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Euro Area Money Demand and International Portfolio Allocation:
A Contribution to Assessing Risks to Price Stability

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Abstract

This paper argues that a stable broad money demand for the euro area over the period 1980-2011 can be obtained by modelling cross border international portfolio allocation. As a consequence, model-based excess liquidity measures, namely the difference between actual M3 growth (net of the inflation objective) and the expected money demand trend dynamics, can be useful to predict HICP inflation.

Keywords: Euro area money demand, inflation forecasts, monetary policy, portfolio allocation

JEL classification: E41, E44, E52, G11, G15

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1 Introduction

This paper argues that a stable broad money demand for the euro area over the period 1980-2011 can be obtained by modelling cross border international portfolio allocation. We first observe that, in this first decade of the new millennium, the breakdown of standard money demand specifications for the euro area and the strong developments in annual M3 growth coincide with large net flows in portfolio investment in the euro area. We then estimate a new money demand, which turns out to be stable, by including variables explaining portfolio flows omitted in the traditional specifications.

The stability of money demand implies that excess liquidity measures are useful to predict inflation. For the short and medium term, we construct model-based excess liquidity measures, namely year-on-year actual M3 growth (net of the inflation objective) minus the year-on-year dynamically simulated values of real money growth, which are able to forecast out-of sample euro area inflation.

We also show that excess liquidity measures are more informative on future inflation developments than simple money growth indicators.

Our main argument is illustrated by Figures 1-2.

Insert Figures 1-2 about here

Figures 1 reports annual inflation computed using the Harmonised Index of Consumer Prices (HICP) and nominal M3 annual growth over the sample 1981-2011. Except after the exacerbation of the financial crisis in 2008 Q3, the evidence shows that, while inflation was very close to 2% with very little volatility in the new millennium, annual nominal M3 growth has been most of the time above the $4\frac{1}{2}$ per cent reference value,[1] raising even to 7.1% over the period 2000 Q1 - 2009 Q2. This behaviour of nominal M3 growth and inflation raises a question on the nature and validity of the long-run link between money and prices.

The link between money growth and inflation in traditional money demand money relies on the hypothesis of a stationary velocity growth. Figure 2 shows that there is a clear upward trend in (inverse) M3 velocity growth up to 2008Q3 and a downtrend thereafter. This trend is visible in the data since 2001 and it is positively correlated

[1] The reference value for M3 growth has been an important signalling device of the ECB's commitment to maintaining price stability over the medium term as the latter is not compatible with excessively high or low monetary growth over protracted periods of time. However, annual money growth has been above $4\frac{1}{2}$% most of the time and the divergence of money growth from this reference value was not used by the ECB as a mechanical signal of risks to price stability.

with net capital flows in non-Monetary Financial Institutions (MFI) portfolio investment.[2] This stylized fact suggests that international portfolio allocation could be a key explanation for the instability of traditional money demand specification for M3 in the last decade.

Moreover, the strength of this link does not seem to weaken during the euro area sovereign debt crisis, from the end of 2009 onward. On 16 October 2009, the Greek Prime Minister George Papandreou in his first parliamentary speech disclosed the country's severe fiscal problems and immediately after on 5 November 2009 the Greek government revealed a revised budget deficit of 12.7% of GDP for 2009, which was the double of the previous estimate. Since then, the sovereign spreads rose sharply for most of the euro area countries, causing the biggest challenge for the European economic and monetary union since its creation.

This was an event, which models could not predict. Equally unpredictable were the numerous non-standard measures introduced by the ECB such as: (i) the Covered Bond Purchase Programme launched in 2009 to reduce money market term rates and ease funding conditions for credit institutions and enterprises; (ii) the Securities Market Programme (SMP) launched in May 2010 to protect the functioning of the monetary policy transmission mechanism by addressing the malfunctioning of certain key government and private bond market segments; (iii) the long-term refinancing operations with a maturity up to one year launched in June 2009 and up to 3 years launched in December 2011 to give banks a longer horizon in their liquidity planning, (iv) the broadening of collateral standards; (v) the reduction of the required reserves ratio from 2% to 1%, which is expected to release liquidity of the banking sector of about 100 billion euro.

In the light of these facts, this paper addresses the possibility that net international capital flows, generated by shifts in the allocation of international portfolios, might explain the instability of traditional money demand by studying first the pre-Euro sovereign debt crisis sample period 1980Q1-2009Q2, and then by investigating the robustness of the main results of the analysis to the extension of the sample, which includes available data up to 2011Q3.

The rest of the paper is structured as follows. Section 2 places our contribution in the literature. Section 3 illustrates first how the long-run relationship between money and prices embedded in traditional money demand models for the euro area broke down after 2001. Then we explore the possibility to reconstruct a stable euro area money demand by including variables explaining portfolio flows, such as domestic and

[2] The net capital flows for the euro area are only available over the period reported in Figure 2.

foreign asset prices, which are omitted in the traditional specifications. In Section 4 we compute the model-based trend dynamics of desired money to provide a time-varying benchmark for the timely assessment of monetary developments compatible with price stability. Section 5 is devoted to show that excess monetary liquidity is a good predictor of euro area HICP inflation in the medium term. Section 6 examines the behaviour of the model during the euro area sovereign debt crisis. Section 7 concludes.

2 Related literature

Several studies have estimated the money demand for broad money (M3) for the euro area. The evidence of parameter instability over the last decade is pervasive.[3] More recent papers have demonstrated that the instability of the euro area money demand can be resolved by adding the growth rate of household wealth (Beyer, 2009) or house prices (Dreger and Wolters, 2010). However, these models correct for long run exogenous shifts with a time trend to capture the trend growth rate of household wealth (Beyer, 2009) or a step dummy from 2002Q1 onwards to capture the permanently change in the income elasticity (Dreger and Wolters, 2010). The main contribution of our paper is to provide further insights on the role of asset prices in the money demand relationship by stressing the relevance of international portfolio allocation as suggested by the anecdotal evidence of Figure 2, but without relying upon exogenous shifts.

It is often argued that portfolio shifts and financial innovation are the root causes of the instability of textbook broad money demand specifications. In fact, euro area broad money demand constructed using income and interest rates was stable up to 2001; since then, it has been affected by strong portfolio shifts (Papademos and Stark, 2010). As for the United States, Carlson et al. (2000) could re-establish a stable

[3] See Brand and Cassola (2000), Coenen and Vega (2001), Calza et al.(2001), Funke (2001), Golinelli and Pastorello (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 (2009). 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. We have re-estimated the Greiber and Setzer's model using latest ECB housing wealth data and it turns out that money is weakly exogenous and the system is no longer stable.

broad money demand over the period 1964-1998 once they accounted for the effects of financial innovation, which led to a permanent upward shift in money velocity around 1990.[4]

Benati (2009), using standard New Keynesian models, shows that the signal-to-noise ratio of monetary aggregates is negligible in low-inflation environments because of the dominant influence of money velocity shocks (see also Estrella and Mishkin, 1997; and De Grauwe and Polan, 2005).[5]

Therefore, the key point is to address the causes of the velocity shifts in order to obtain a stable money demand. We take this lead by focusing specifically on international portfolio shifts.

An alternative explanation of the instability of broad money is represented by non-linearities. This argument can be rationalized on the basis of adjustment costs in re-allocating the portfolio, which implies that money balances are re-adjusted towards the desired target only when the deviations become relatively large. Terasvirta and Eliasson (2001), for example, find a stable broad money demand for the United Kingdom.

One potential implication of non-linear models is that the effects of excessively fast or slow monetary growth on the economy could be regime-dependent. Therefore, the use of non-linear model-based indicators ought to be preceded by an accurate analysis of the monetary conditions characterizing the state of the economy. Conversely, linear models have the advantage that one can construct excess liquidity measures, whose interpretation does not depend on the state of the economy and, therefore, are much simpler and more manageable concepts.

The instability of traditional money demand models for the main currency areas has led the profession to build macro models that are independent from it. The intuition of this generation of New Keynesian models can be illustrated by recalling the undergraduate textbook IS-LM model with an aggregate supply side. Money balances do not enter the spending decisions underlying the IS curve, and they do not determine the supply curve. If monetary policy is characterized by a Taylor-type interest rate rule, then the equilibrium of the model is determined independently of

[4] Carlson, et al. (2000) examined the evidence for a stable M2 relationship using a smooth-shift variable, which they defined as 0.0 before 1990, 1.0 after 1994, and increasing linearly in between, to proxy the financial innovations that gave rise to the instabilities observed in the early 1990s.

[5] Several studies have shown 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).

a money demand relation (Woodford, 2003).

Reconstructing a macro model with money is beyond the scope of this paper. We simply show that a stable money demand relation for the euro area can be estimated once taking explicitly into account domestic and cross-border portfolio shifts. Then, we use the model to construct a money-based leading indicator for inflation.

3 A stable euro area money demand

3.1 The instability of traditional specification with domestic opportunity costs

To illustrate the instability of traditional money demand model for the euro area, we consider the relation estimated by Calza, Gerdesmeier and Levy (2001) (henceforth denoted as CGL). This model has been the workhorse for the ECB staff's internal analysis in the early years of the Economic and Monetary Union and it has been widely used in the context of the monetary analysis carried out at the ECB (see ECB, 2004). It constitutes a useful benchmark, as it features a very traditional long-run money demand, where (the log of) real money is determined by income and the opportunity cost of holding money.

We, therefore, consider as a benchmark the following cointegrating relation estimated using the Johansen (1995) procedure over the sample 1980 Q1 - 1999 Q4 (standard errors are reported in parenthesis below their respective coefficients in all equations of this paper):

$$m_t - p_t = \beta_0 + \underset{(0.04)}{1.25} y_t - \underset{(0.29)}{0.92} \left(i_t^{ST} - i_t^{own} \right),$$

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 domestic short-term market interest rates, i_t^{ST}, and the own rate of return on M3, i_t^{own}.

We use the estimated coefficients to construct the disequilibrium in money demand over the sample 1980 Q1 - 1999 Q4 measured by $m_t - p_t - \beta_0 - 1.25 y_t + 0.92 \left(i_t^{ST} - i_t^{own} \right)$. Stationarity of this term is a necessary condition for the structural stability of the implied money demand. Figure 3 illustrates the failure of this traditional money demand model. Over the period 2000-2009, the long-run equilibrium does not show any sign of mean reversion. 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 1980-2009.

Insert Figure 3 about here

To further investigate the performance of the model, we conduct an out-of-sample forecasting exercise. More precisely, given initial estimates of the parameters obtained with estimation over the sample 1980 Q1 - 1999 Q4, real money growth has been forecasted 4-step ahead by stochastic dynamic simulation adding recursively one observation at the time up to 2009 Q2. The simulated out-of-sample annual growth of real M3 differs significantly from the realized data (see Figure 3).

3.2 A new specification with domestic and foreign asset prices

Figure 2 shows that the extra-euro area portfolio flows could explain the changes in the velocity of money. This implies that the conventional specification should be extended to include a broader set of opportunity cost variables related to the domestic portfolio shifts between banks/government and households as well as the cross-border portfolio shifts between residents and non-residents. We do so by augmenting the traditional money demand specification with expected returns on domestic and foreign stocks and bonds.

Typically, money demand functions with risky asset prices include the level of domestic stock prices (Friedman, 1988; Choudhry, 1996) or 3-year average of domestic quarterly stock returns (Carstensen, 2006). To measure expectations in the stock market we exploit a simple model known as the "FED model" (see Lander et al., 1997; Koivu et al., 2005). According to the "FED model" the equalization of risk adjusted long-run returns in the stock and the bond markets implies cointegration between the earnings yield (i.e. the inverse of the price-earnings ratio) and the long-term bond yield.[6] As a consequence, the deviations from the long-run equilibrium

[6] The long-run equilibrium of the FED model can be derived by combining the dynamic dividend growth model of Campbell and Shiller (1988) and the n-period coupon bond yield model of Shiller (1979). The FED model has been criticised because 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.

should predict future returns in at least one of the two markets. The empirical evidence form the US supports the hypothesis that if the price-earnings ratio is above the bond yield, equity prices decline until the long-run equilibrium between the two variables is re-established.[7]

On the basis of this evidence we propose an empirical model capable of analyzing simultaneously the long-run equilibria of euro area money demand, domestic asset prices and foreign asset prices. In particular, we use cointegration analysis to identify three long-run relationships (i.e. a money demand for the euro area, a relation for domestic assets and a relation for foreign assets) based on the specification of the following VAR in levels:

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

where $m_t - p_t$ is the log of real money, y_t is real GDP, i_t is the short-term interest rate, R_t is the yield to maturity of long-term bonds, $q_t - e_t$ is the log of the price-earnings ratio of the stock market index and x_t is the log of the USD/EUR exchange rate[8].

3.3 The data set

We bring the model to the data by considering historical series of quarterly data for the euro area and the United States first over the period 1980 Q1 to 2009 Q2 and then to include the euro area sovereign debt crisis up to 2011Q3 for which high quality data for the euro area are available. All variables are measured as end-of-period and seasonally adjusted whenever it applies. Except for the interest rates, all the variables are expressed in logarithms.

The real euro area M3 holdings are calculated as the nominal broad monetary aggregate M3 deflated by the GDP deflator.[9] With regard to the financial variables, the short-term interest rate for the euro area is a weighted average of the national three-month interbank interest rates up to end of 1998, and Euribor afterwards. Similarly, the long-term interest rate is constructed as a weighted average of the yields

[7] 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).

[8] The short-term interest rate for the euro area (i_t^{EA}) can be proxied either by the three-month money market rate (i_t^{ST}) or by the own rate of return on money (i_t^{own}), given that $i_t^{ST} - i_t^{own}$ presents a clear long-run comovement with i_t^{ST}, with an estimated coefficient ammounting to approximately 0.5.

[9] The use of the GDP deflator is consistent with the use of real GDP as scale variable.

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 short-term interest rate is the three-month money market rate on Treasury bills and the long-term interest rate corresponds to the yields on the ten-year US Treasury notes and bonds or their closest substitutes. The price-earnings ratio for the euro area and the United States are obtained from DataStream.

Appendix 1 contains a detailed description of the construction and sources of the variables used in this study.

3.4 A stable money demand specification

The empirical 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. The lag length is set equal to three according to the Schwarz criteria.

We first simplified the general specification represented (1) by excluding the exchange rate and the US short-term interest rate, as they were not statistically significant.[10] The general system has then been reduced to the following seven variables:

$$\mathbf{X}_t = \mathbf{A}(L)\mathbf{X}_{t-1} + v_t, \qquad (2)$$
$$\mathbf{X}_t' = \left[\begin{array}{cccccccc} m_t - p_t & y_t & i_t^{own} & q_t^{EA} - e_t^{EA} & R_t^{EA} & q_t^{US} - e_t^{US} & R_t^{US} \end{array}\right].$$

The Johansen (1995) test for the joint hypothesis of both the rank order and the deterministic component allows - in absence of a deterministic trend - 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 at 5% (see Table 1). The number of cointegrating vectors remain equal to three if the trace test is conducted over the period 1980-1998, when the traditional money demand specification is functioning properly.[11]

[10] It could be argued that the exchange rate and the US short term interest rate are important missing variables in the dynamics of the model. When including 4 lags of the dynamics of these variables as exogenous in the system, the results on all other variables remain invariant as the coefficients on the exchange rate and the US short-term interest rates are generally not statistically significant and are unable to explain part of the variance of the variables in the system.

[11] We also carried out standard unit root tests and show that the variables are not stationary over

Insert Table 1 about here

The treatment of the deterministic component in the cointegrating space reflects the nature of the time series considered in the analysis. It seems natural to rule out the presence of a deterministic trend in equilibrium long-run returns to investment in the bond and stock markets, while it is generally preferable to have a linear trend when considering macroeconomic variables such as money and GDP. However, we have also tested whether all the results presented in the following sections would be robust to the introduction of a general deterministic trend in the system.

Restrictions are needed to identify the three cointegrating relations. Therefore, 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, while the second and the third cointegrating relations aim at capturing the FED model for the euro area and the United States, respectively.

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^2_8 with 8 degree of freedom above 30 without and with the deterministic trend, respectively.[12]

Second, in the light of this rejection, we consider a more general structure where money is directly affected by domestic and foreign risky asset prices:

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

The first cointegrating vector is consistent with a long-run money demand function. The second and third cointegrating vectors bear a clear relation to an extended version

the sample period (results are available upon request).

[12] 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.

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=4.02 with a tail probability of 0.53 (i.e. χ^2_6=6.31 with deterministic trend).

Parameters and standard errors, estimated over the sample 1980 Q1 - 2009 Q2, are as follows:[13]

$$m_t - p_t = \beta_{10} + \underset{(0.052)}{1.92}\, y_t + \underset{(0.040)}{0.45} \left(q_t^{EA} - e_t^{EA}\right)$$
$$- \underset{(0.040)}{0.45} \left(q_t^{US} - e_t^{US}\right) + \underset{(0.55)}{1.56} R_t^{EA} - \underset{(0.55)}{1.56} R_t^{US} \qquad (3)$$

$$q_t^{EA} - e_t^{EA} = \beta_{20} + \underset{(3.21)}{17.91} i_t^{own} - \underset{(2.65)}{20.52} R_t^{EA} \qquad (4)$$

$$q_t^{US} - e_t^{US} = \beta_{30} - \underset{(4.63)}{28.37} R_t^{US} \qquad (5)$$

The results reported in Figure 4 illustrate that our system exhibits a money demand cointegrating vector that is mean reverting or, in other words, stationary. The system (3)-(5) is hereafter referred to as DFR.[14]

Insert Figure 4 about here

To be sure that money plays a key role in the system, first, we set equal to zero the coefficient on $m_t - p_t$ and normalize to unity the coefficient on y_t. The test rejects strongly the exclusion of money from the above system (χ^2_7=33.21) at 1% significance level. Second, we impose restrictions on the adjustment coefficients of the system (3)-(5) to asses whether money is weakly exogenous: $\alpha_{11} = \alpha_{12} = \alpha_{13} = 0$. The test rejects such hypothesis (χ^2_9=23.40) at 1% significance level.

Therefore, we can safely argue that the solid line in the upper part of Figure 4 represents the residuals from the long-run money demand. There is a notable hump in excess money demand in 2008-2009 and this is due to the fall in real GDP. The excess money demand is due to the uncertainty surrounding the crisis period. To account for unexpected circumstances, households demanded more real money balances that they really needed to purchase consumption goods. As it will be shown in Section 6, this shock is of a temporary nature.

[13] The results with the deterministic trend are very similar. Importantly, the estimated income elasticity of money demand is not affected by the treatment of the deterministic trend in the cointegrating analysis.

[14] To identify the model, we impose restrictions in the long-run space. Specifically, the relevant non-income terms in the money demand equation are equal and opposite in sign, and they have identical standard deviations as an outcome of the estimation procedure.

Given the system of equations, 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 (see the other two lines in the bottom part of Figure 4). 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 (see Section 4).

The number of cointegrating vectors (see Table 1) and coefficients' estimates of the cointegrating parameters are robust when the system is estimated over the sample period 1980-1998. To further investigate the issue of structural stability of our estimates, we apply the recursive analysis and structural stability tests. The results (available upon request) provide evidence for the stability of the parameters determining the long-run solution and for the validity of the identifying restrictions. In particular, the Nyblom (1989) test, which evaluates the time-invariance of the entire parameter vector in the cointegrating space, suggests that the system is stable at all possible sample splits, with SupQ(t/T) = 4.32 (p-value = 0.393) and meanQ(t/T) = 2.15 (p-value = 0.367). We then test the stability of the parameters determining the short-run dynamics of the money demand equation using the Plomberg, *et al.* (1989) fluctuations test. The results show that the null of parameters stability of the short-run coefficients of the money demand cannot be rejected at every possible sample splits. The results of the model remain robust also when extending the analysis to include the sovereign debt crisis (see Section 6). Overall, the cointegrating relation between money and prices estimated within this system does not suffer from the problem of instability characterizing traditional money demand models.

In this regard, it is important to mention a comparative analysis of existing empirical models of euro area money demand (including our model) by Barigozzi and Conti (2010), based on adopting a time-varying cointegration test. The results of this study indicate that a time-invariant relation explaining real money balances cannot be rejected by the data only in the case of the DFR model.

The analysis of the coefficients determining the short-run dynamics suggests that the impact of the three disequilibria is rather pervasive as, particularly real M3 growth and real GDP growth react to some or all the disequilibria (see Table 2).

Insert Table 2 about here

Asset prices (with the exception of the US price earnings ratio) are weakly exogenous. Nevertheless, they are all important to identify the system.[15] The key point

[15] We started with a larger system by including also the US short term interest rate and the exchange

is that it is difficult to forecast asset price dynamics and this explains why most of the asset prices are weakly exogenous. At the same time the US price earnings ratio is strongly affected by deviations from euro area money demand. The fact that only the US stock market is predictable using lag measures of excess liquidity is consistent with the stance of this paper, if the excess liquidity measures are the results of capital outflows from the United States to the euro area due to euro area investors flying out of the US stock market and staying liquid rather than investing in euro area risky assets.

Given the specification of the long-run properties of the DFR system and the short-run dynamics, Figure 5 illustrates the performance of the model to predict real M3 growth in the euro area using both (*i*) estimated coefficients over the entire sample (in sample, upper part) and (*ii*) recursively estimated coefficients after 1998 (out-of-sample, bottom part).

Insert Figure 5 about here

The 4-step ahead stochastic dynamic simulations results shown in Figure 5 indicate that the out-of-sample prediction of real M3 growth tracks the in-sample prediction very tightly. Moreover, the comparison of Figures 3 and 5 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 model predicts a rise, which matches the pattern of the observed data. These results back the structural stability of the model.

On the basis of this model set-up, two additional main observations are in order:

(i) asset price developments are an important determinant of monetary developments in the euro area, due to their effect on the velocity of money.

(ii) the linkages between money and asset price developments run in both directions, so that excess monetary liquidity or disequilibria in asset prices can trigger corrective responses in all markets.

4 Excess monetary liquidity

The aim of this section is to compute the model-based expected trend dynamics of money and, as a result, derive excess liquidity measures, by solving the cointegrated

rate. We then dropped these two variables from the analysis as they were not significant to identify the system of equations.

VAR model forward and computing year-on-year developments of real money growth.

Specifically, we compute three alternative measures of expected trend dynamics of money evaluated at time t: (i) the stochastic dynamic simulation at time $t+1$ to capture the short-term trend dynamics; (ii) the stochastic dynamic simulation at time $t+4$ to capture the medium-term trend dynamics and (iii) the stochastic dynamic simulation at time $t+40$ to capture the long-term trend dynamics.

As for the trend dynamics in goods prices, we consider two alternative hypotheses: first, following the approach to compute the $4\frac{1}{2}\%$ reference value for annual M3 growth,[16] we choose a constant value, specifically we set $\Delta\overline{p}^{obj} = 1.9\%$ to capture the ECB's definition of price stability after 2003 as "below but close to 2% "; second, we set the trend dynamics in prices at actual year-on-year GDP deflator inflation, $\Delta\overline{p}_t$. These assumptions allow us to compute two sets of alternative measures of excess liquidity (the bar denotes year-on-year growth rates):

$$L_t^i = \left(\Delta\overline{M}_t - \Delta\overline{p}^{obj}\right) - \left(\Delta\overline{m}_{t+i|t} - \Delta\overline{p}_{t+i|t}\right), \quad i = 1, 4, 40 \tag{6}$$

$$R_t^i = \left(\Delta\overline{M}_t - \Delta\overline{p}_t\right) - \left(\Delta\overline{m}_{t+i|t} - \Delta\overline{p}_{t+i|t}\right), \quad i = 1, 4, 40. \tag{7}$$

Expression (6) indicates that excess monetary liquidity is positive if actual year-on-year M3 growth net of the inflation objective is higher than the trend dynamics in expected real M3. Expression (7) indicates that excess monetary liquidity is positive if the actual year-on-year real M3 growth is higher than the trend dynamics in expected real M3.

The trend dynamics in expected M3 $(\Delta\overline{m}_{t+i|t} - \Delta\overline{p}_{t+i|t})$ are reported in Figure 6.

Insert Figure 6 about here

The implied excess liquidity measures are reported in Figure 7 (L_t^i on the left panel and R_t^i on the right panel) together with the annual HICP inflation rate.

[16] The reference value for M3 growth is computed as follows. Consider a simple money demand specification of the following type $m_t - p_t = \alpha + \beta y_t - \gamma\widetilde{i}_t$, where $\widetilde{i}_t$ is a vector of opportunity costs. The rate of nominal money growth is then equal to the quantity equation: $\Delta m_t = \Delta p_t + \beta\Delta y_t - \gamma\Delta\widetilde{i}_t = \Delta p_t + \Delta y_t - \Delta v_t$, where $\Delta v_t = (1-\beta)\Delta y_t + \gamma\Delta\widetilde{i}_t$ is the change in the velocity of money. The reference value ($\Delta\overline{m}^{ref} = \Delta\overline{p}^{obj} + \Delta\overline{y} - \Delta\overline{v}$) is computed using long-term trends for output growth ($\Delta\overline{y}$) and velocity ($\Delta\overline{v}$) and under the hypothesis of an inflation objective over the medium term ($\Delta\overline{p}^{obj}$). By assuming a value for $\Delta\overline{y}$ between 2% and $2\frac{1}{2}\%$ (this is the estimated trend potential output of the euro area before 1999), a value for $\Delta\overline{v}$ between –1% and $-\frac{1}{2}\%$ (this is the estimated trend velocity for the euro area before 1999) and the ECB's definition of price stability (inflation rate below 2%), the ECB computed in 1998 the reference value for M3 growth to be equal to $4\frac{1}{2}\%$ per annum.

Insert Figure7 about here

The following results are important to point out:

1) The sum of the long-term expected real M3 growth (bottom panel of Figure 6) and the inflation objective, which is consistent with the ECB reference value concept, increases from 4-5% in the first half of the 1980s to 6% in 1986 and remains almost constant for 16 years up to 2002. Then, it shows an upward trend since 2003 and it amounts to 7.1% per annum in 2009 Q2, which is 2.6% higher than the ECB's reference value.

2) The estimated excess liquidity measures using (6) and (7) do not feature any specific trend after 1998 and often they cross the zero value (see Figure 7), suggesting that potential protracted risks to price stability are corrected over time during the 2000s.

3) The medium and long-term excess liquidity indicators hint at excess monetary liquidity over the period 2006 Q1 - 2008 Q2, when the ECB steadily increased the key interest rates. The gap between actual money growth and the desired value started to close in 2007 Q4, fell after the Lehman's bankruptcy and became negative in 2009.

4) The three L_t^i measures point to the existence of protracted excess monetary liquidity before 1994, which is associated with higher inflation.

Overall, a time-varying concept of trend dynamics in M3 growth could improve the ECB monetary analysis, particularly if the derived excess liquidity measures are leading indicators of inflation. The next section investigates the properties of the estimated excess liquidity measures to forecast HICP inflation.

5 Excess liquidity and future HICP inflation

In order to be accountable and to guide expectations, several central banks give a quantitative definition of price stability over a certain horizon. The ECB defines price stability as a year-on-year increase in the HICP for the euro area of below, but close to 2%. Price stability is maintained over the medium term (generally between 4 to 8 quarters ahead). Needless to say that if the ECB is successful in maintaining price stability, the annual inflation rate would be close to 2%. Then, no forecasting model would beat such a benchmark. Indeed, forecasting inflation has become a very difficult challenge particularly over the past two decades.[17] Even if it is difficult

[17] Atkeson and Ohanian (2001), Stock and Watson (2006) and Ang et al. (2007)) using a diverse set of methods document that the performance of models in forecasting US inflation has significantly diminished since the mid-1980s.

to beat a constant, an indicator that is statistically significant in explaining future inflation can still be used to inform the policymaker about future developments in goods prices and the potential risks to price stability.

We test whether excess monetary liquidity measures can be used as leading indicators to forecast HICP inflation.

The natural question to address is whether actual money growth in excess of the quantity that households wish to hold is going to raise the volume of expenditures and receipts, which will lead to a bidding up of prices and perhaps also to a temporary increase in output. Generally, prices adjust more rapidly than quantities; though, it is rare to have immediate price adjustments. Therefore, the dynamics of inflation can be studied assuming that expectations are based on lagged inflation rates as well as other indicators (such as cost push factors and money-based indicators). Here, we focus on the money-based indicators.

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

$$\pi_{t+k} = a^k + b^k \left(L^{\pi}\right) \pi_t^q + c^k \left(L^x\right) x_t + \varepsilon_{t+k}^k, \qquad k = 4, 6, 8, 10, 12 \tag{8}$$

where $\pi_{t+k} = 100 \left[\left(\frac{P_{t+k}}{P_t} \right)^{4/k} - 1 \right]$ is the annualized HICP inflation computed over k-quarters ahead, π_t^q is the quarterly inflation rate, $x_{k,t}$ is a money-based indicator and $b^k \left(L^{\pi}\right)$ and $c^k \left(L^x\right)$ are finite polynomials endogenously determined based on the Schwarz criteria.

Three different exercises are carried out. First, the set of equations in (8) is estimated over the entire sample period 1980 Q1 – 2009 Q2 to assess the statistically significance of the coefficients. The results, which are reported in Table 3, suggest that excess liquidity measures (6), in particular those based on medium- and long-term equilibrium values for M3 growth, can help explain future inflation at all horizon. Medium- and long-term excess monetary liquidity of 100 basis points leads to an increase of HICP inflation of about 10-15 basis points within two years and of about 17-22 basis after 12 quarters.

Insert Table 3 about here

It is useful to point out that year-on-year nominal money growth, which is one component of excess liquidity measures, is not statistically significant at 4 to 8 quarters ahead. This result reinforces the role of excess liquidity measures as a tool to assess risks to price stability. On the contrary, money-based indicators such as (7) are not statistically significant. Needless to say that excess liquidity measured using the constant ECB's reference value yields the same results obtained using the year-on-year nominal money growth.

Second, given that inflation has generally become harder to forecast over the last two decades owing to the decline in its volatility, the same exercise has been carried out since the early 1990s. The results, which are reported in Table 4, suggest the key role of the short-term liquidity measure (6) in forecasting HICP at all horizons and the role of the medium- and long-term liquidity measures to predict inflation at horizons above two years.

Insert Table 4 about here

It is important to stress that the point elasticity are marginally lower for excess monetary liquidity measured using medium or long-term trend dynamics (about 10 basis points at various horizons). Conversely, the point elasticity of the short-term excess liquidity becomes significant and is about 40 basis points in the first two years to decline to about 20 basis points thereafter. All other measures, except money at 3-year horizon, are not statistically significant.

Third, we test the statistical forecasting performance based on forecasts errors over the period 1999 Q1 – 2009 Q2, when inflation volatility was very low and HICP inflation was close to 2%. The inflation equation (8) and earlier the parameters of the cointegrated VAR (3)-(5) are estimated recursively by adding one observation at the time since 1999 Q1. This implies that the CVAR parameters are estimated recursively and the model-based excess liquidity measures are out-of-sample statistics. The forecasting performance of the alternative models is compared vis-à-vis a univariate autoregressive model. The statistics used for the forecasting evaluation are standard measures, such as the mean squared forecast errors (see Table 5), the bias (see Table 6) and the variance of the forecast errors (see Table 7).

Insert Tables 5-6-7 about here

Also using this approach, the excess liquidity measures (6) beat the benchmark over both sample periods (1980-2009 and 1991-2009), particularly at 4 to 6 quarters horizons. This is an important additional result given the definition of price stability in the medium term. The main driving force of the forecast errors is not the bias (plus or minus 1-2 percentage points), but its variance. This explains why it is difficult to beat a constant, here represented by 1.9% to capture the ECB's definition of price stability. However, the excess liquidity measures beat also the constant, when the models are estimated recursively over the sample period 1991-2009.

6 The behaviour of the model during the euro area sovereign debt crisis

The euro area sovereign debt crisis that begun at the end of 2009 offers an interesting opportunity to evaluate the robustness of the results discussed in the previuos sections. In fact, a new unpredictable phase started in 2009Q3, as the sovereign debt crisis came as a shock as well as highly unpredictable were the numerous non-standard measures introduced by the ECB.

We first analyse the stability of the cointegrating relationships when the estimation is performed over the sample period 1980Q1-2011Q3. The estimated coefficients of the long-run relations are similar to those obtained via estimation of the sample when excluding the crisis:

$$\begin{aligned} m_t - p_t &= \beta_{10} + \underset{(0.05)}{2.00} y_t + \underset{(0.05)}{0.53} \left(q_t^{EA} - e_t^{EA}\right) \\ &\quad - \underset{(0.05)}{0.53} \left(q_t^{US} - e_t^{US}\right) + \underset{(0.70)}{1.36} R_t^{EA} - \underset{(0.70)}{1.36} R_t^{US} \\ q_t^{EA} - e_t^{EA} &= \beta_{20} + \underset{(2.74)}{15.13} i_t^{own} - \underset{(2.31)}{16.63} R_t^{EA} \\ q_t^{US} - e_t^{US} &= \beta_{30} - \underset{(3.07)}{18.38} R_t^{US}. \end{aligned}$$

As a result, the measures of disequilibria (i.e. the cointegration residuals) estimated over the two samples largely overlap (see Figure 8).

Also the estimated loading coefficients are very close to those obtained when excluding the crisis period (see Table 8).

Insert Figures 8 and Table 8 about here

Second, we have assessed the ability of the model estimated up to 2009Q2 to forecast real money growth and real GDP growth unconditionally or conditionally to asset price developments. The results reported in Figure 9 suggest that the model could forecast real GDP growth particularly well, while the forecast of real M3 growth improves if the projections are conditioned to actual asset price developments.

These results are very informative and are consistent with the view (see Giannone, et al, 2011) that the 'big shock' is propagated to economic activity largely through conventional channels, rather than as a fundamental change (a 'structural break') in the behaviour of the economy.

Finally, we have computed out of sample forecast over the period 1999Q1-2011Q3. The forecast is less precise relative to the period before the euro area sovereign debt crisis. Yet, the MSFE remain below the benchmark model. These results are driven by the higher volatility in inflation largely because of the particularly pronounced collapse in commodity prices. Overall HICP inflation and HICP inflation excluding food and energy have very different patterns since 2008 (see Figure 10). While overall HICP inflation fell by 4.7 percentage points from peak to trough, HICP inflation excluding food and energy declined by only 1.2 percentage points. Similarly, during the post-recession period (2010-11) overall HICP inflation rebounded much more strongly than HICP inflation excluding food and energy.

To consider these developments, we have also forecasted HICP inflation excluding food and energy using the excess liquidity measures. The results reported in Table 9 suggest that excess liquidity measures are very useful forward-looking indicators of inflation, particularly 8-quarters ahead, as they beat the autoregressive benchmark as well as the constant rate.

7 Conclusions

This paper has introduced an empirical model aimed at quantifying the effects of international portfolio flows on the velocity of money in the euro area via movements in international asset prices. The anecdotal evidence shows a strong comovement between net cross-border portfolio flows and M3 velocity growth in the euro area from 2001 onwards, the period in which the traditional money demand based on output and interest rates turns out to be unstable.

The empirical model characterizes money demand as part of a broader portfolio allocation problem, where domestic and foreign asset prices influence money holdings. The system 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.

Our empirical results support the hypothesis that the new euro area money demand in an open economy with euro area and US stock and bond prices is stable. This implies that fluctuations in international financial markets are among the key determinants of the observed path of euro area money growth in the last decade.

This result is relevant to determine the stock of money holdings which is consistent with price stability in the long term and to provide a model that can explain monetary growth.

Furthermore, we find that measures of excess monetary liquidity, namely the gap between year-on-year quarterly M3 growth and model-based expected money demand trend dynamics, is statistically significant in forecasting euro area HICP inflation. As a rule of thumb, an excess of M3 growth (net of 1.9%) beyond the expected money demand trend dynamics of 100 basis points leads to an increase of HICP inflation 4-8 quarters ahead of about 10-15 basis points.

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References

[1] Ang A., Bekaert, G., Wei M., 2007, "Do macro variables, asset markets, or surveys forecast inflation better?", *Journal of Monetary Economics*, 54: 1163-1212.

[2] Artis, M., Beyer A., 2004, "Issues in money demand: The case of Europe", *Journal of Common Market Studies*, 42: 717-736.

[3] Asness, C., 2003, "Fight the FED model: The relationship between future returns and stock and bond market yield", *Journal of Portfolio Management*, 30: 11-24.

[4] Assenmacher-Wesche K., S. Gerlach, 2007, "Money at low frequencies", *Journal of the European Economic Association*, 5: 534-542.

[5] Atkeson A.,. Ohanian L.E., 2001, "Are Phillips curves useful for forecasting inflation?", *Quarterly Review*, Federal Reserve Bank of Minneapolis, 25: 2-11.

[6] Avouyi-Dovi S., B. M. Dreyfus, A. Drumetz, F. Oung, V. Jean-Guillaume, 2006, "La fonction de demande de monnaie pour la zone euro: un réexamen", *Banque de France NER*, No. 142.

[7] Barigozzi M., Conti A., 2010, "On the sources of euro-area money demand instability. A time-varying cointegrating analysis", mimeo.

[8] Bekaert G., E. Engstrom, 2008, "Inflation and the stock market: Understanding the "FED model"", mimeo.

[9] Benati L., 2009, "Long-run evidence on money growth and inflation", *ECB Working Paper Series*, No 1027.

[10] Beyer A., 2009, "A stable model for euro area money demand: Revisiting the role of wealth, *ECB Working Paper Series*, No 1111.

[11] BoucherC., 2006, "Stock prices–inflation puzzle and the predictability of stock market returns", *Economics Letters*, 90: 205–212.

[12] Brand C., N. Cassola, 2004, "A money demand system for euro area M3", *Applied Economics*, 36: 817-838.

[13] Bruggeman A., Donati P., Warne A., 2003, "Is the demand for euro area M3 stable?", *ECB Working Paper Series*, No. 255.

[14] Calza,A., Gerdesmeier D., Levy J., 2001, "Euro area money demand: measuring the opportunity costs appropriately", *IMF Working Paper Series*, No. 179.

[15] Campbell J.Y., Shiller R.J., 1988, "Valuation ratios and the long-run stock market outlook", *Journal of Portfolio Management*, 24: 11–26.

[16] Campbell, J.Y.,Vuolteenaho T., 2004, "Inflation illusion and stock prices", *American Economics Review Papers and Proceedings*, 94: 19–23.

[17] Carlson, J. B., Hoffman D. L., Keen, B. D., Rasche R.H., 2000 "Results of a study of the stability of cointegrating relations comprised on board monetary aggregates", *Journal of Monetary Economics*, 46: 345-83.

[18] Carstensen K., 2006, "Stock market downswing and the stability of European Monetary Union money demand", *Journal of Business and Economic Statistics*, 25: 395-402.

[19] Choudhry T., 1996, "Real stock prices and the long-run money demand function: Evidence from Canada and the USA," *Journal of International Money and Finance*, 15: 1–17.

[20] Coenen G., Levin A.T., Wieland, V., 2005, "Data uncertainty and the role of money as an information variable for monetary policy", *European Economic Review*, 49: 975-1006.

[21] Coenen G., Vega J.L., 2001, “The demand for M3 in the euro area”, *Journal of Applied Econometrics*, 16: 727-748.

[22] De Grauwe P.,Polan, M., 2005, “Is inflation always and everywhere a monetary phenomenon?”, *Scandinavian Journal of Economics*, 107: 239-259.

[23] De Santis R.A., Favero, C., Roffia B., 2008, “Euro area money demand and international portfolio allocation: Assessing risks to price stability”, *ECB Working Paper Series*, n. 926.

[24] Dreger C. and J. Wolters, 2009, “Investigating M3 money demand in the euro areas”, *Journal of International Money and Finance*, 29: 111-122.

[25] Dreger C., Wolters J., 2010, “Money demand and the role of monetary indicators in forecasting euro area inflation”, *DIW Discussion Paper*, n. 1064.

[26] ECB, 2004, *The Monetary Policy of the ECB*, Frankfurt am Main. http://www.ecb.int/pub/pdf/other/monetarypolicy2004en.pdf.

[27] Estrella A., Mishkin, F.S., 1997, “Is there a role for monetary aggregates in the conduct of monetary policy?”, *Journal of Monetary Economics*, 40: 279-304.

[28] Friedman M., 1988, “Money and the stock market”, *Journal of Political Economy*, 96: 221–245.

[29] Funke M., 2001, “Money demand in euroland”, *Journal of International Money and Finance*, 20: 701-713.

[30] Garratt A., K. Lee M.,. Pesaran M.H., Shin Y., 2006, *Global and National Macroeconometric Modelling. A Long-run Structural Approach.* Oxford, Oxford University Press.

[31] Gerlach S., Svensson L., 2003, “Money and inflation in the euro area: A case for monetary indicators?”, *Journal of Monetary Economics*, 50, 1649-72.

[32] Golinelli R.,. Pastorello S., 2002, “Modelling the demand for M3 in the euro area”, *European Journal of Finance*, 8, 371–401.

[33] Giannone D., Lenza L., Pill H..Reichlin L., 2011, “Non-standard monetary policy measures and monetary developments”. In.*Interest Rates, Prices and Liquidity - Lessons from the Financial Crisis*, Jagjit S. Chadha and Sean Holly (eds.), Cambridge University Press: pp 195-221.

[34] Greiber C., Lemke W., 2005, “Money demand and macroeconomic uncertainty”, *Bundesbank Discussion Paper Series: Economic Studies*, No. 26.

[35] Greiber C.. Setzer R., 2007, “Money and housing – evidence for the euro area and the US”, *Bundesbank Discussion Paper Series: Economic Studies*, No. 12.

[36] Johansen S., 1995, “Identifying restrictions of linear equations – with applications to simultaneous equations and cointegration”, *Journal of Econometrics*, 69: 111-132.

[37] Koivu M., Pennanen T., Ziemba W.T., 2005, “Cointegration analysis of the FED model”, *Finance Research Letters*, 2: 248–259.

[38] Kugler P., Kaufmann S., 2005, “Does money matter for inflation in the euro area?”, *OeNB working paper*, No. 103.

[39] Lander, J., Orphanides A., Douvogiannis M., 1997, “Earnings, forecasts and the predictability of stock returns: evidence from trading the S&P”, *Journal of Portfolio Management*, 23: 24-35.

[40] MacKinnon J.G., Haug, A., Michelis, L., 1999, “Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration”, *Journal of Applied Econometrics*, 14: 563-577.

[41] Nelson E., 2003, “The future of monetary aggregates in monetary policy analysis”, *Journal of Monetary Economics*, 50: 1029-1059.

[42] Nyblom J., 1989, “Testing for the constancy of parameters over time”, *Journal of the American Statistical Association*, 84: 223-30.

[43] Papademos L.D, Stark, J., 2010, *Enhancing Monetary Analysis*, ECB, Frankfurt am Main.

[44] Pesaran M. H., Shin Y., 2002, “Long-run structural modelling”, *Econometric Reviews*, 21: 49-87.

[45] PlobergerW., Kramer W, Kontrus, K. 1989, “A new test for structural stability in the linear regression model”, *Journal of Econometrics*, 40:307–318.

[46] Shiller R. J., 1979, “The volatility of long term interest rates and expectations models of the term structure”, *Journal of Political Economy*, 87: 1190–1219.

[47] Stock J.,Watson M.W., 1999, "Forecasting inflation", *Journal of Monetary Economics*, 44: 293-335.

[48] Stock J.H., Watson M.W,. , 2006, "Why has US inflation become harder to forecast?", *NBER Working Papers*, No. 12324.

[49] Thomas J., Zhang F., 2007, "Inflation illusion and stock prices: A comment", *Yale University School of Management Working Paper*.

[50] Terasvirta, T., Eliasson, A.C., 2001, "Non-linear error correction and the UK demand for broad money", *Journal of Applied Econometrics* 16: 277–288.

8 Appendix 1: 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, euro-13 from January 2007, euro-15 from January 2008 and euro-16 from January 2009). 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).[18] 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 - GDP

The quarterly nominal and real GDP is calculated by aggregating national GDP data using the irrevocable fixed exchange rates. From 2009 Q1 onwards the series covers the euro-16 countries series; prior to this date the series is an extrapolation based on the growth rates calculated from the existing member states' series. The quarterly seasonally adjusted real GDP series for the euro area (at market constant prices taken 1995 as the base year) is constructed using the same procedure as the nominal GDP series.

Sources: ECB calculations, Eurostat.

C - Goods 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).

[18] 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, on 11 July 2006 for Slovenia, 10 July 2007 for Cyprus and Malta, and 8 July 2008 for Slovakia.

Sources: ECB, ECB calculations, Eurostat.

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

Source: see, for details, Bruggeman et al., 2003.

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 and the dividend yields are obtained from DataStream constituents for the euro area and the United States.

Source: DataStream.

G - Exchange rate

The nominal US dollar/euro exchange rate represents the exchange rate US dollar/1 euro (ECU), spot a 2.15 pm (CET), monthly average. Source: BIS.

G - Cross-border portfolio flows

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).

Source: ECB.

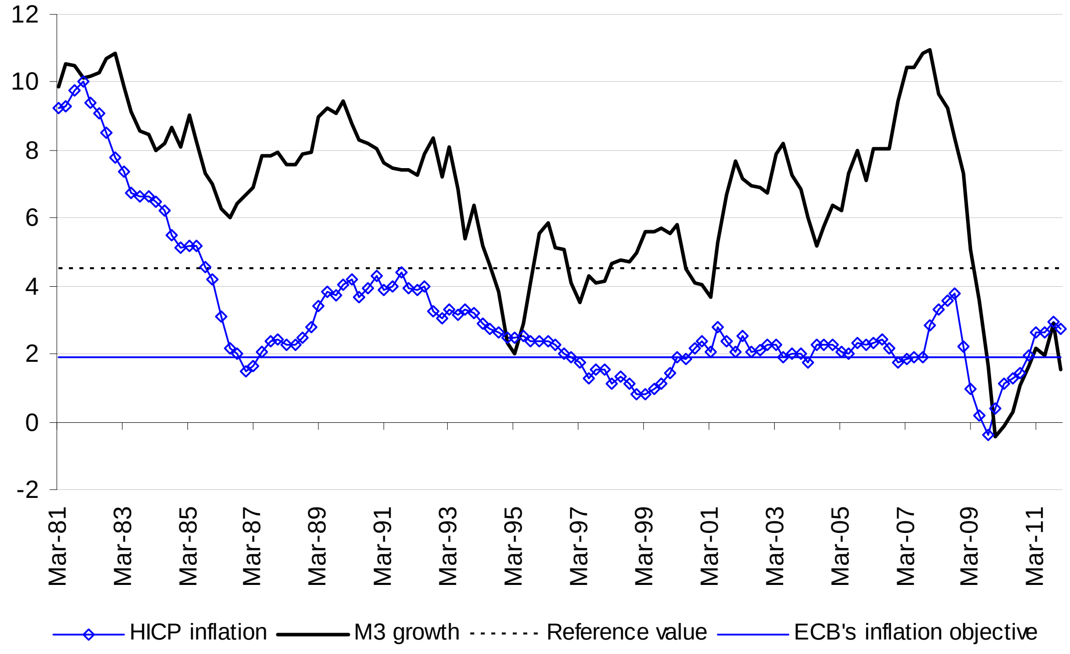


Fig. 1. Annual HICP inflation and M3 growth in the euro area. Source: ECB, Eurostat. Annual percentage changes (1981Q1 – 2011Q4).

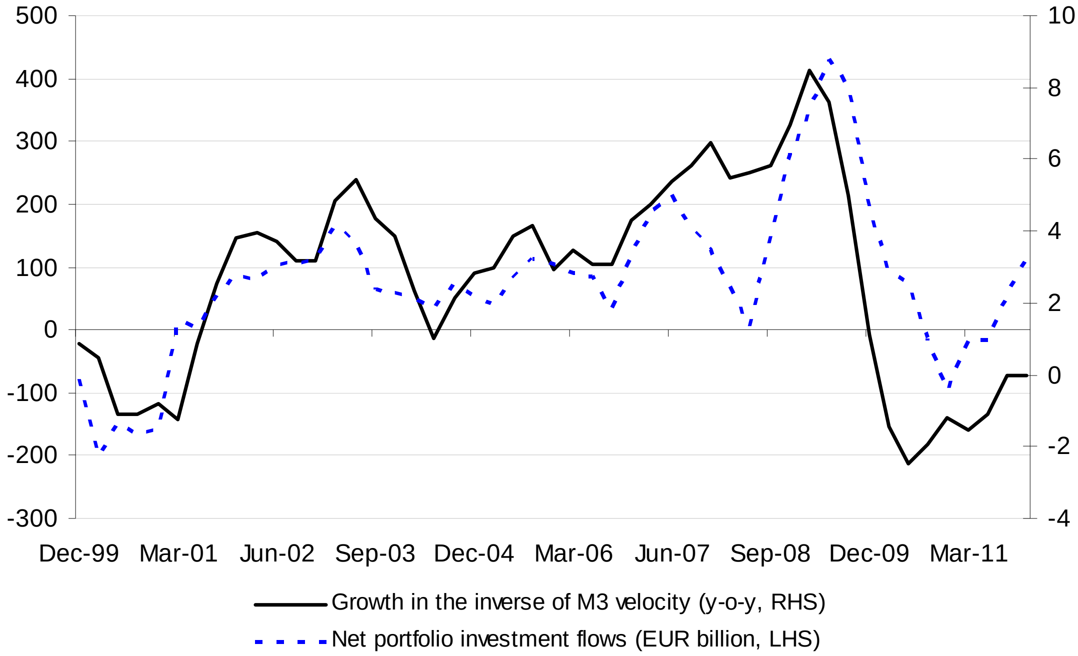
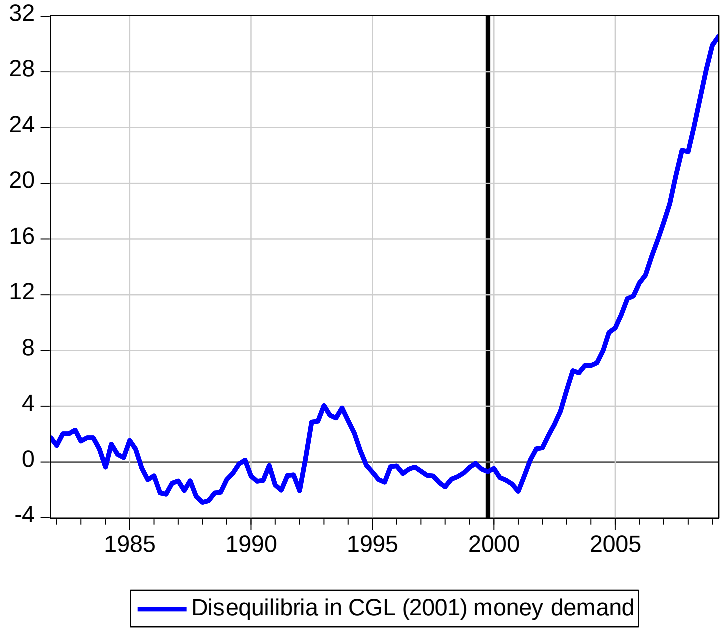


Fig. 2. Euro area annual M3 velocity growth and net flows in portfolio investment between non-monetary financial institutions (MFI)**.** Sources: ECB, ECB calculations. Annual percentage changes; annual flows in EUR billions (1999Q4 – 2011Q4).



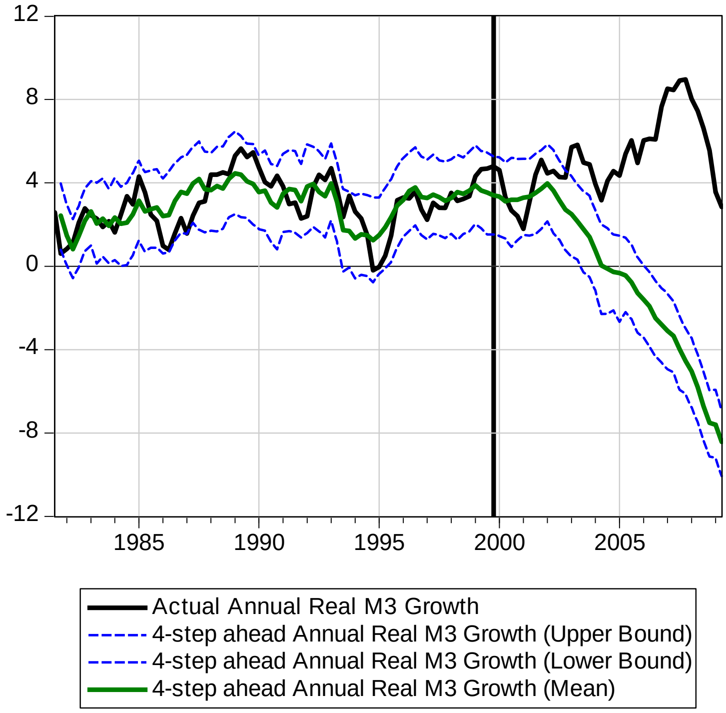
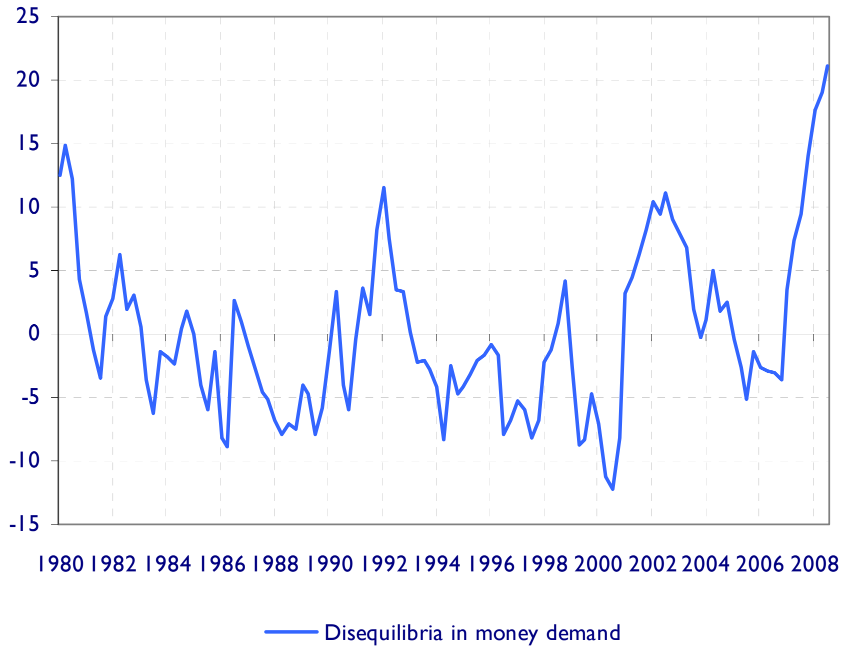


Fig. 3. Calza et al. (CGL) money demand for the euro area: its structural instability and 4-step ahead out-of-sample (from 2000 Q1) projections of real money growth. Notes: The disequilibrium in the CGL money demand model is computed as follows: $m_t - p_t - \beta_0 - 1.25 y_t + 0.92\left(i_t^{ST} - i_t^{own}\right)$. 4-step ahead stochastic simulations are within the 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. Disequilibria in percent; real money growth in annual percentage changes; sample period: 1980Q1 - 2009Q2.

(in percent)



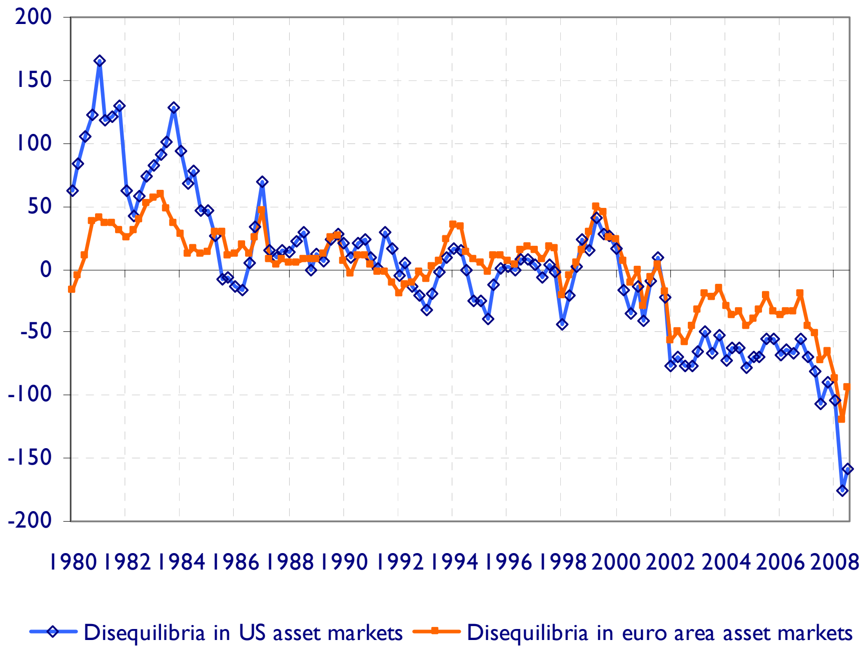


Fig. 4. The DFR money demand model for the euro area. Notes: The disequilibria in the DFR model are computed over the sample period 1980Q1 - 2009Q2 as follows

1) *Disequilibria in the money demand:*

$m_t - p_t - \beta_{10} - 1.92 y_t - 0.45(q_t^{EA} - e_t^{EA}) + 0.45(q_t^{US} - e_t^{US}) - 1.56 R_t^{EA} + 1.56 R_t^{US}$.

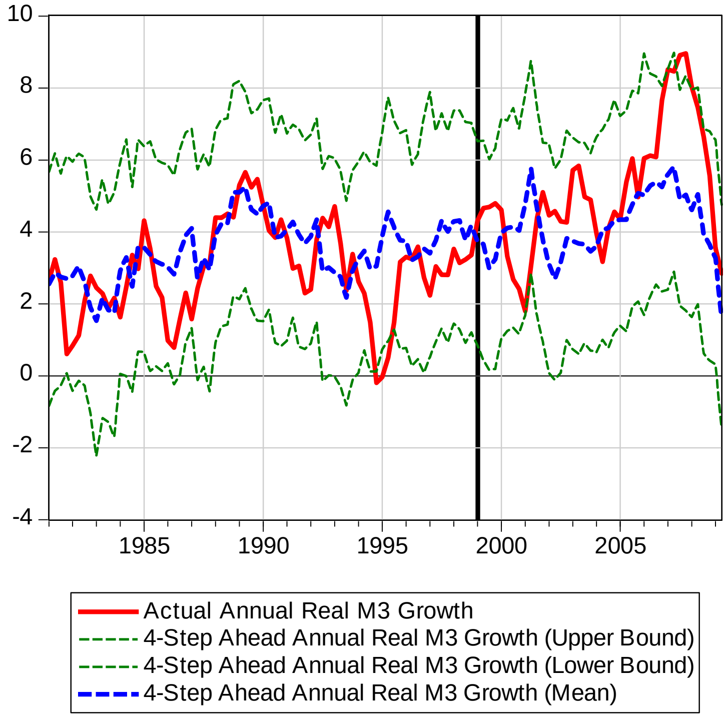
1) *Disequilibria in the euro area asset market*:

$(q_t^{EA} - e_t^{EA}) - \beta_{20} + 20.52 R_t^{EA} - 17.91 i_t^{OWN\_EA}$

2) *Disequilibria in the US asset market*:

$(q_t^{US} - e_t^{US}) - \beta_{30} + 28.37 R_t^{US}$

In sample (1981Q1 – 2009Q2)



In sample (1981Q1 – 1998Q4)
Out of sample from 1999Q1 to 2009Q2

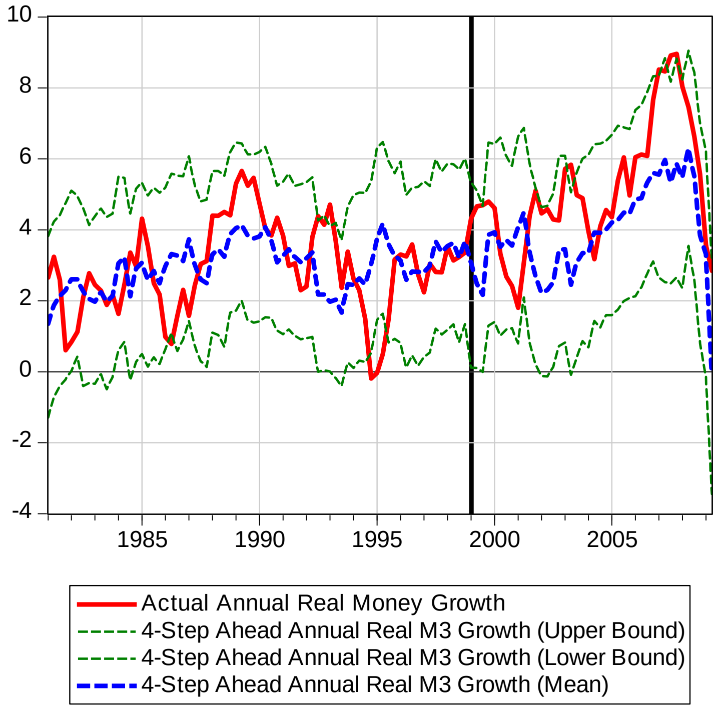


Fig. 1. Projections of real money growth based on the DFR money demand for the euro area (annual percentage changes, sample period: 1980Q1 - 2009Q2).

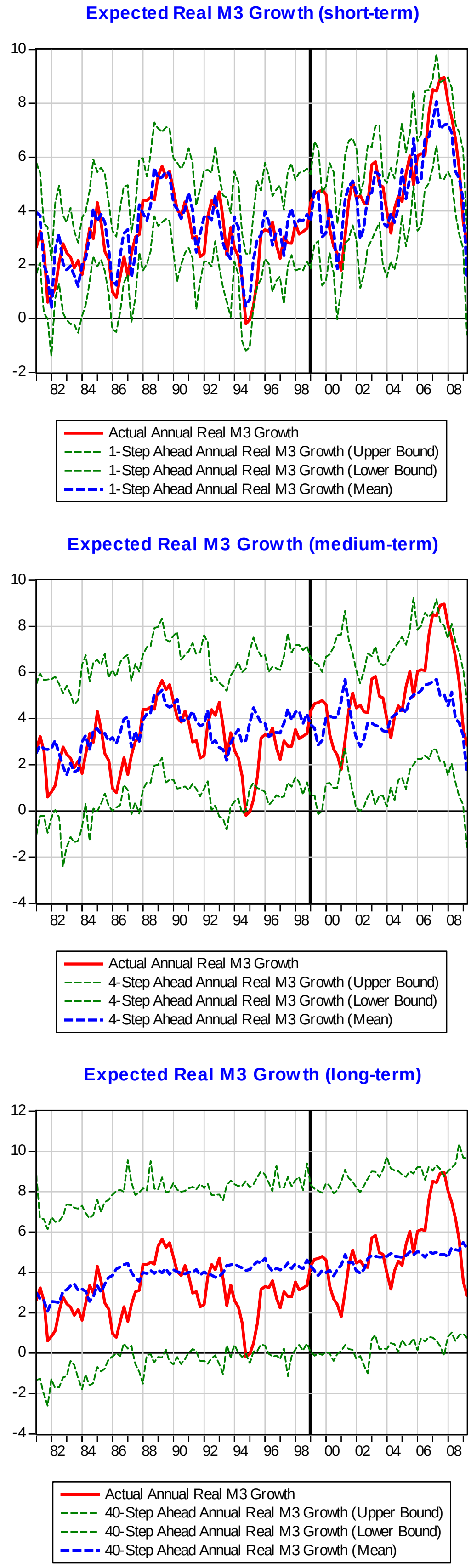


Fig. 2. Expected real M3 Growth: Short-, medium- and long-term (annual percentage changes, sample period: 1980Q1 - 2009Q2).

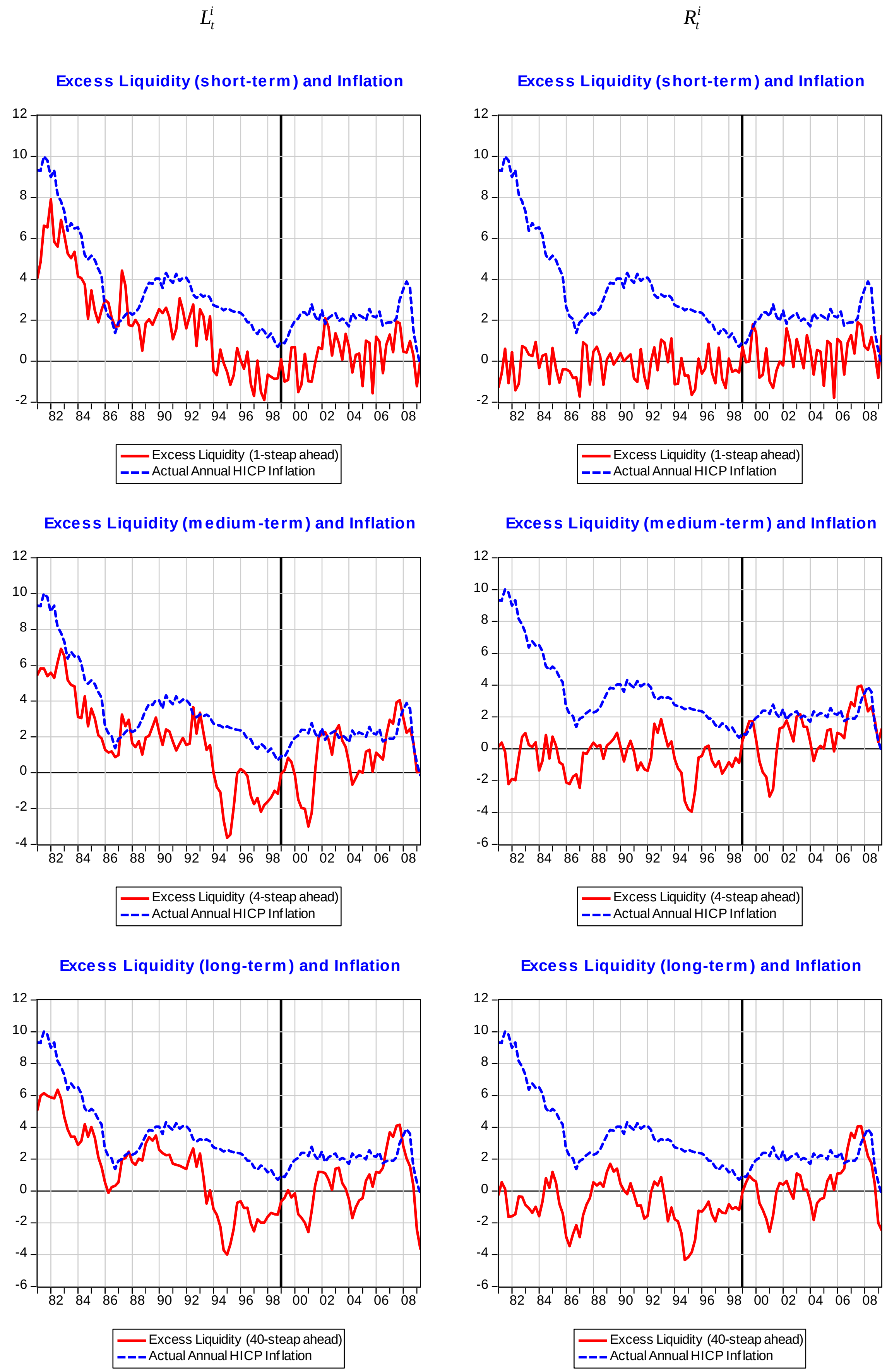


Fig. 3. Excess liquidity measures and HICP inflation (annual percentage changes, sample period: 1980Q1 -2009Q2).

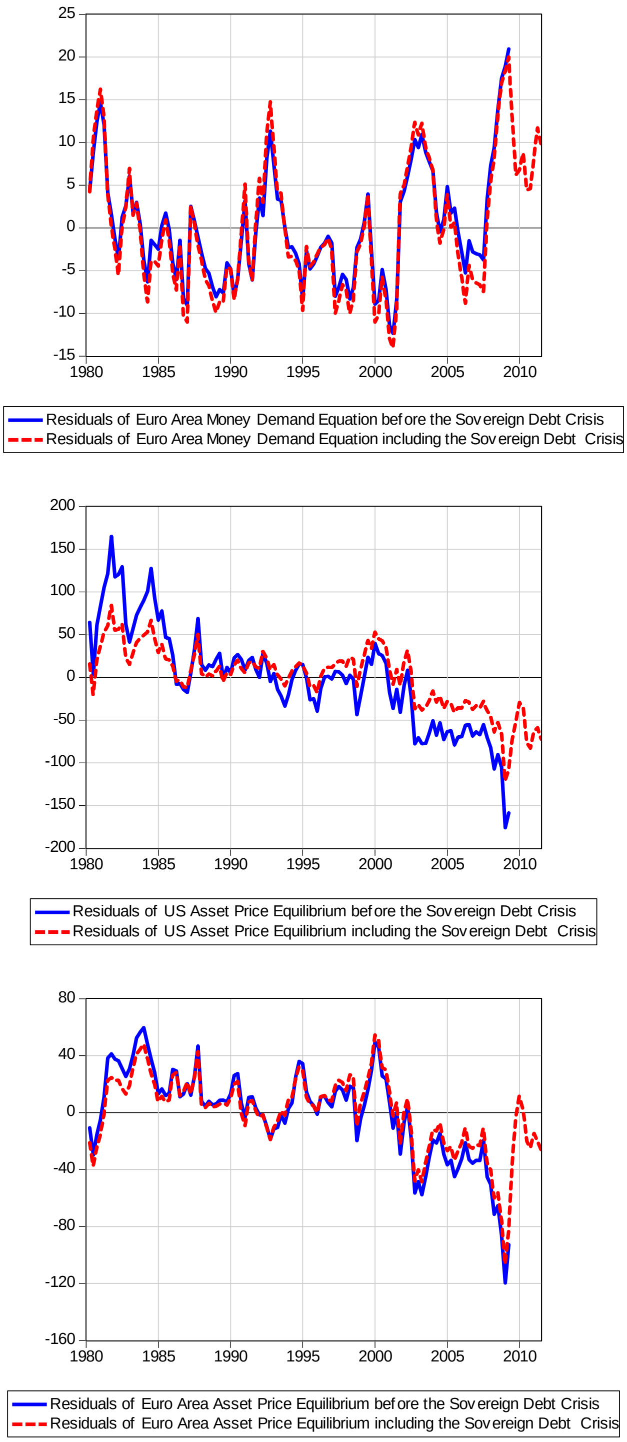


Fig. 8. The disequilibra in money demand and asset prices before and after the sovereign debt crisis (sample period: 1980Q1 - 2011Q3). Note: The cointegrating residuals are derived using the same model estimated over two different sample periods. The residuals before the euro area sovereign debt crisis are estimated using the sample period 1980Q1-2009Q2. The residuals including the euro area sovereign debt crisis are estimated using the sample period 1980Q1-2011Q3. Residuals of euro area money demand equation before the sovereign debt crisis: $m_t - p_t - \beta_{10} - 1.92y_t - 0.45\left(q_t^{EA} - e_t^{EA}\right) + 0.45\left(q_t^{US} - e_t^{US}\right) - 1.56R_t^{EA} + 1.56R_t^{US}$. Residuals of euro area money demand equation after the sovereign debt crisis: $m_t - p_t - \beta_{10} - 2.00y_t - 0.53\left(q_t^{EA} - e_t^{EA}\right) + 0.53\left(q_t^{US} - e_t^{US}\right) - 1.36R_t^{EA} + 1.36R_t^{US}$. Residuals of US asset price equilibrium before the sovereign debt crisis: $\left(q_t^{US} - e_t^{US}\right) - \beta_{30} + 28.37R_t^{US}$. Residuals of US asset price equilibrium after the sovereign debt crisis: $\left(q_t^{US} - e_t^{US}\right) - \beta_{30} + 18.38R_t^{US}$. Residuals of EA asset price equilibrium before the sovereign debt crisis: $\left(q_t^{EA} - e_t^{EA}\right) - \beta_{20} + 20.52R_t^{EA} - 17.91i_t^{OWN\_EA}$. Residuals of EA asset price equilibrium after the sovereign debt crisis: $\left(q_t^{EA} - e_t^{EA}\right) - \beta_{20} + 16.62R_t^{EA} - 15.13i_t^{OWN\_EA}$.

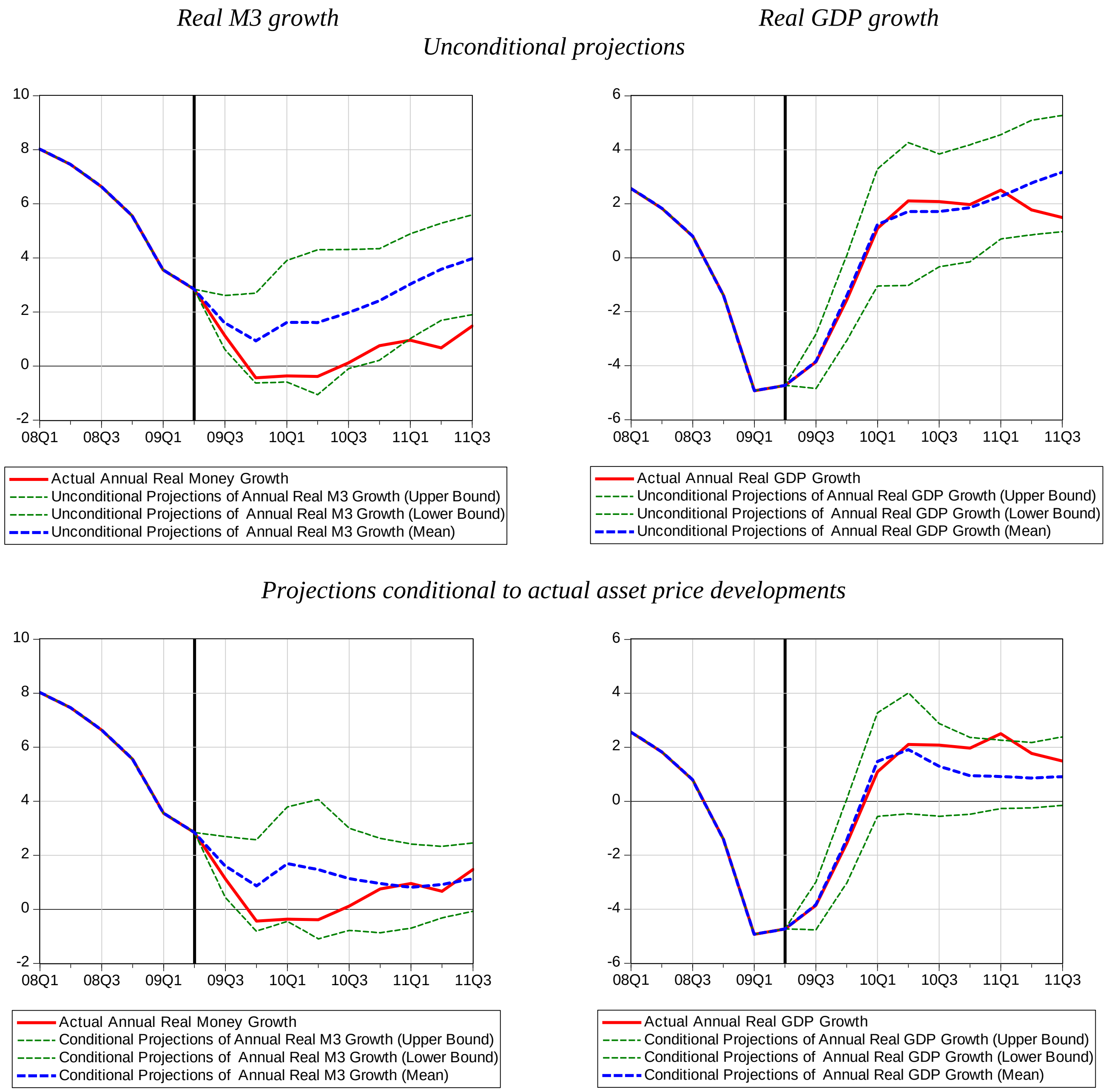


Fig. 9. Out of sample projections of real money growth and real GDP growth over the euro area sovereign debt crisis from 2009Q3 to 2011Q3.

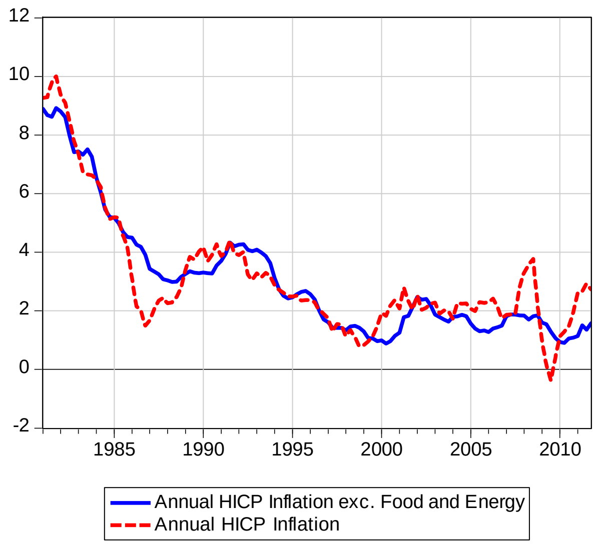


Fig. 10. Overall HICP inflation and HICP inflation excluding food and energy. Percent. Sample period: 1981Q1 - 2011Q3)

Table 1
Johansen test for cointegration in the DFR model.

	Sample 1980 Q1 - 2009 Q2			Sample 1980 Q1 - 1998 Q4		
H0: rank ≤ p	Eigenvalue	Trace Statistic	P-value*	Eigenvalue	Trace Statistic	P-value*
p = 0	0.401	185.966	0.000	0.576	178.804	0.000
p ≤ 1	0.350	127.080	0.001	0.392	116.228	0.006
p ≤ 2	0.221	77.459	0.046	0.341	79.957	0.029
p ≤ 3	0.141	48.748	0.137	0.303	49.537	0.120
p ≤ 4	0.112	31.266	0.125	0.165	23.204	0.515
p ≤ 5	0.080	17.616	0.111	0.092	10.067	0.633
p ≤ 6	0.068	8.047	0.081	0.040	2.987	0.583

Notes: Sample period: 1980Q1 - 2009Q2. Trend assumption: no determistic trend (restricted constant). Trace test indicates 3 cointegrating eqn(s) at the 0.05 level. * MacKinnon, et al. (1999) p-values.

Table 2
DFR money demand system for the euro area.

	$\Delta(m_t - p_t)$	$\Delta(y_t)$	$\Delta(q_t^{US} - e_t^{US})$	$\Delta(q_t^{EA} - e_t^{EA})$	$\Delta(R_t^{EA})$	$\Delta(R_t^{US})$	$\Delta(i\_own_t^{EA})$
CointEq1	**-0.036**	**-0.024**	**-1.034**	**-0.081**	**-0.008**	**0.037**	**0.002**
St err	***0.02***	***0.02***	***0.25***	***0.33***	***0.01***	***0.02***	***0.01***
t-stat	[-2.06343]	[-1.58069]	[-4.15623]	[-0.24713]	[-0.62226]	[1.66293]	[0.37625]
CointEq2	**-0.020**	**0.011**	**-0.257**	**-0.099**	**-0.008**	**0.015**	**-0.003**
St err	*0.01*	*0.01*	*0.09*	*0.12*	*0.00*	*0.01*	*0.00*
t-stat	[-3.03440]	[1.91574]	[-2.72352]	[-0.80206]	[-1.64454]	[1.74501]	[-1.31271]
CointEq3	**0.005**	**-0.004**	**0.094**	**0.021**	**0.003**	**-0.005**	**0.001**
St err	*0.00*	*0.00*	*0.03*	*0.04*	*0.00*	*0.00*	*0.00*
t-stat	[2.13599]	[-1.85481]	[2.89775]	[0.49005]	[1.78382]	[-1.78888]	[1.49140]
$\Delta(m_{t-1} - p_{t-1})$	**0.201**	**0.113**	**-0.914**	**-4.178**	**-0.027**	**-0.075**	**-0.017**
St err	*0.11*	*0.10*	*1.58*	*2.06*	*0.08*	*0.14*	*0.03*
t-stat	[1.83741]	[1.17059]	[-0.58000]	[-2.02491]	[-0.32777]	[-0.52558]	[-0.54255]
$\Delta(m_{t-2} - p_{t-2})$	**-0.064**	**0.067**	**0.154**	**2.126**	**0.049**	**0.182**	**-0.015**
St err	*0.11*	*0.09*	*1.54*	*2.02*	*0.08*	*0.14*	*0.03*
t-stat	[-0.60128]	[0.70326]	[0.09958]	[1.05124]	[0.60267]	[1.30418]	[-0.48744]
$\Delta(y_{t-1})$	**0.052**	**0.112**	**-2.014**	**4.123**	**0.111**	**0.238**	**0.137**
St err	*0.13*	*0.12*	*1.94*	*2.54*	*0.10*	*0.18*	*0.04*
t-stat	[0.39051]	[0.94318]	[-1.03865]	[1.62391]	[1.08350]	[1.36116]	[3.49127]
$\Delta(y_{t-2})$	**0.187**	**-0.106**	**-4.762**	**-7.844**	**-0.008**	**-0.333**	**0.071**
St err	*0.14*	*0.13*	*2.08*	*2.73*	*0.11*	*0.19*	*0.04*
t-stat	[1.29995]	[-0.83122]	[-2.28649]	[-2.87695]	[-0.07029]	[-1.76855]	[1.67500]
$\Delta(q_{t-1}^{US} - e_{t-1}^{US})$	**0.018**	**0.021**	**0.219**	**0.035**	**0.003**	**-0.015**	**0.006**
St err	*0.01*	*0.01*	*0.13*	*0.17*	*0.01*	*0.01*	*0.00*
t-stat	[1.95884]	[2.62618]	[1.64252]	[0.19915]	[0.35873]	[-1.26439]	[2.18487]
$\Delta(q_{t-2}^{US} - e_{t-2}^{US})$	**0.005**	**0.000**	**0.058**	**-0.040**	**0.007**	**-0.001**	**0.002**
St err	*0.01*	*0.01*	*0.14*	*0.19*	*0.01*	*0.01*	*0.00*
t-stat	[0.54023]	[0.03913]	[0.40965]	[-0.21425]	[0.88946]	[-0.11157]	[0.54210]
$\Delta(q_{t-1}^{EA} - e_{t-1}^{EA})$	**-0.010**	**-0.011**	**-0.157**	**-0.003**	**0.005**	**0.015**	**-0.001**
St err	*0.01*	*0.01*	*0.11*	*0.14*	*0.01*	*0.01*	*0.00*
t-stat	[-1.31997]	[-1.59584]	[-1.46026]	[-0.02102]	[0.83000]	[1.54226]	[-0.67163]
$\Delta(q_{t-2}^{EA} - e_{t-2}^{EA})$	**0.001**	**-0.002**	**-0.066**	**-0.133**	**-0.006**	**-0.008**	**-0.001**
St err	*0.01*	*0.01*	*0.11*	*0.15*	*0.01*	*0.01*	*0.00*
t-stat	[0.15939]	[-0.25819]	[-0.58377]	[-0.90155]	[-0.93244]	[-0.76673]	[-0.61010]
$\Delta(R_{t-1}^{EA})$	**-0.084**	**0.234**	**4.638**	**0.867**	**0.293**	**0.006**	**0.132**
St err	*0.19*	*0.17*	*2.74*	*3.59*	*0.14*	*0.25*	*0.06*
t-stat	[-0.44140]	[1.39174]	[1.68996]	[0.24134]	[2.02591]	[0.02341]	[2.36570]

	$\Delta(m_t - p_t)$	$\Delta(y_t)$	$\Delta(q_t^{US} - e_t^{US})$	$\Delta(q_t^{EA} - e_t^{EA})$	$\Delta(R_t^{EA})$	$\Delta(R_t^{US})$	$\Delta(i\_own_t^{EA})$
$\Delta(R_{t-2}^{EA})$	**0.011**	**0.006**	**2.290**	**1.024**	**-0.013**	**-0.107**	**-0.009**
St err	*0.19*	*0.17*	*2.81*	*3.68*	*0.15*	*0.25*	*0.06*
t-stat	[0.05708]	[0.03603]	[0.81405]	[0.27820]	[-0.08686]	[-0.42270]	[-0.15645]
$\Delta(R_{t-1}^{US})$	**0.214**	**0.091**	**-3.085**	**-2.822**	**0.098**	**0.011**	**0.045**
St err	*0.10*	*0.09*	*1.51*	*1.98*	*0.08*	*0.14*	*0.03*
t-stat	[2.04030]	[0.98451]	[-2.04131]	[-1.42644]	[1.23649]	[0.08159]	[1.47956]
$\Delta(R_{t-2}^{US})$	**-0.028**	**-0.021**	**-2.783**	**-1.271**	**0.044**	**-0.024**	**0.028**
St err	*0.10*	*0.09*	*1.49*	*1.95*	*0.08*	*0.13*	*0.03*
t-stat	[-0.27404]	[-0.22523]	[-1.87067]	[-0.65284]	[0.56372]	[-0.18200]	[0.91732]
$\Delta(i\_own_{t-1}^{EA})$	**-0.069**	**-0.062**	**-4.746**	**-2.428**	**-0.073**	**0.323**	**0.110**
St err	*0.387*	*0.343*	*5.596*	*7.325*	*0.295*	*0.505*	*0.113*
t-stat	[-0.17749]	[-0.18001]	[-0.84815]	[-0.33145]	[-0.24855]	[0.63950]	[0.97230]
$\Delta(i\_own_{t-2}^{EA})$	**0.060**	**-0.169**	**-10.196**	**-7.687**	**-0.154**	**0.085**	**0.236**
St err	*0.35*	*0.31*	*5.09*	*6.66*	*0.27*	*0.46*	*0.10*
t-stat	[0.17040]	[-0.54357]	[-2.00511]	[-1.15465]	[-0.57569]	[0.18450]	[2.29056]
Statistics							
Adj. R-squared	0.27	0.34	0.18	0.17	0.11	0.00	0.48
S.E. equation	0.54	0.48	7.81	10.22	0.41	0.71	0.16
F-statistic	3.62	4.68	2.55	2.44	1.84	1.01	7.68

Notes: Sample period: 1980Q1 - 2009Q2. The disequilibria in the DFR model are computed as follows

$$CointEq\_1 = m_{t-1} - p_{t-1} - \beta_{10} - 1.92 y_{t-1} - 0.45(q_{t-1}^{EA} - e_{t-1}^{EA}) + 0.45(q_{t-1}^{US} - e_{t-1}^{US}) - 1.56 R_{t-1}^{EA} + 1.56 R_{t-1}^{US}$$

$$CointEq\_2 = (q_{t-1}^{EA} - e_{t-1}^{EA}) - \beta_{20} + 20.52 R_{t-1}^{EA} - 17.91 i_{t-1}^{OWN\_EA}$$

$$CointEq\_3 = (q_{t-1}^{US} - e_{t-1}^{US}) - \beta_{30} + 28.37 R_{t-1}^{US}$$

Table 3
Performance of excess liquidity measures in forecasting inflation**.**

		horizon				
		4	6	8	10	12
Excess liquidity based on	coeff.	0.105	0.089	0.105	0.154	0.204
the ECB's reference value for	s.e.	(0.081)	(0.088)	(0.08)	(0.072)	(0.062)
M3 growth (4.5%)	t-stat.	[1.285]	[1.012]	[1.321]	[2.126]	[3.282]
Excess liquidity based on L^i_t	**coeff.**	**0.237**	**0.198**	**0.109**	**0.114**	**0.089**
(short-term trend dynamics)	**s.e.**	**(0.085)**	**(0.09)**	**(0.06)**	**(0.052)**	**(0.051)**
	t-stat.	**[2.777]**	**[2.197]**	**[1.802]**	**[2.183]**	**[1.751]**
Excess liquidity based on L^i_t	**coeff.**	**0.129**	**0.109**	**0.105**	**0.157**	**0.173**
(medium-term trend dynamics)	**s.e.**	**(0.057)**	**(0.059)**	**(0.063)**	**(0.05)**	**(0.047)**
	t-stat.	**[2.259]**	**[1.841]**	**[1.66]**	**[3.121]**	**[3.729]**
Excess liquidity based on L^i_t	**coeff.**	**0.155**	**0.134**	**0.121**	**0.164**	**0.216**
(long-term trend dynamics)	**s.e.**	**(0.064)**	**(0.07)**	**(0.077)**	**(0.073)**	**(0.062)**
	t-stat.	**[2.444]**	**[1.926]**	**[1.569]**	**[2.243]**	**[3.485]**
Excess liquidity based on R^i_t	coeff.	-0.009	-0.082	0.01	0.041	0.026
(short-term trend dynamics)	s.e.	(0.134)	(0.137)	(0.09)	(0.072)	(0.076)
	t-stat.	[-0.071]	[-0.599]	[0.107]	[0.574]	[0.337]
Excess liquidity based on R^i_t	coeff.	-0.006	-0.044	-0.006	0.043	0.04
(medium-term trend dynamics)	s.e.	(0.119)	(0.115)	(0.079)	(0.059)	(0.068)
	t-stat.	[-0.054]	[-0.382]	[-0.075]	[0.731]	[0.591]
Excess liquidity based on R^i_t	coeff.	-0.028	0.205	0.012	0.065	0.078
(long-term trend dynamics)	s.e.	(0.131)	(0.048)	(0.083)	(0.074)	(0.083)
	t-stat.	[-0.215]	[4.275]	[0.145]	[0.882]	[0.94]
Residuals of the money demand	coeff.	-0.022	-0.032	-0.01	0.001	-0.001
cointegrating vector	s.e.	(0.026)	(0.029)	(0.016)	(0.015)	(0.015)
	t-stat.	[-0.837]	[-1.133]	[-0.61]	[0.084]	[-0.066]
	coeff.	0.105	0.089	0.105	0.154	0.204
Year-on-year nominal M3 growth	s.e.	(0.081)	(0.088)	(0.08)	(0.072)	(0.062)
	t-stat.	[1.285]	[1.012]	[1.321]	[2.126]	[3.282]
	coeff.	0.283	0.374	0.31	0.346	0.613
Quarterly nominal M3 growth	s.e.	(0.171)	(0.153)	(0.149)	(0.153)	(0.206)
	t-stat.	[1.654]	[2.439]	[2.075]	[2.262]	[2.982]
	coeff.	-0.058	0.229	0.005	0.056	0.071
Year-on-year real M3 growth	s.e.	(0.127)	(0.05)	(0.078)	(0.066)	(0.075)
	t-stat.	[-0.457]	[4.588]	[0.068]	[0.842]	[0.95]
	coeff.	0.029	-0.06	0.043	0.097	0.089
Quarterly real M3 growth	s.e.	(0.212)	(0.116)	(0.151)	(0.12)	(0.127)
	t-stat.	[0.136]	[-0.519]	[0.286]	[0.808]	[0.699]

Source: Sample period 1980Q1 – 2009Q2. Based on bivariate forecasts of inflation (except for the benchmarks) using the Stock and Watson (1999) methodology.

Table 4
Performance of excess liquidity measures in forecasting inflation**.**

		horizon				
		4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	coeff.	0.071	0.051	0.04	0.07	0.099
	s.e.	(0.093)	(0.079)	(0.056)	(0.044)	(0.036)
	t-stat.	[0.769]	[0.652]	[0.713]	[1.576]	[2.778]
Excess liquidity based on L^i_t (short-term trend dynamics)	**coeff.**	**0.439**	**0.443**	**0.325**	**0.253**	**0.215**
	s.e.	**(0.124)**	**(0.114)**	**(0.085)**	**(0.069)**	**(0.057)**
	t-stat.	**[3.543]**	**[3.867]**	**[3.831]**	**[3.672]**	**[3.758]**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**coeff.**	**0.094**	**0.078**	**0.052**	**0.08**	**0.102**
	s.e.	**(0.086)**	**(0.071)**	**(0.049)**	**(0.034)**	**(0.024)**
	t-stat.	**[1.099]**	**[1.099]**	**[1.066]**	**[2.328]**	**[4.204]**
Excess liquidity based on L^i_t (long-term trend dynamics)	**coeff.**	**0.11**	**0.085**	**0.057**	**0.084**	**0.117**
	s.e.	**(0.092)**	**(0.079)**	**(0.057)**	**(0.047)**	**(0.036)**
	t-stat.	**[1.193]**	**[1.067]**	**[1.002]**	**[1.816]**	**[3.297]**
Excess liquidity based on R^i_t (short-term trend dynamics)	coeff.	0.181	0.114	0.007	0.054	0.111
	s.e.	(0.196)	(0.176)	(0.132)	(0.092)	(0.078)
	t-stat.	[0.924]	[0.648]	[0.054]	[0.588]	[1.412]
Excess liquidity based on R^i_t (medium-term trend dynamics)	coeff.	-0.001	-0.025	0.011	0.077	0.09
	s.e.	(0.105)	(0.087)	(0.066)	(0.036)	(0.03)
	t-stat.	[-0.014]	[-0.283]	[0.16]	[2.14]	[3.019]
Excess liquidity based on R^i_t (long-term trend dynamics)	coeff.	0.011	-0.02	0.029	0.081	0.111
	s.e.	(0.111)	(0.092)	(0.064)	(0.049)	(0.041)
	t-stat.	[0.102]	[-0.222]	[0.447]	[1.662]	[2.688]
Residuals of the money demand cointegrating vector	coeff.	-0.014	-0.005	0.008	0.021	0.022
	s.e.	(0.027)	(0.024)	(0.012)	(0.008)	(0.008)
	t-stat.	[-0.538]	[-0.211]	[0.722]	[2.589]	[2.639]
Year-on-year nominal M3 growth	coeff.	0.071	0.051	0.04	0.07	0.099
	s.e.	(0.093)	(0.079)	(0.056)	(0.044)	(0.036)
	t-stat.	[0.769]	[0.652]	[0.713]	[1.576]	[2.778]
Quarterly nominal M3 growth	coeff.	0.232	0.2	0.117	0.126	0.191
	s.e.	(0.18)	(0.172)	(0.121)	(0.089)	(0.083)
	t-stat.	[1.29]	[1.166]	[0.964]	[1.412]	[2.297]
Year-on-year real M3 growth	coeff.	-0.011	-0.035	0.005	0.057	0.085
	s.e.	(0.108)	(0.088)	(0.065)	(0.048)	(0.04)
	t-stat.	[-0.105]	[-0.394]	[0.072]	[1.204]	[2.128]
Quarterly real M3 growth	coeff.	0.052	0.005	0.013	0.08	0.127
	s.e.	(0.21)	(0.192)	(0.144)	(0.084)	(0.079)
	t-stat.	[0.25]	[0.026]	[0.089]	[0.947]	[1.615]

Source: Sample period 1991Q1 – 2009Q2. Based on bivariate forecasts of inflation (except for the benchmarks) using the Stock and Watson (1999) methodology.

Table 5
Out-of-sample euro area inflation forecast with excess liquidity measures: MSFE (1999Q1 – 2009Q2).

Starting period 1981 Q1

			horizon		
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	1.018	1.082	1.293	1.481	1.189
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.646**	**0.666**	**0.870**	**0.957**	**0.756**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**0.872**	**0.915**	**1.067**	**1.108**	**1.003**
Excess liquidity based on L^i_t (long-term trend dynamics)	**0.827**	**0.879**	**1.113**	**1.237**	**1.044**
Excess liquidity based on R^i_t (short-term trend dynamics)	0.988	0.992	1.014	1.028	1.009
Excess liquidity based on R^i_t (medium-term trend dynamics)	0.994	0.993	1.010	1.035	1.030
Excess liquidity based on R^i_t (long-term trend dynamics)	0.775	0.972	1.048	1.072	1.041
Residuals of the money demand cointegrating vector	0.932	0.902	0.968	0.990	1.007
Year-on-year nominal M3 growth	1.018	1.082	1.293	1.481	1.189
Quarterly nominal M3 growth	0.986	0.984	1.047	1.282	1.102
Year-on-year real M3 growth			1.040	1.123	1.082
Quarterly real M3 growth	0.971	0.994	1.008	1.027	0.977
Random Walk	1.238	1.028	1.019	1.546	1.629
Constant = 1.9%	0.563	0.464	0.578	0.775	0.648

Starting period 1991 Q1

			horizon		
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	0.972	0.936	0.947	0.920	0.767
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.747**	**0.698**	**0.793**	**1.090**	**0.929**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**0.898**	**0.918**	**0.956**	**0.955**	**0.811**
Excess liquidity based on L^i_t (long-term trend dynamics)	**0.879**	**0.890**	**0.955**	**0.896**	**0.689**
Excess liquidity based on R^i_t (short-term trend dynamics)	0.904	0.912	0.958	0.963	0.977
Excess liquidity based on R^i_t (medium-term trend dynamics)	0.972	0.951	0.963	0.895	0.821
Excess liquidity based on R^i_t (long-term trend dynamics)	0.955	0.911	0.989	0.816	0.588
Residuals of the money demand cointegrating vector	0.957	0.969	1.001	0.971	0.909
Year-on-year nominal M3 growth	0.972	0.936	0.947	0.920	0.767
Quarterly nominal M3 growth	0.912	0.937	0.879	0.880	0.795
Year-on-year real M3 growth			0.937	0.830	0.637
Quarterly real M3 growth	0.915	0.930	0.957	0.927	0.882
Random Walk	2.057	1.886	1.467	2.186	2.584
Constant = 1.9%	0.935	0.851	0.833	1.096	1.028

Notes: MSFE computed over the period 1999Q1 – 2009Q2. Based on bivariate forecasts of inflation using the Stock and Watson (1999) methodology. $MSFE^M = (1/T)\sum_{t=1}^{T}(\pi_{h,l+k} - \pi^M_{h,l+k})^2$ =*mean squared forecast errors*, where $\pi^M_{h,l+k}$ represents the inflation forecasts generated by the various models. The table shows the MSFE relative to the autoregressive benchmark.

Table 6

Out-of-sample euro area inflation forecast with excess liquidity measures: Bias (1999Q1 – 2009Q2).

Starting period 1981Q1

	horizon				
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	-0.241	-0.324	-0.226	-0.194	-0.208
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.030**	**0.011**	**0.065**	**0.063**	**0.030**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**-0.126**	**-0.196**	**-0.111**	**-0.073**	**-0.112**
Excess liquidity based on L^i_t (long-term trend dynamics)	**-0.126**	**-0.214**	**-0.135**	**-0.106**	**-0.145**
Excess liquidity based on R^i_t (short-term trend dynamics)	-0.161	-0.255	-0.172	-0.143	-0.193
Excess liquidity based on R^i_t (medium-term trend dynamics)	-0.196	-0.272	-0.187	-0.166	-0.208
Excess liquidity based on R^i_t (long-term trend dynamics)	-0.209	-0.287	-0.220	-0.202	-0.242
Residuals of the money demand cointegrating vector	-0.072	-0.184	-0.121	-0.117	-0.163
Year-on-year nominal M3 growth	-0.241	-0.324	-0.226	-0.194	-0.208
Quarterly nominal M3 growth	-0.188	-0.273	-0.222	-0.191	-0.209
Year-on-year real M3 growth			-0.266	-0.250	-0.262
Quarterly real M3 growth	-0.194	-0.265	-0.182	-0.163	-0.199
Random Walk	-0.053	-0.029	0.082	0.088	0.045
Constant = 1.9%	0.096	0.088	0.121	0.120	0.102

Starting period 1991Q1

	horizon				
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	-0.116	-0.075	-0.034	-0.005	0.009
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.048**	**0.080**	**0.126**	**0.156**	**0.176**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**-0.035**	**0.007**	**0.051**	**0.111**	**0.122**
Excess liquidity based on L^i_t (long-term trend dynamics)	**-0.050**	**-0.012**	**0.028**	**0.064**	**0.070**
Excess liquidity based on R^i_t (short-term trend dynamics)	-0.001	0.046	0.112	0.150	0.159
Excess liquidity based on R^i_t (medium-term trend dynamics)	-0.035	-0.008	0.057	0.092	0.100
Excess liquidity based on R^i_t (long-term trend dynamics)	-0.060	-0.032	0.034	0.020	0.010
Residuals of the money demand cointegrating vector	0.001	0.034	0.100	0.146	0.156
Year-on-year nominal M3 growth	-0.116	-0.075	-0.034	-0.005	0.009
Quarterly nominal M3 growth	-0.030	0.013	0.012	0.074	0.057
Year-on-year real M3 growth	-0.094	-0.074	-0.006	-0.044	-0.064
Quarterly real M3 growth	-0.030	0.017	0.069	0.097	0.119
Random Walk	-0.053	-0.029	0.082	0.088	0.045
Constant = 1.9%	0.096	0.088	0.121	0.120	0.102

Notes: Bias computed over the period 1999Q1 – 2009Q2. Based on bivariate forecasts of inflation using the Stock and Watson (1999) methodology. $Bias_k^M = \sum_{l=1}^{T}\left(\pi_{l+k} - \pi_{l+k}^M\right)/T$, where $\pi_{h,l+k}^M$ represents the inflation forecasts generated by the various models.

Table 7

Out-of-sample euro area inflation forecast with excess liquidity measures: Variance (1999Q1 – 2009Q2).

Starting period 1981 Q1

	horizon				
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	1.155	0.908	0.442	0.274	0.210
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.768**	**0.624**	**0.327**	**0.197**	**0.160**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**1.022**	**0.819**	**0.394**	**0.227**	**0.201**
Excess liquidity based on L^i_t (long-term trend dynamics)	**0.969**	**0.777**	**0.406**	**0.249**	**0.201**
Excess liquidity based on R^i_t (short-term trend dynamics)	1.151	0.865	0.357	0.196	0.178
Excess liquidity based on R^i_t (medium-term trend dynamics)	1.145	0.856	0.350	0.190	0.176
Excess liquidity based on R^i_t (long-term trend dynamics)	0.879	0.828	0.351	0.185	0.163
Residuals of the money demand cointegrating vector	1.104	0.811	0.354	0.194	0.188
Year-on-year nominal M3 growth	1.155	0.908	0.442	0.274	0.210
Quarterly nominal M3 growth	1.139	0.847	0.350	0.233	0.191
Year-on-year real M3 growth			0.326	0.173	0.162
Quarterly real M3 growth	1.119	0.861	0.351	0.189	0.168
Random Walk	1.472	0.962	0.382	0.317	0.345
Constant = 1.9%	0.661	0.427	0.206	0.148	0.128

Starting period 1991 Q1

	horizon				
	4	6	8	10	12
Excess liquidity based on the ECB's reference value for M3 growth (4.5%)	0.683	0.472	0.249	0.137	0.103
Excess liquidity based L^i_t (short-term trend dynamics)	**0.533**	**0.350**	**0.194**	**0.138**	**0.094**
Excess liquidity based L^i_t (medium-term trend dynamics)	**0.642**	**0.469**	**0.250**	**0.130**	**0.094**
Excess liquidity based L^i_t (long-term trend dynamics)	**0.628**	**0.454**	**0.252**	**0.129**	**0.088**
Excess liquidity based R^i_t (short-term trend dynamics)	0.648	0.464	0.241	0.121	0.106
Excess liquidity based R^i_t (medium-term trend dynamics)	0.695	0.485	0.252	0.125	0.100
Excess liquidity based R^i_t (long-term trend dynamics)	0.681	0.464	0.261	0.121	0.079
Residuals of the money demand cointegrating vector	0.686	0.494	0.255	0.123	0.097
Year-on-year nominal M3 growth	0.683	0.472	0.249	0.137	0.103
Quarterly nominal M3 growth	0.653	0.478	0.233	0.125	0.103
Year-on-year real M3 growth			0.248	0.121	0.081
Quarterly real M3 growth	0.655	0.475	0.248	0.128	0.104
Random Walk	1.472	0.962	0.382	0.317	0.345
Constant = 1.9%	0.661	0.427	0.206	0.148	0.128

Notes: Variance of the forecast error computed over the period 1999Q1 – 2009Q2. Based on bivariate forecasts of inflation using the Stock and Watson (1999) methodology. $VFE_k^M = \sum_{l=1}^{T} \left(\pi_{l+k} - \pi_{l+k}^M\right)^2 / T$, where $\pi_{h,l+k}^M$ represents the inflation forecasts generated by the various models.

Table 8
The adjustment coefficients.

	$\Delta(m_t - p_t)$	$\Delta(y_t)$	$\Delta(q_t^{US} - e_t^{US})$	$\Delta(q_t^{EA} - e_t^{EA})$	$\Delta(R_t^{EA})$	$\Delta(R_t^{US})$	$\Delta(i\_own_t^{EA})$
				Sample period 1980Q1-2009Q2			
CointEq1	**-0.036**	**-0.024**	**-1.034**	**-0.081**	**-0.008**	**0.037**	**0.002**
St err	(-0.017)	(-0.015)	(-0.249)	(-0.326)	(-0.013)	(-0.022)	(-0.005)
CointEq2	**-0.020**	**0.011**	**-0.257**	**-0.099**	**-0.008**	**0.015**	**-0.003**
St err	(-0.007)	(-0.006)	(-0.094)	(-0.124)	(-0.005)	(-0.009)	(-0.002)
CointEq3	**0.005**	**-0.004**	**0.094**	**0.021**	**0.003**	**-0.005**	**0.001**
St err	(-0.002)	(-0.002)	(-0.032)	(-0.042)	(-0.002)	(-0.003)	(-0.001)
				Sample period 1980Q1-2011Q3			
CointEq1	**-0.046**	**-0.014**	**-0.710**	**-0.123**	**-0.002**	**0.017**	**0.001**
St err	(-0.013)	(-0.011)	(-0.198)	(-0.241)	(-0.01)	(-0.017)	(-0.004)
CointEq2	**-0.025**	**0.016**	**-0.215**	**-0.171**	**-0.004**	**0.013**	**-0.002**
St err	(-0.007)	(-0.006)	(-0.102)	(-0.124)	(-0.005)	(-0.009)	(-0.002)
CointEq3	**0.010**	**-0.006**	**0.060**	**0.079**	**0.001**	**-0.006**	**0.001**
St err	(-0.003)	(-0.002)	(-0.039)	(-0.047)	(-0.002)	(-0.003)	(-0.001)

CointEq1 (residuals of euro area money demand equation before the sovereign debt crisis):
$m_t - p_t - \beta_{10} - 1.92 y_t - 0.45(q_t^{EA} - e_t^{EA}) + 0.45(q_t^{US} - e_t^{US}) - 1.56 R_t^{EA} + 1.56 R_t^{US}$.
CointEq1 (residuals of euro area money demand equation after the sovereign debt crisis):
$m_t - p_t - \beta_{10} - 2.00 y_t - 0.53(q_t^{EA} - e_t^{EA}) + 0.53(q_t^{US} - e_t^{US}) - 1.36 R_t^{EA} + 1.36 R_t^{US}$.
CointEq2 (residuals of US asset price equilibrium before the sovereign debt crisis):
$(q_t^{US} - e_t^{US}) - \beta_{30} + 28.37 R_t^{US}$.
CointEq2 (residuals of US asset price equilibrium after the sovereign debt crisis):
$(q_t^{US} - e_t^{US}) - \beta_{30} + 18.38 R_t^{US}$.
CointEq3 (residuals of EA asset price equilibrium before the sovereign debt crisis):
$(q_t^{EA} - e_t^{EA}) - \beta_{20} + 20.52 R_t^{EA} - 17.91 i_t^{OWN\_EA}$.
CointEq3 (residuals of EA asset price equilibrium after the sovereign debt crisis):
$(q_t^{EA} - e_t^{EA}) - \beta_{20} + 16.62 R_t^{EA} - 15.13 i_t^{OWN\_EA}$.

Table 9

Out-of-sample euro area inflation forecast with excess liquidity measures: MSFE (1999Q1-2011Q3)

	horizon				
	4	6	8	10	12
	HICP inflation				
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.866**	**0.838**	**0.794**	**0.773**	**0.824**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**0.923**	**0.951**	**0.913**	**0.916**	**0.909**
Excess liquidity based on L^i_t (long-term trend dynamics)	**0.926**	**0.967**	**0.965**	**0.870**	**0.842**
Random Walk	2.060	2.196	1.651	1.809	2.264
Constant = 1.9%	0.896	0.871	0.791	0.747	0.769
	HICP inflation exc. food and energy				
Excess liquidity based on L^i_t (short-term trend dynamics)	**0.887**	**0.729**	**0.661**	**0.651**	**0.690**
Excess liquidity based on L^i_t (medium-term trend dynamics)	**0.845**	**0.840**	**0.881**	**0.873**	**0.825**
Excess liquidity based on L^i_t (long-term trend dynamics)	**0.854**	**0.698**	**0.698**	**0.727**	**0.719**
Random Walk	1.451	1.600	1.713	2.056	2.641
Constant = 1.9%	1.878	1.628	1.444	1.382	1.355

Notes: MSFE computed over the period 1999Q1- 2011Q3. Based on bivariate forecasts of inflation using the Stock and Watson (1999) methodology. $MSFE^M = (1/T)\sum_{t=1}^{T}(\pi_{h,l+k} - \pi^M_{h,l+k})^2$ =*mean squared forecast errors*, where $\pi^M_{h,l+k}$ represents the inflation forecasts generated by the various models. The table shows the MSFE relative to the autoregressive benchmark.