the DFR model rate of 1 percentage point leads to an increase of HICP inflation 6 quarters ahead of about 13 basis points. Finally, given that asset prices are timely available, real-time assessment of inflationary risks is feasible by comparing actual money growth with model-based simulated values.

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7 Appendix A: Description of the data and their sources

The historical series used in this study span the sample period from 1980 Q1 to 2007 Q3 and refer to the euro area (i.e. the euro area-11 for months up to December 2000, euro area-12 from January 2001 and euro-13 from January 2007 onwards). The quarterly data refer to end-of-quarter. All data are seasonally adjusted, whenever it applies.

A - Monetary aggregates

The broad monetary aggregate M3 for the euro area is constructed using the monthly seasonally adjusted end-month stocks and flows. The series is constructed as follows. The seasonally adjusted index of the notional stock is rebased to be equal to 100 in January 2007 and then multiplied by the seasonally adjusted outstanding amounts in the same month (this stock being derived by aggregating national stocks at the irrevocable fixed exchange rates).[19] The percentage changes between any two dates (after October 1997) corresponds to the change in the stock excluding the effects of reclassifications, other revaluations and exchange rate variations (and from January 2001 and 2007 excluding the effect of the enlargement of the euro area). Sources: ECB, ECB calculations.

B - Nominal and real GDP

The quarterly nominal and real GDP is calculated by aggregating national GDP data using the irrevocable fixed exchange rates. From 2007 Q1 onwards the series covers the euro-13 countries series. From 2006 Q4 back to 2001 Q1 the series is an extrapolation based on the growth rate calculated from the euro-12 countries series and from 2000 Q4 backwards is an extrapolation based on the growth rate calculated from the euro-11 countries series. The quarterly seasonally adjusted real GDP series for the euro area (at market constant prices taken 19995 as the base year) is constructed using the same procedure as the nominal GDP series. Sources: ECB calculations, Eurostat.

C - Good price indices

The HICP index for the euro area is the seasonally adjusted overall based on consumption expenditure weights at irrevocable fixed exchange rates. Data before January 1995 are compiled from monthly rates of national CPIs excluding owner occupied housing (except for Spain). Sources: ECB, ECB calculations, Eurostat.

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[19] The seasonal adjustment is carried out on the aggregated (index and stock) series for the euro area. From here onwards with irrevocable fixed exchange rates it is meant the exchange rates fixed on 31 December 1998 for the first euro area 11 countries, the exchange rate predetermined on 19 June 2000 for Greece and on the 11 July 2006 for Slovenia.

The GDP deflator for the euro area is calculated as a simple ratio between nominal and real GDP (see above). Sources: ECB calculations, Eurostat.

D - Interest rates

The euro area interest rates are a weighted average of the national interest rates calculated using M3 weights. Short-term interest rates are the three-month money market rates. From January 1999 onwards the three-month EURIBOR is used. Long-term interest rates correspond to ten-year government bond yields or the closest available maturity and are also calculated using M3 weights. The own rate of return of euro area M3 for the euro area used in this paper is constructed as a weighted average of the national own rates of return of M3, where the latter are calculated as a weighted average of the rates of return of the different instruments included in M3 (see, for details, Bruggeman et al., 2003). From July 2003 onwards, with the introduction of the euro area MFI interest rates statistics, the own rate of return on M3 is calculated using a bridge equation. More precisely, the stable long-term relationship linking the own rate of M3 (i_t^{OWN}) to the three-month market interest rate (i_t^{ST}) is estimated to be the following: $i_t^{OWN} = \underset{(3.01)}{0.53}\, i_t^{ST}$. The corresponding dynamic equation turns out to be:

$$\begin{aligned}\Delta i_t^{OWN} = \;& \underset{(0.04)}{0.25}\,\Delta i_{t-1}^{OWN} + \underset{(0.04)}{0.09}\,\Delta i_{t-6}^{OWN} - \underset{(0.04)}{0.12}\,\Delta i_{t-8}^{OWN} + \underset{(0.01)}{0.21}\,\Delta i_t^{ST} + \underset{(0.01)}{0.04}\,\Delta i_{t-10}^{ST} \\ & - \underset{(0.01)}{0.06}\,(i_{t-1}^{OWN} - 0.53 i_{t-1}^{ST}) + \underset{(0.00)}{0.06}\,D92M1 + \underset{(0.00)}{0.00}\,D93M1 + \underset{(0.00)}{0.00}\,D95M3\end{aligned}$$

where D92M1, D93M1 and D95M3 are dummies taking value 1 in January 1992, January 1993 and March 1995, respectively (zero elsewhere). Sources: BIS, ECB, ECB calculations, Reuters.

The US short-term interest rate is the three-month money market rate on treasury bills, end of the month, while the long-term interest rate is the correspond to the ten-year US treasury notes and bonds yields, also end-of month. Source: FED.

E - Price/earnings ratio and dividend yields

The price-earnings ratio is derived by dividing total market value by the total earnings, thus providing an earnings-weighted average of price/earnings ratios of the DataStream constituents for the euro area and the United States. Similalrly, the dividend yield is derived by dividing total dividends by market value. The indices for the euro area are defined as “regional indices”. To compute them, individual market data are converted to a common currency. Weightings within each regional index are determined by the market value of each constituent country. The weightings therefore do not represent the relative size of the economies. They have been calculated to reflect the relative size of the stock market capitalisation. As regards the selection criteria, a representative set of stocks is chosen for each market, broadly covering 75%-80% of the total market capitalisation. Source: DataStream.

F - MFI net external assets and cross-border portfolio flows

MFI net external assets flows is determined as the difference between external asset and liability flows of euro area MFI. The assets flows (i.e. claims of euro area MFI on non-euro area residents) comprise shares and other equities, securities other than shares, loans, gold and gold receivables, and receivables from the IMF. The liabilities (i.e. instruments held by non-euro area residents and issued by euro area MFIs) flows comprise money market funds shares/units, debt securities up to 2 years and deposits.

Non-MFI net portfolio flows is determined as the difference between portfolio asset and liability flows of the non-MFI sector. The portfolio assets flows (i.e. instruments issued by non-euro area residents) comprises equities and debt securities. The portfolio liabilities (i.e. instruments held by non-euro area residents) flows comprise equities (excluding money market funds shares/units) and debt securities (excluding debt securities up to 2 years). On the basis of the so called "monetary presentation" of the balance of payments, non-financial and financial transactions by the non-MFI sector are equal (with the opposite sign) to a change in net external assets of the MFI sector. Source: ECB.

8 Appendix B: Testing the assumptions of the model

The theoretical model is based on some assumptions, which have been tested. The results are reported in Tables B1-B3.

Specifically, Table B1 shows that euro area and US net wealth are cointegrated, supporting the assumption that the size effect is stationary.

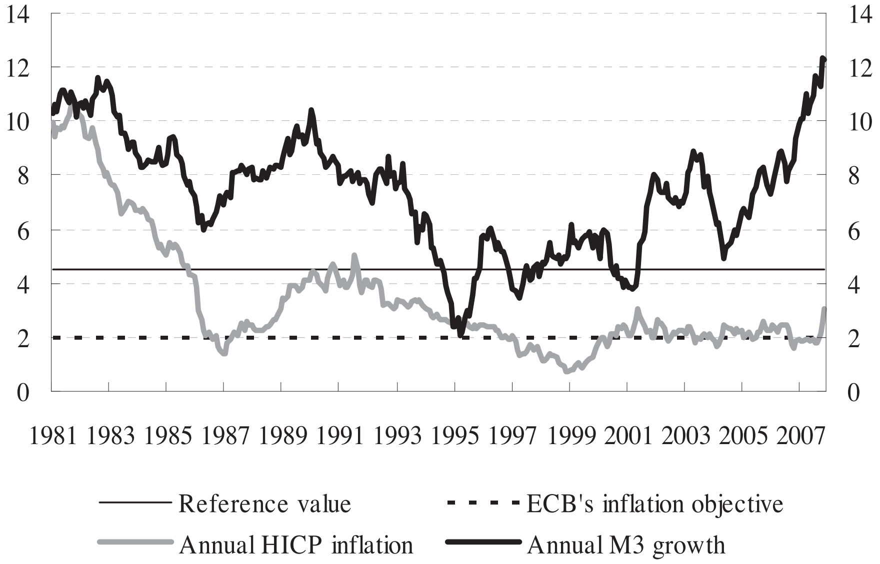
Table B2 shows the cointegration test between earnings yields and dividend yields in both the euro area and the US and the results support the hypothesis that the pay out ratio is stationary.

Finally, the unit root tests included in Table B3 indicate that dividend yield growth is I(0).

Figure 1

Annual HICP inflation and nominal M3 growth in the euro area

(annual percentage changes)

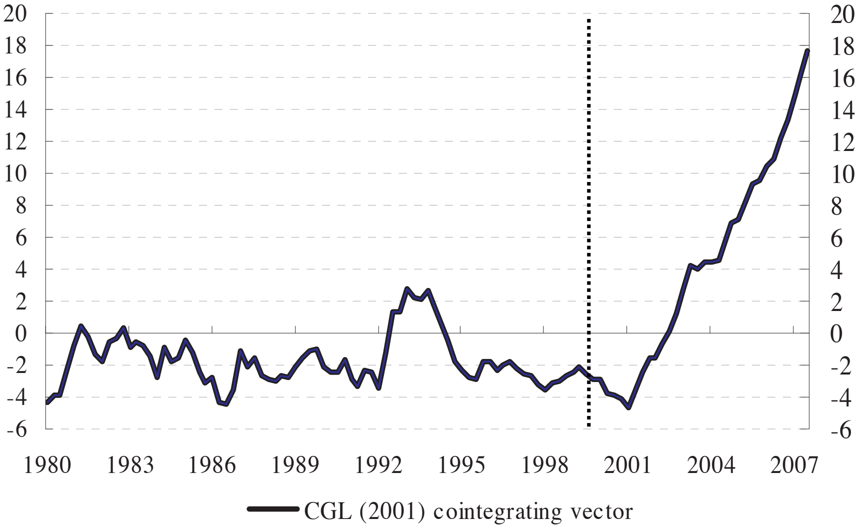


Sources: ECB, Eurostat. Last observation: November 2007.

Figure 2

The structural instability of the Calza et al. (CGL) money demand for the euro area

Cointegrating money demand (pecent)

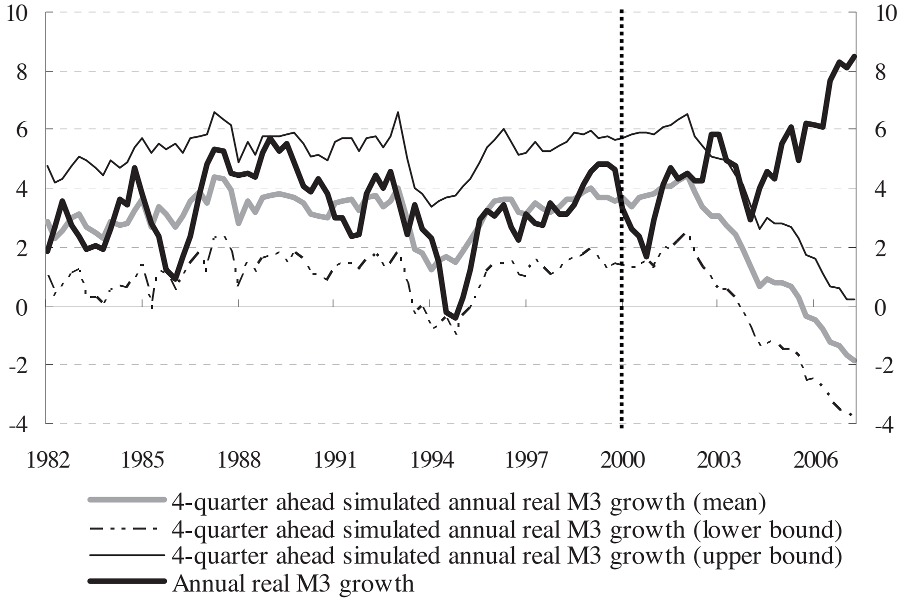


Source: Based on the Calza-Gerdesmeier-Levy (2001) money demand model. Last observation: 2007 Q3.
Note: the disequilibrium in the CGL money demand model is computed as follows: $m_t - p_t - \beta_0 - 1.34 y_t + 0.76(i_t^{ST} - i_t^{OWN})$.

Figure 3

Projections of real money growth based on the CGL money demand for the euro area: out-of-sample from 2000 Q1

(annual percentage changes)

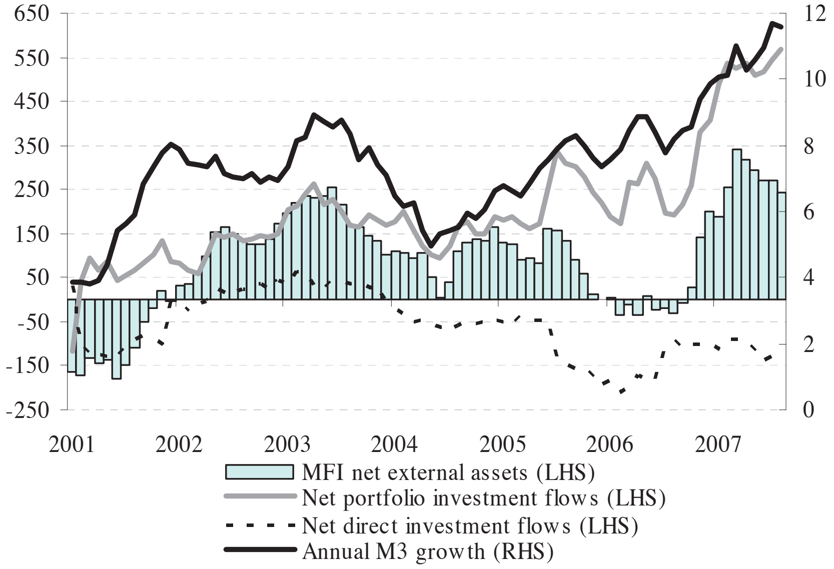


Source: Based on the CGL money demand model. Last observation: 2007 Q3.
Note: Stochastic simulations are within sample up to 1999 Q4 and out-of-sample from 2000 Q1 onwards. Coefficients are kept constant after 1999 due to the instability of money demand.

Figure 4

Annual M3 growth, MFI net external assets and net flows in portfolio and direct investment in the euro area

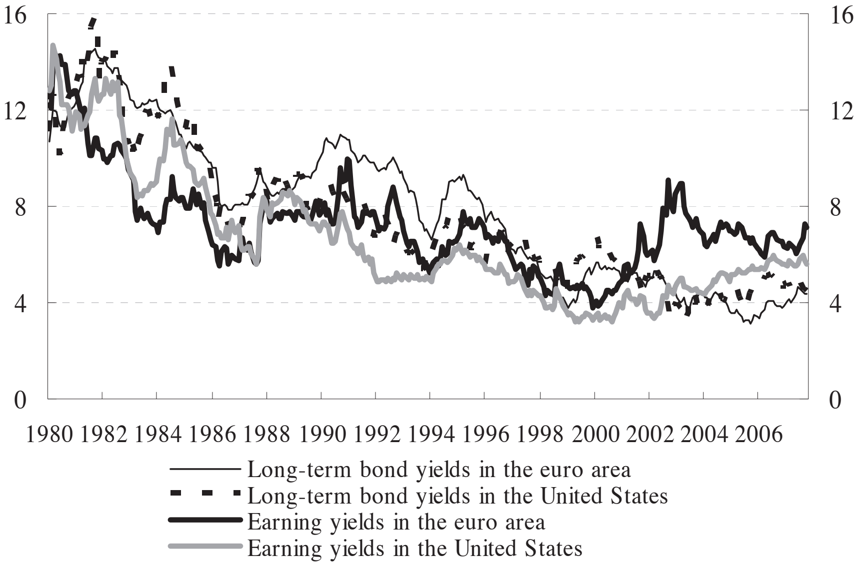
(annual percentage changes; annual flows in EUR bns)



Sources: ECB, ECB calculations. Last observation: October 2007.

Figure 5

Earning yields and long-term (10 years) bond yields in the euro area and the United States

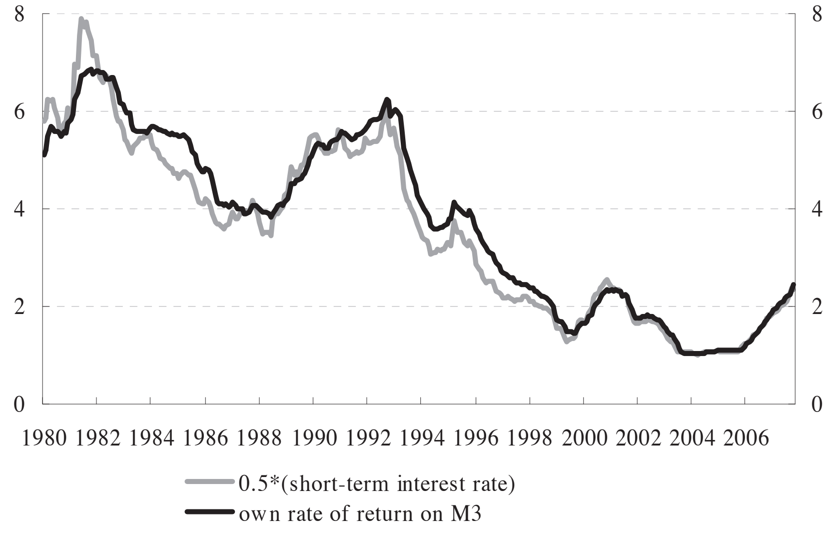


Sources: BIS, DataStream, ECB calculations, Reuters. Last observation: October 2007.
Note: earning yields in percent, bond yields in percentages per annum

Figure 6

Short-term interest rates and the own rate of return on M3 in the euro area

(percentages per annum)

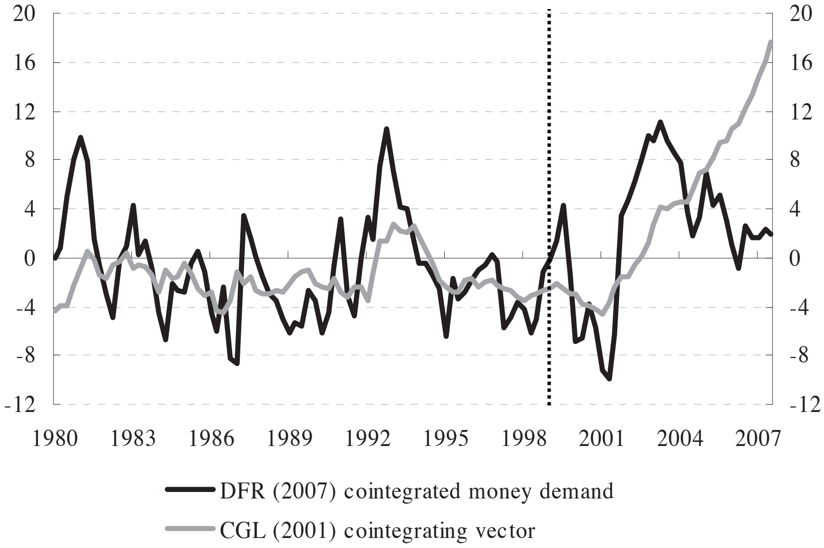


Sources: BIS, ECB, ECB calculations, Reuters. Last observation: October 2007.

Figure 7

The CGL (2001) and DFR (2007) money demand models for the euro area

Cointegrating money demand models (percent)



Sources: Based on the CGL and De Santis-Favero-Roffia (2007) money demand models (see Section 4.3). Last observation: 2007 Q3.

Note: the disequilibria in the CGL and in the DFR money demand models are computed respectively as follows:

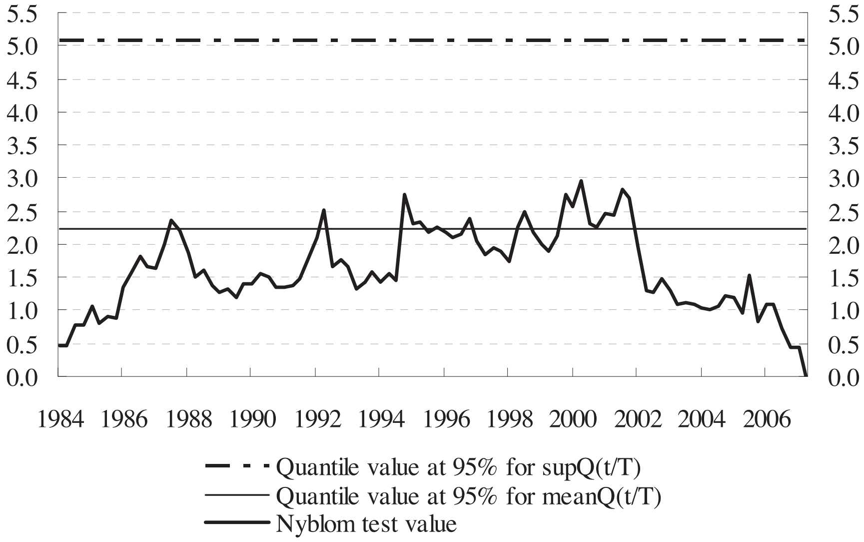
CGL $m_t - p_t - \beta_0 - 1.34 y_t + 0.76(i_t^{ST} - i_t^{OWN})$

DFR: $m_t - p_t - \beta_{10} - 1.84 y_t - 0.38(q_t^{EA} - e_t^{EA}) + 0.38(q_t^{US} - e_t^{US}) - 1.37 R_t^{EA} + 1.37 R_t^{US}$.

Values are re-scaled to average zero over the sample period.

Figure 8A

Nyblom test for the stability of the long-run parameters



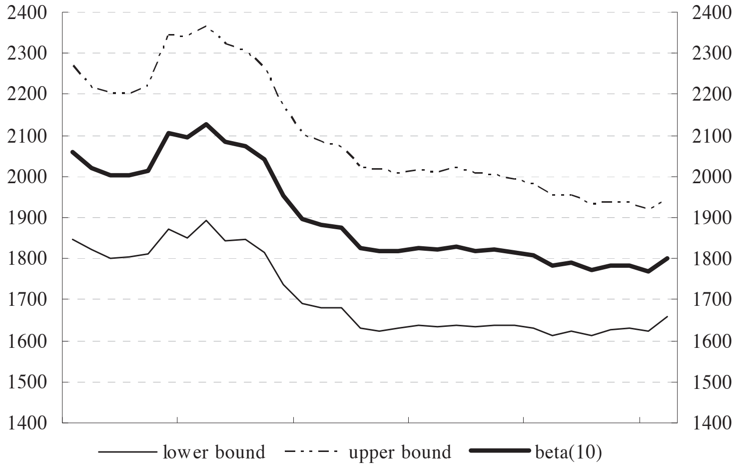
Notes: based on the bootstrapping approach with 1000 replications. The quantile values from the empirical distribution at 95% are 5.09 for the supremum test (SupQ(t/T)) and 2.22 for the mean test (meanQ(t/T)). SupQ(t/T) = 2.968 (p-value = 0.814), meanQ(t/T) = 1.619 (p-value = 0.680).

Figure 8B

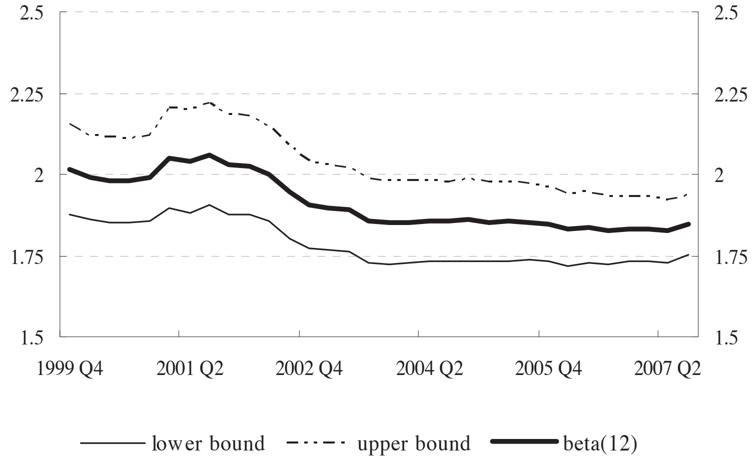
Recursive estimates for the coefficients of the DFR (2007) money demand model

coint_1: $m_t - p_t = \beta_{10} + 1.84 y_t + 0.38(q_t^{EA} - e_t^{EA}) - 0.38(q_t^{US} - e_t^{US}) + 1.37 R_t^{EA} - 1.37 R_t^{US}$

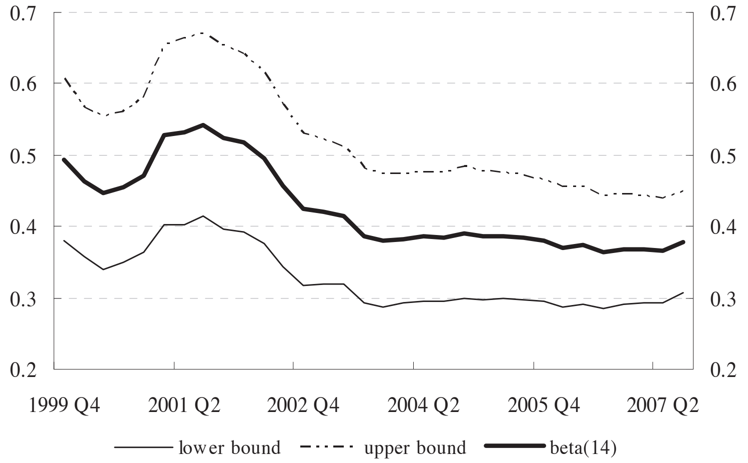
β_{10} *(constant)*



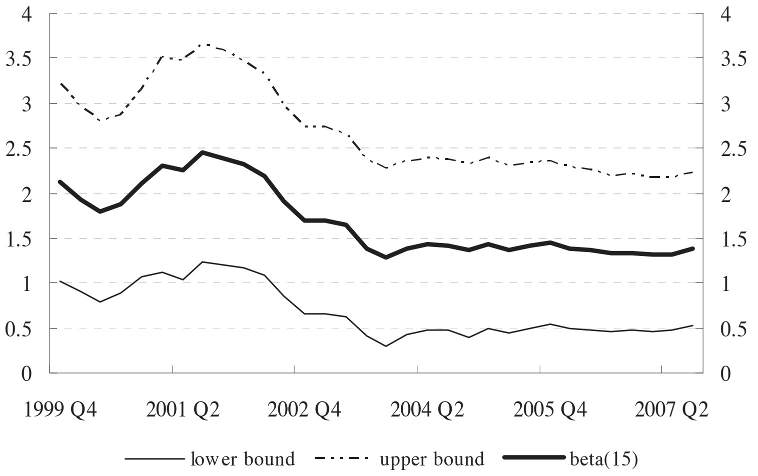
β_{12} *(coefficient of* y_t *)*



β_{14} *(coefficient of* $(q_t^{EA} - e_t^{EA}) - (q_t^{US} - e_t^{US})$ *)*

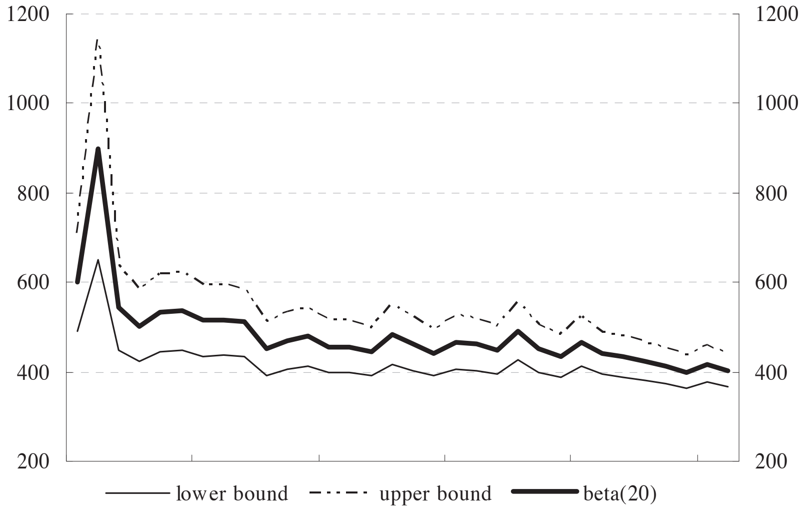


β_{15} (coefficient of $(R_t^{EA} - R_t^{US})$)

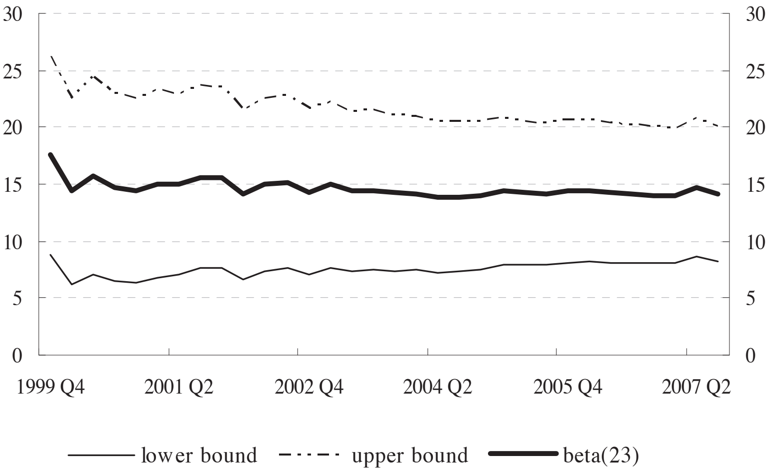


coint_2: $(q_t^{EA} - e_t^{EA}) = \beta_{20} + 15.83 i_t^{OWN} - 14.11 R_t^{EA}$

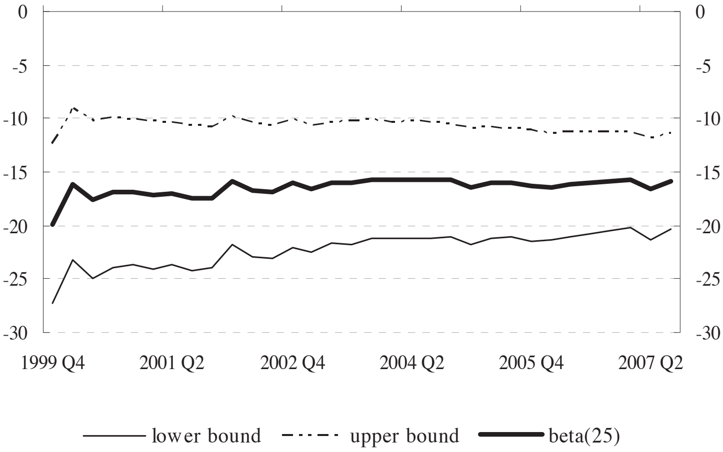
β_{20} (constant)



β_{23} (coefficient of i_t^{OWN})

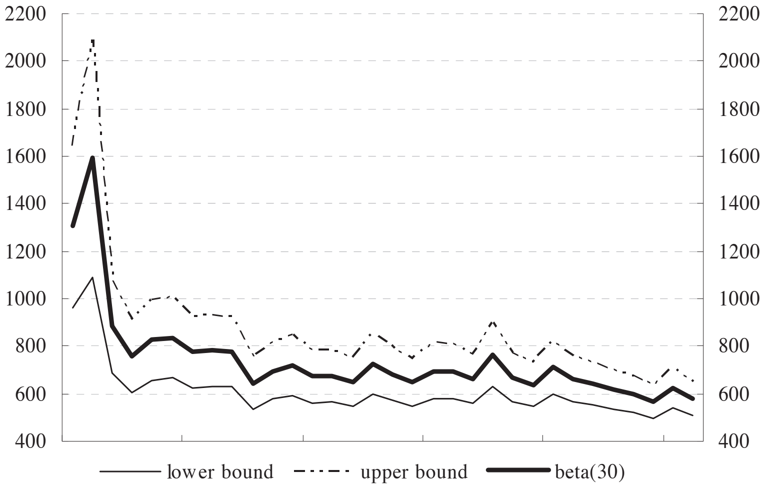


β_{25} *(coefficient of* R_t^{EA} *)*

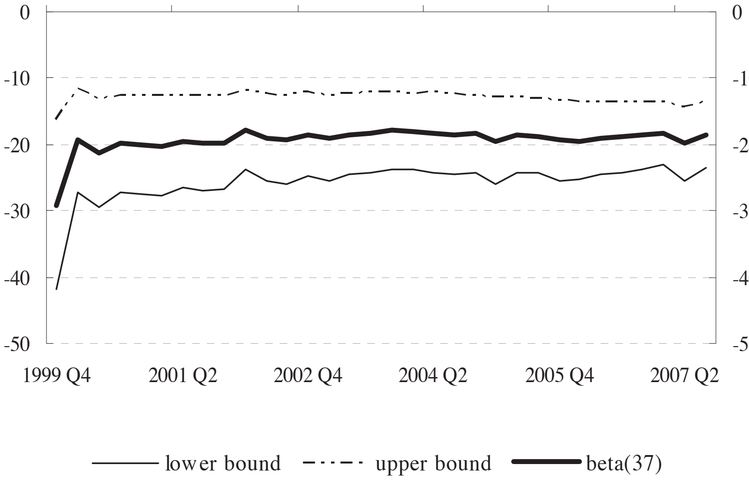


coint_3: $(q_t^{US} - e_t^{US}) = \beta_{30} - 18.46R_t^{US}$

β_{30} *(constant)*



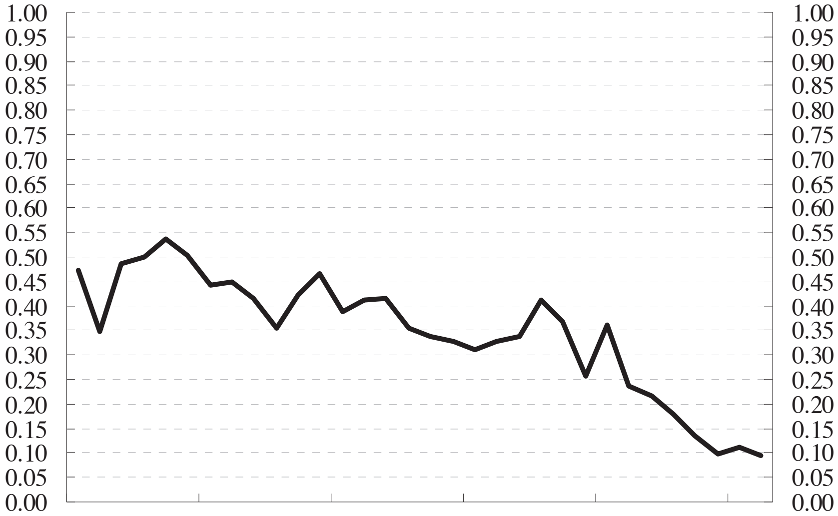
β_{37} *(coefficient of* R_t^{US} *)*



Sources: Based on the DFR money demand model (see Section 3.3). Last observation: 2007 Q3.

Figure 8C

Recursive estimates for the validity of the identifying restrictions (p-value)



Recursive Chow forecast test for the stability of the short-run dynamics of the money demand equation (p-value)

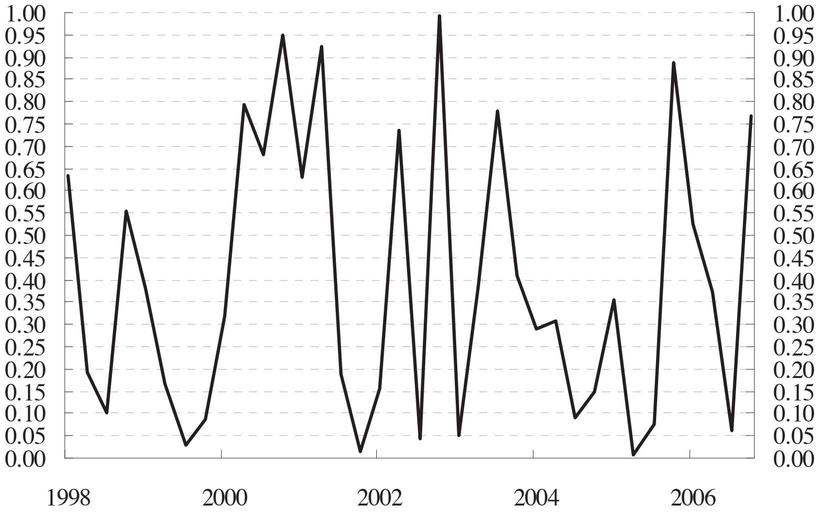
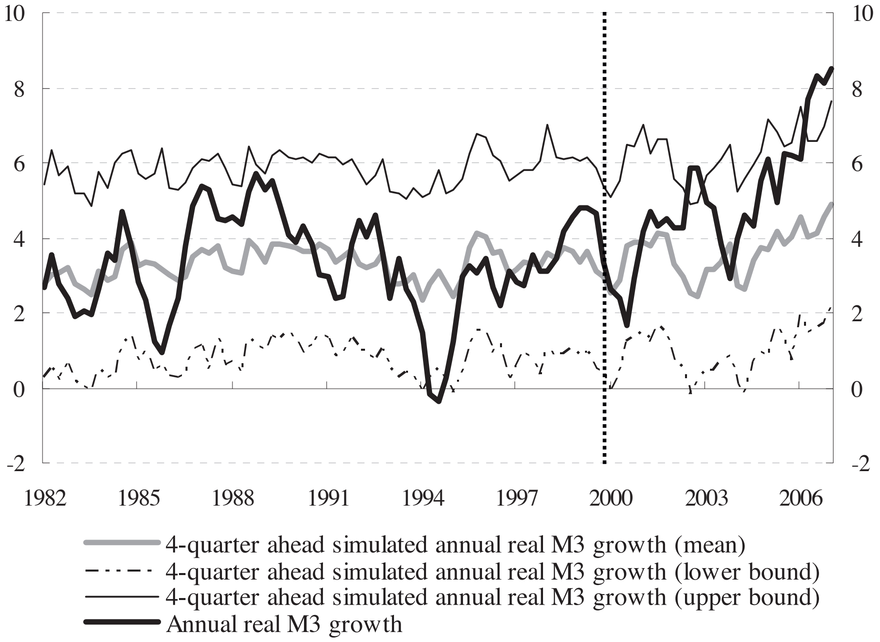


Figure 9

Projections of real money growth based on the DFR (2007) money demand for the euro area: out-of-sample from 2000 Q1

(annual percentage changes)

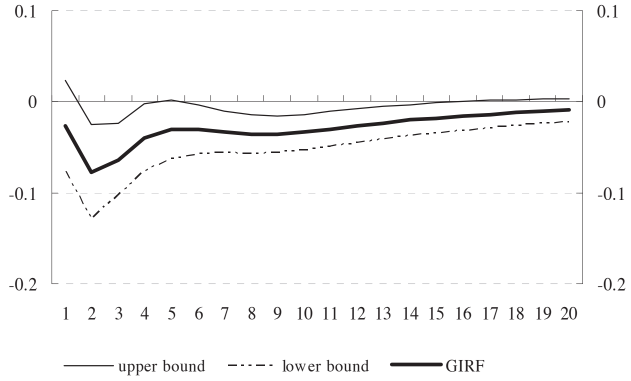


Sources: based on the DFR money demand model. Last observation: 2007 Q3.
Note: Coefficients are in sample up to 1999 Q4 and estimated recursively from 2000 Q1 onwards.

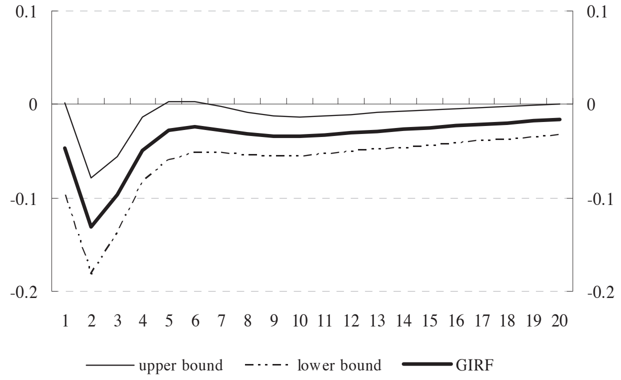
Figure 10

Generalized impulse responses of euro area real M3 growth to the different disequilibria (one standard deviation innovation, ± 1 standard error)

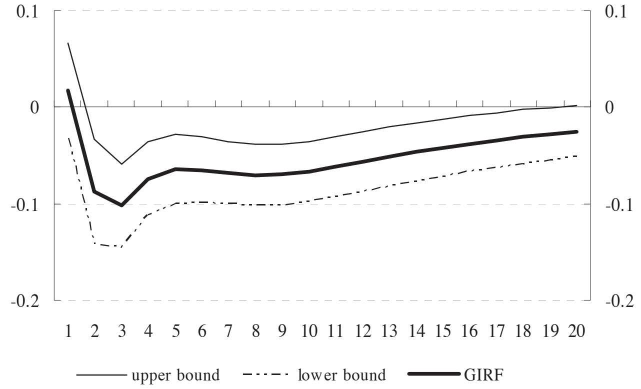
Response of the quarterly annualized change in real M3 to coint_1



Response of the quarterly annualized change in real M3 to coint_2



Response of the quarterly annualized change in real M3 to coint_3



Source: Based on DFR (2007) money demand model estimated over the sample 1980 Q1-2007 Q3.
Notes: It is common in the VAR literature to use a one standard deviation confidence interval (although this is narrower than for other statistical exercises). See, e.g. Bagliano, F. C. and Favero, C. A. (1999), "Information from Financial Markets and VAR Measures of Monetary Policy", *European Economic Review*, 43, 825-837.
The three cointegrating vectors have the following specifications:

coint_1: $m_t - p_t = \beta_{10} + 1.84 y_t + 0.38(q_t^{EA} - e_t^{EA}) - 0.38(q_t^{US} - e_t^{US}) + 1.37 R_t^{EA} - 1.37 R_t^{US}$

coint_2: $(q_t^{EA} - e_t^{EA}) = \beta_{20} + 15.83 i_t^{OWN} - 14.11 R_t^{EA}$

coint_3: $(q_t^{US} - e_t^{US}) = \beta_{30} - 18.46 R_t^{US}$

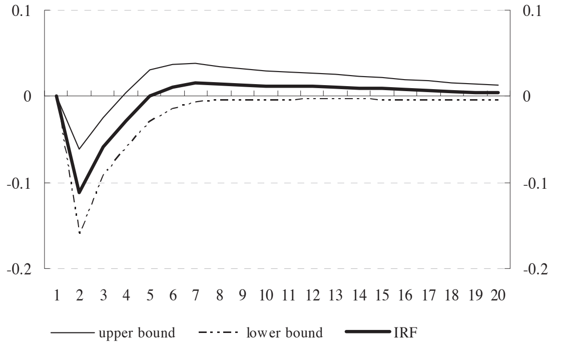
where, for the euro area, m_t = M3, y_t = real GDP, p_t =GDP deflator, i_t^{OWN} =own rate of return on M3, R_t^{EA} =long-term bond yields, $q_t^{EA} - e_t^{EA}$ = price-earnings ratio, and, for the United States, R_t^{US} =long-term bond yields and $q_t^{US} - e_t^{US}$ = price-earnings ratio, all expressed in logarithms apart from the interest rates.

Figure 11

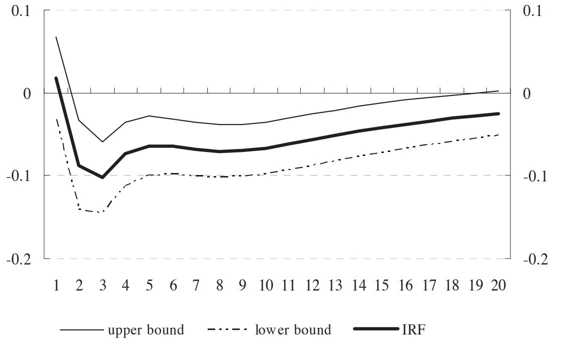
Impulse responses of euro area real M3 growth to structural shocks in the US and euro area financial markets (one standard deviation innovation, ± 1 standard error)

Assumption: US asset markets do not respond to shocks in the euro area markets; while euro area asset markets respond to shocks in US markets.

Response of the quarterly annualized change in real M3 to coint_2



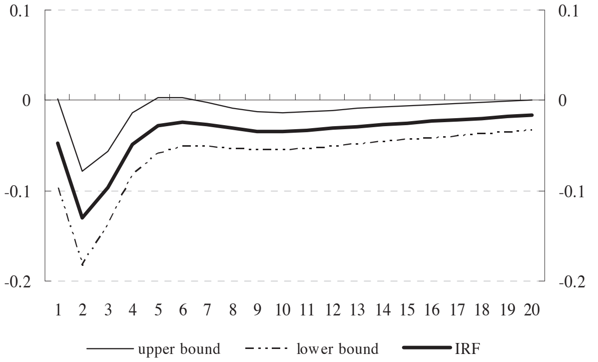
Response of the quarterly annualized change in real M3 to coint_3



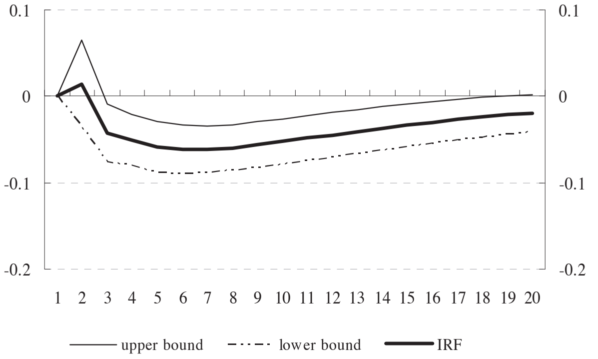
Source: Based on DFR (2007) money demand model estimated over the sample 1980 Q1-2007 Q3.
Note: see Figure 10.

Assumption: Euro area asset markets do not respond to shocks in US markets; while US asset markets respond to shocks in the euro area.

Response of the quarterly annualized change in real M3 to coint_2



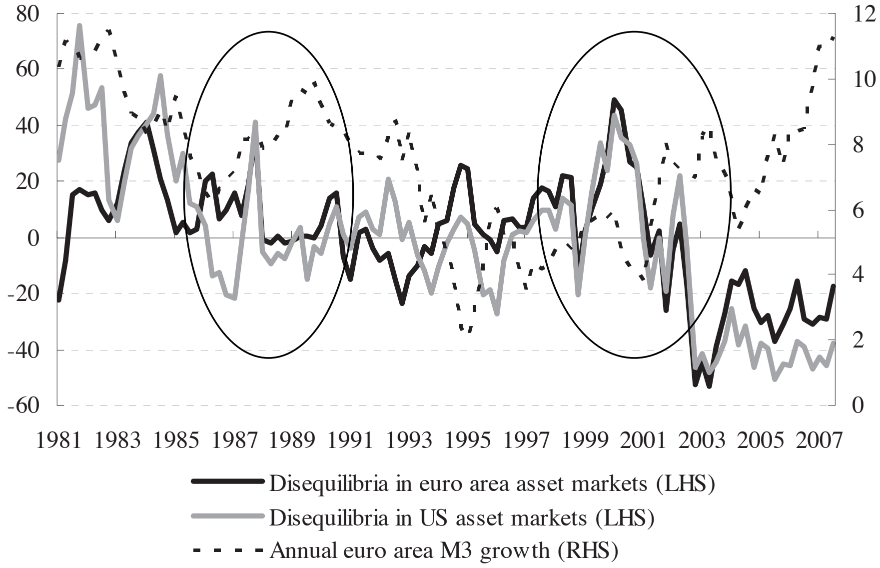
Response of the quarterly annualized change in real M3 to coint_3



Source: Based on DFR (2007) money demand model estimated over the sample 1980 Q1-2007 Q3.
Note: see Figure 10.

Figure 12

Disequilibria in asset markets in the euro area and in the United States *(percent, annual percentage changes)*

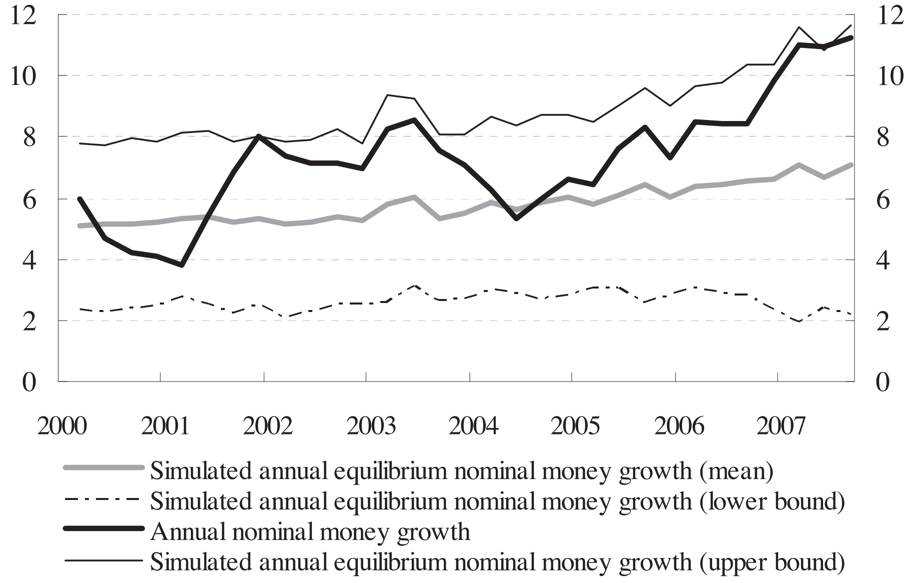


Sources: based on the DFR money demand model. Last observation: 2007 Q3.

Figure 13

Steady state equilibrium of nominal M3 growth based on the DFR (2007) money demand for the euro area, recursive estimate over the sample 1999 Q4 – 2007 Q3

(annual percentage changes)

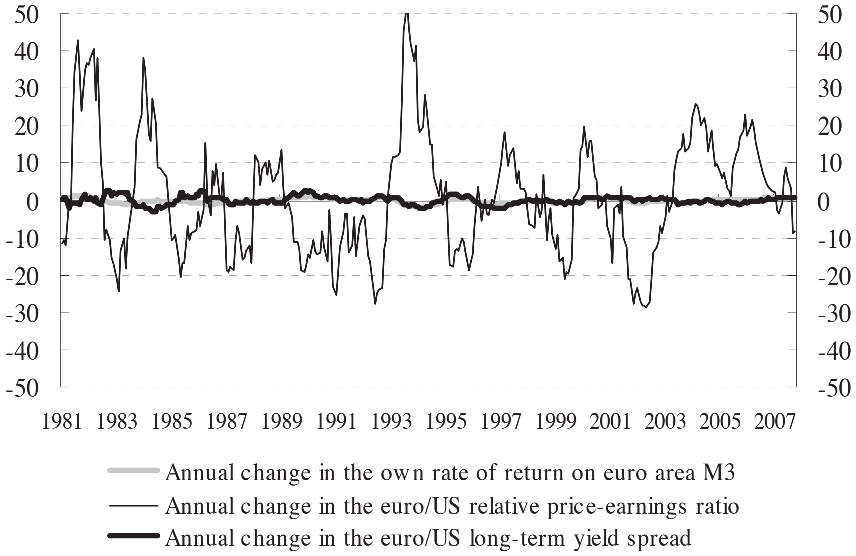


Sources: based on the DFR money demand model. Last observation: 2007 Q3.
Note: Coefficients are in sample up to 1999 Q4 and estimated recursively from 2000 Q1 onwards.

Figure 14

The determinants of the equilibrium money (M3) growth for the euro area

(annual percentage changes)

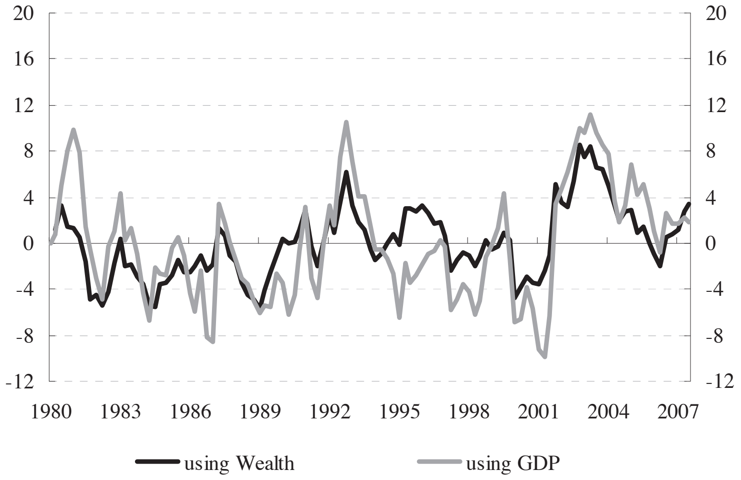


Sources: BIS, Datastream, ECB, ECB calculations, Reuters. Last observation: October 2007.

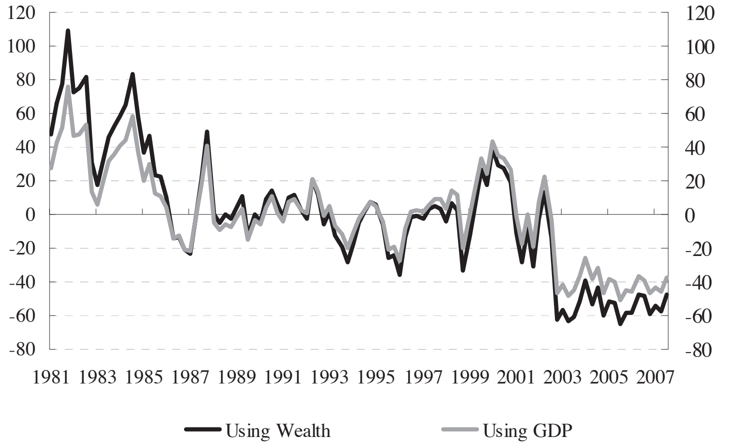
Figure 15

Comparisons of the deviations in the three cointegrated vectors based on real GDP and real net wealth *(percent)*

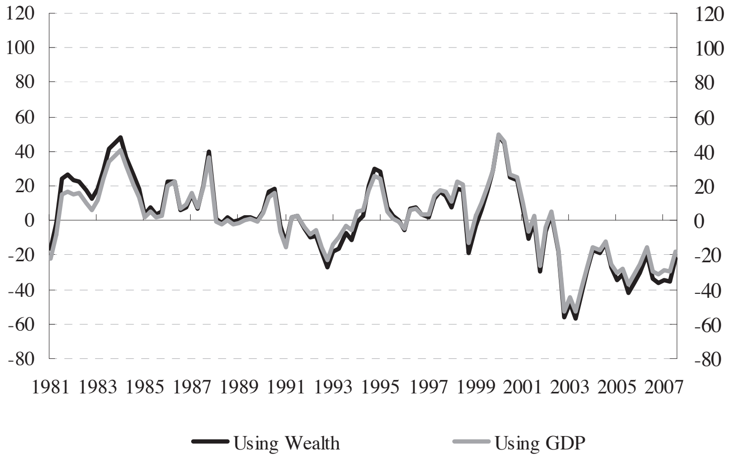
Disequilibrium in real money stock (coint_1)



Disequilibrium in euro area asset markets (coint_2)



Disequilibrium in US asset markets (coint_3)



Sources: based on the DFR money demand model. Last observation: 2007 Q3.

Table 1

Johansen test for cointegration in the DFR (2007) model

Lags interval (in first differences): 1 to 2
Unrestricted cointegration rank test (trace)
Sample period: 1980 Q1 – 2007 Q3

$H_0 : rank \leq p$	Eigenvalue	Trace test-statistic	95% critical value	Prob**	Maximum eigenvalue test-statistic	95% critical value	Prob**
$p = 0$	0.393	177.973 *	134.678	0.000	53.843	47.079 *	0.008
$p \leq 1$	0.322	124.131 *	103.847	0.001	41.976	40.957 *	0.038
$p \leq 2$	0.302	82.155 *	76.973	0.019	38.763	34.806 *	0.016
$p \leq 3$	0.157	43.392	54.079	0.313	18.424	28.588	0.540
$p \leq 4$	0.091	24.968	35.193	0.402	10.361	22.300	0.806
$p \leq 5$	0.072	14.607	20.262	0.250	8.072	15.892	0.539
$p \leq 6$	0.059	6.536	9.165	0.153	6.536	9.165	0.153

Notes:
Trend assumption: no determistic trend (restricted constant).
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level.
Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

Table 2

Johansen test for cointegration in the DFR (2007) model

Lags interval (in first differences): 1 to 2
Unrestricted cointegration rank test (trace)
Sample period: 1980 Q1 – 1999 Q4

$H_0 : rank \leq p$	Eigenvalue	Trace test-statistic	95% critical value	Prob**	Maximum eigenvalue test-statistic	95% critical value	Prob**
$p = 0$	0.475	165.38 *	134.678	0.000	0.475	49.584 *	0.026
$p \leq 1$	0.378	115.795 *	103.847	0.006	0.378	36.605	0.143
$p \leq 2$	0.325	79.19 *	76.973	0.034	0.325	30.284	0.157
$p \leq 3$	0.257	48.907	54.079	0.134	0.257	22.849	0.227
$p \leq 4$	0.165	26.057	35.193	0.339	0.165	13.891	0.472
$p \leq 5$	0.111	12.166	20.262	0.434	0.111	9.055	0.428
$p \leq 6$	0.040	3.111	9.165	0.560	0.040	3.111	0.560

Notes: see Table 1.

Table 3

DFR (2007) money demand system for the euro area

Sample period: 1980 Q1 – 2007 Q3

	$\Delta(m_t - p_t)$	$\Delta(y_t)$	$\Delta(q_t^{US} - e_t^{US})$	$\Delta(q_t^{EA} - e_t^{EA})$	$\Delta(R_t^{EA})$	$\Delta(R_t^{US})$	$\Delta(i\_own_t^{EA})$
CointEq1	**-0.034**	**0.006**	**-1.385**	**0.101**	**-0.018**	**0.031**	**0.001**
St err	***-0.02***	***-0.02***	***-0.31***	***-0.41***	***-0.02***	***-0.03***	***-0.01***
t-stat	[-1.55733]	[0.33078]	[-4.43802]	[0.24576]	[-1.07516]	[1.02436]	[0.16851]
CointEq2	**-0.013**	**0.017**	**-0.373**	**-0.202**	**-0.009**	**0.016**	**-0.003**
St err	*-0.01*	*-0.01*	*-0.10*	*-0.14*	*-0.01*	*-0.01*	*0.00*
t-stat	[-1.82191]	[2.78961]	[-3.62451]	[-1.49143]	[-1.59647]	[1.59499]	[-1.35518]
CointEq3	**0.000**	**-0.009**	**0.112**	**0.076**	**0.005**	**-0.005**	**0.002**
St err	*0.00*	*0.00*	*-0.04*	*-0.06*	*0.00*	*0.00*	*0.00*
t-stat	[0.08336]	[-3.67917]	[2.67622]	[1.37192]	[2.05633]	[-1.33496]	[1.73407]
$\Delta(m_{t-1} - p_{t-1})$	**0.150**	**0.120**	**0.083**	**-2.306**	**0.042**	**0.024**	**-0.032**
St err	*-0.11*	*-0.09*	*-1.57*	*-2.08*	*-0.09*	*-0.15*	*-0.03*
t-stat	[1.36090]	[1.32663]	[0.05280]	[-1.11064]	[0.48660]	[0.15827]	[-0.93670]
$\Delta(m_{t-2} - p_{t-2})$	**0.139**	**0.013**	**0.801**	**1.420**	**0.093**	**0.164**	**-0.014**
St err	*-0.11*	*-0.09*	*-1.53*	*-2.02*	*-0.08*	*-0.15*	*-0.03*
t-stat	[1.29701]	[0.14866]	[0.52314]	[0.70296]	[1.11365]	[1.10712]	[-0.40605]
$\Delta(y_{t-1})$	**-0.057**	**0.076**	**-2.022**	**4.629**	**0.070**	**0.121**	**0.107**
St err	*-0.14*	*-0.12*	*-2.00*	*-2.64*	*-0.11*	*-0.19*	*-0.04*
t-stat	[-0.40796]	[0.66062]	[-1.01027]	[1.75207]	[0.64211]	[0.62275]	[2.44084]
$\Delta(y_{t-2})$	**0.057**	**-0.010**	**-3.163**	**-4.540**	**0.039**	**-0.398**	**0.076**
St err	*-0.14*	*-0.12*	*-2.03*	*-2.68*	*-0.11*	*-0.20*	*-0.04*
t-stat	[0.40346]	[-0.08930]	[-1.55868]	[-1.69431]	[0.35009]	[-2.02755]	[1.69311]
$\Delta(q_{t-1}^{US} - e_{t-1}^{US})$	**0.007**	**0.015**	**0.236**	**0.041**	**0.006**	**-0.011**	**0.004**
St err	*-0.01*	*-0.01*	*-0.13*	*-0.18*	*-0.01*	*-0.01*	*0.00*
t-stat	[0.78884]	[1.97438]	[1.75695]	[0.22964]	[0.81933]	[-0.82325]	[1.51766]
$\Delta(q_{t-2}^{US} - e_{t-2}^{US})$	**-0.001**	**0.003**	**0.128**	**0.039**	**0.007**	**0.005**	**0.002**
St err	*-0.01*	*-0.01*	*-0.14*	*-0.18*	*-0.01*	*-0.01*	*0.00*
t-stat	[-0.10144]	[0.35348]	[0.92842]	[0.21414]	[0.98229]	[0.36387]	[0.79810]
$\Delta(q_{t-1}^{EA} - e_{t-1}^{EA})$	**-0.008**	**-0.011**	**-0.158**	**-0.053**	**0.003**	**0.011**	**-0.001**
St err	*-0.01*	*-0.01*	*-0.11*	*-0.14*	*-0.01*	*-0.01*	*0.00*
t-stat	[-1.02264]	[-1.88649]	[-1.50311]	[-0.38202]	[0.54290]	[1.03273]	[-0.52389]
$\Delta(q_{t-2}^{EA} - e_{t-2}^{EA})$	**0.000**	**-0.003**	**-0.066**	**-0.132**	**-0.006**	**-0.011**	**-0.002**
St err	*-0.01*	*-0.01*	*-0.11*	*-0.14*	*-0.01*	*-0.01*	*0.00*
t-stat	[0.00827]	[-0.54317]	[-0.60374]	[-0.92214]	[-0.99041]	[-1.01132]	[-0.96475]
$\Delta(R_{t-1}^{EA})$	**-0.129**	**0.127**	**3.214**	**-0.924**	**0.254**	**-0.092**	**0.132**
St err	*-0.19*	*-0.16*	*-2.69*	*-3.56*	*-0.15*	*-0.26*	*-0.06*
t-stat	[-0.68422]	[0.81893]	[1.19353]	[-0.26002]	[1.73548]	[-0.35136]	[2.22167]

	$\Delta(m_t - p_t)$	$\Delta(y_t)$	$\Delta(q_t^{US} - e_t^{US})$	$\Delta(q_t^{EA} - e_t^{EA})$	$\Delta(R_t^{EA})$	$\Delta(R_t^{US})$	$\Delta(i\_own_t^{EA})$
$\Delta(R_{t-2}^{EA})$	**-0.212**	**0.043**	**3.733**	**2.603**	**0.014**	**0.057**	**-0.029**
St err	*-0.19*	*-0.16*	*-2.75*	*-3.63*	*-0.15*	*-0.27*	*-0.06*
t-stat	[-1.09689]	[0.27170]	[1.35738]	[0.71697]	[0.09413]	[0.21294]	[-0.48253]
$\Delta(R_{t-1}^{US})$	**0.207**	**0.095**	**-2.079**	**-2.997**	**0.144**	**0.053**	**0.038**
St err	*-0.10*	*-0.08*	*-1.46*	*-1.93*	*-0.08*	*-0.14*	*-0.03*
t-stat	[2.01817]	[1.13168]	[-1.42411]	[-1.55481]	[1.81867]	[0.37484]	[1.19525]
$\Delta(R_{t-2}^{US})$	**0.087**	**-0.008**	**-2.041**	**-1.547**	**0.045**	**-0.028**	**0.036**
St err	*-0.10*	*-0.08*	*-1.42*	*-1.88*	*-0.08*	*-0.14*	*-0.03*
t-stat	[0.86672]	[-0.10346]	[-1.43297]	[-0.82273]	[0.58492]	[-0.20315]	[1.13766]
$\Delta(i\_own_{t-1}^{EA})$	**0.254**	**0.053**	**-4.934**	**-1.919**	**0.039**	**0.433**	**0.156**
St err	*-0.382*	*-0.313*	*-5.438*	*-7.179*	*-0.296*	*-0.526*	*-0.120*
t-stat	[0.66571]	[0.16893]	[-0.90733]	[-0.26734]	[0.13293]	[0.82258]	[1.30792]
$\Delta(i\_own_{t-2}^{EA})$	**0.144**	**-0.086**	**-11.967**	**-9.055**	**-0.301**	**-0.024**	**0.250**
St err	*-0.35*	*-0.28*	*-4.92*	*-6.50*	*-0.27*	*-0.48*	*-0.11*
t-stat	[0.41535]	[-0.30280]	[-2.42989]	[-1.39269]	[-1.12480]	[-0.05124]	[2.31052]
Statistics							
R-squared	0.35	0.29	0.32	0.29	0.29	0.13	0.51
Adj. R-squared	0.24	0.16	0.20	0.16	0.17	-0.02	0.43
Sum sq. resids	23.99	16.14	4871.70	8491.73	14.39	45.65	2.36
S.E. equation	0.51	0.42	7.32	9.66	0.40	0.71	0.16
F-statistic	3.09	2.30	2.64	2.29	2.33	0.85	6.00
Log likelihood	-72.00	-50.61	-358.94	-388.94	-44.42	-106.74	53.25
Akaike AIC	1.65	1.25	6.96	7.52	1.14	2.29	-0.67
Schwarz SC	2.07	1.67	7.38	7.94	1.56	2.71	-0.25
Mean dependent	0.95	0.54	0.69	0.56	-0.07	-0.07	-0.03
S.D. dependent	0.59	0.46	8.16	10.55	0.44	0.70	0.21

Source: Based on the DFR (2007) money demand model.
Note: for the specification of the three cointegrating vectors, see the notes to Figure 10.

Table 4

Relation between net capital flows and the disequilibria in DFR (2007) model

Based on quarterly flows

Variable		Net external assets	Net external assets	Net portfolio flows	Net debt securities flows	Net equities flows
		1980 - 2007	1999 - 2007			
Cointegrating vector 1		**1.073**	**2.214**	**0.687**	**1.248**	**-0.561**
	t-stat	*[1.486]*	*[1.248]*	*[0.411]*	*[0.953]*	*[-0.494]*
	adjusted R^2	*0.14*	0.04	0.38	-0.03	0.56
Cointegrating vector 2		**-0.354**	**-0.728**	**-0.530**	**-0.162**	**-0.368**
	t-stat	*[-2.111]*	*[-1.89]*	*[-1.46]*	*[-0.546]*	*[-1.496]*
	adjusted R^2	*0.158*	0.10	0.42	-0.06	0.59
Cointegrating vector 3		**-0.190**	**-0.538**	**-0.605**	**-0.169**	**-0.436**
	t-stat	*[-1.484]*	*[-1.605]*	*[-2.003]*	*[-0.667]*	*[-2.145]*
	adjusted R^2	*0.1407*	0.07	0.45	-0.05	0.62

Based on annual flows

Variable		Net external assets	Net external assets	Net portfolio flows	Net debt securities flows	Net equities flows
		1980 - 2007	1999 - 2007			
Cointegrating vector 1		**7.179**	**1.928**	**-6.487**	**5.316**	**-4.066**
	t-stat	*[3.084]*	*[0.24]*	*[-1.538]*	*[1.941]*	*[-1.707]*
	adjusted R^2	0.22	0.31	0.47	0.03	0.50
Cointegrating vector 2		**-2.169**	**-1.726**	**2.716**	**-1.508**	**0.657**
	t-stat	*[-4.189]*	*[-1.259]*	*[1.844]*	*[-2.453]*	*[0.828]*
	adjusted R^2	0.28	0.35	0.49	0.10	0.46
Cointegrating vector 3		**-0.979**	**-1.006**	**0.525**	**-1.672**	**-0.519**
	t-stat	*[-2.624]*	*[-0.97]*	*[0.341]*	*[-3.101]*	*[-0.751]*
	adjusted R^2	0.21	0.33	0.42	0.20	0.46

Source: Based on the DFR (2007) money demand model.
Notes:
(a) For the definition of the variables and the cointegrating vectors see Table 3 and Figure 10.
(b) A dummy has been introduced for 2000 in order to take into account of the fact that the portfolio investment flows have been affected in that period by a large merger and acquisition transaction occurred in February 2000, which was mirrored by equity flows as it was implemented via an exchange of shares.

Table 5
Forecasting inflation with excess money growth measures

Variable	Impact after 6 quarters	Impact after 8 quarters	adj. R^2	Bias	St. Deviation Forecasts	Variance forecast error	Bias^2	MSFE
	Sample 1980 Q1 - 2007 Q4			Out-of-sample 2000 Q1 - 2007 Q4				
Excess M3 growth - CGL (a)	**0.047**	**0.056**	**0.752**	**-0.130**	**0.226**	**0.212**	**0.017**	**0.229**
	(0.04)	(0.049)						
Excess M3 growth - DFR (a)	**0.147**	**0.177**	**0.768**	**-0.146**	**0.225**	**0.196**	**0.021**	**0.217**
	(0.052)	(0.066)						
Excess M3 growth - CGL (b)	**0.032**	**0.038**	**0.823**	**-0.126**	**0.224**	**0.181**	**0.016**	**0.197**
	(0.030)	(0.036)						
Excess M3 growth - DFR (b)	**0.122**	**0.147**	**0.833**	**-0.075**	**0.221**	**0.169**	**0.006**	**0.175**
	(0.047)	(0.0590)						
Nominal M3 growth	**0.175**	**0.200**	**0.847**	**-0.056**	**0.231**	**0.242**	**0.003**	**0.246**
	(0.014)	(0.050)						
Benchmarks								
Autoregressive			**0.823**	**0.009**	**0.219**	**0.184**	**0.000**	**0.184**
Constant = 1.9%				**0.250**	**0.000**	**0.048**	**0.063**	**0.111**
Random walk				**0.189**	**0.477**	**0.282**	**0.036**	**0.318**

Source: based on bivariate forecasts of inflation (except for the benchmarks), using the Stock and Watson methodology. Standard errors are reported in parenthesis.

Table B1

Johansen test for cointegration of total wealth in the United States and the euro area

Lags interval (in first differences): 1 to 2
Unrestricted cointegration rank test (trace)
Sample period: 1980 Q1 – 2007 Q4

$H_0 : rank \leq p$	Eigenvalue	Trace test-statistic	95% critical value	Prob**	Maximum eigenvalue test-statistic	95% critical value	Prob**
$p = 0$	0.146	20.882 *	20.262	0.041	17.216	15.892 *	0.031
$p \leq 1$	0.033	3.665	9.165	0.464	3.665	9.165	0.464

Notes: see Table 1.
Sources: Federal Reserve Board, ECB estimates.

Table B2

Johansen test for cointegration of the dividend and the earnings yield in the United States and the euro area

Lags interval (in first differences): 1 to 2
Unrestricted cointegration rank test (trace)
Sample period: 1980 Q1 – 2007 Q3

$H_0 : rank \leq p$	Eigenvalue	Trace test-statistic	95% critical value	Prob**	Maximum eigenvalue test-statistic	95% critical value	Prob**
For the euro area							
$p = 0$	0.144	24.954 *	20.262	0.010	17.206	15.892 *	0.031
$p \leq 1$	0.067	7.748	9.165	0.092	7.748	9.165	0.092
For the United States							
$p = 0$	0.134	20.818 *	20.262	0.042	16.014	15.892 *	0.048
$p \leq 1$	0.042	4.804	9.165	0.306	4.804	9.165	0.306

Notes: see Table 1.
Sources: Datastream.

Table B3

Unit root tests of the dividend growth in the United States and in the euro area

Dickey-Fuller, Augmented Dickey-Fuller, Phillips-Perron and KPSS tests

Test	Dividend growth *(euro area)*		Dividend growth *(US)*	
	I(1) (levels) *(without trend)*	**I(1) (levels)** *(with a trend)*	**I(1) (levels)** *(without trend)*	**I(1) (levels)** *(with trend)*
Dickey-Fuller	-9.12***	-10.33***	-8.3***	-9.58***
Augmented Dickey-Fuller	-11.05***	-11.07***	-10.41***	-10.41***
Phillips-Perron	-11.06***	-11.09***	-10.41***	-10.42***
KPSS	0.13	0.04	0.13	0.08

Note: The *Augmented Dickey-Fuller* test includes lagged differences whose number is dictated by the Schwarz criterion, while for the *Phillips-Perron* test the number of truncation lags is determined by the Newey West criterion. For the all the tests, apart from the Kwiatowski, Phillips, Schmidt and Shin test, the failure to reject the null would suggest the series is non-stationary.
For all the tests, *** indicates rejecting the null hypothesis at 1% significance level; ** at 5% significance level while * at 10% significance level.

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