FIW – Working Paper

FIW Working Paper N° 119
April 2013

Money demand and the role of monetary indicators in forecasting euro area inflation

Christian Dreger[1] and Jürgen Wolters[2]

Abstract

This paper examines the stability of money demand and the forecasting performance of a broad monetary aggregate (M3) in predicting euro area inflation. Excess liquidity is measured as the difference between the actual money stock and its fundamental value, the latter determined by a money demand function. The out-of sample forecasting performance is compared to widely used alternatives, such as the term structure of interest rates. The results indicate that the evolution of M3 is still in line with money demand even in the period of the financial and economic crisis. Monetary indi-cators are useful to predict inflation, if the forecasting equations are based on measures of excess liquidity.

JEL: C22, C52, E41
Keywords: Money demand, excess liquidity, inflation forecasts

Authors

[1] German Institute for Economic Research (DIW Berlin), Mohrenstr. 58, D-10117 Berlin, cdreger@diw.de
[2] Freie Universität Berlin, Boltzmannstr. 20, D-14195 Berlin, juergen.wolters@fu-berlin.de

Money demand and the role of monetary indicators in forecasting euro area inflation

Christian Dreger and Jürgen Wolters[1]

Abstract: This paper examines the stability of money demand and the forecasting performance of a broad monetary aggregate (M3) in predicting euro area inflation. Excess liquidity is measured as the difference between the actual money stock and its fundamental value, the latter determined by a money demand function. The out-of sample forecasting performance is compared to widely used alternatives, such as the term structure of interest rates. The results indicate that the evolution of M3 is still in line with money demand even in the period of the financial and economic crisis. Monetary indicators are useful to predict inflation, if the forecasting equations are based on measures of excess liquidity.

Keywords: Money demand, excess liquidity, inflation forecasts

JEL Classification: C22, C52, E41

---

[1] Dreger: German Institute for Economic Research (DIW Berlin), Mohrenstr. 58, D-10117 Berlin, cdreger@diw.de, Wolters: Freie Universität Berlin, Boltzmannstr. 20, D-14195 Berlin, juergen.wolters@fu-berlin.de. An earlier version of the paper has been presented at Ghent University, June 2012. We would like to thank the participants of the workshop for helpful comments and suggestions.

1 Introduction

Achieving and maintaining the stability of the price level is a main goal for central banks all over the world. Especially in the medium and long run, inflation is inherently a monetary phenomenon. Therefore, the ECB regularly observes the evolution of money stocks in the so called Quarterly Monetary Assessment (Fischer, Lenza, Pill and Reichlin, 2009).

However, while money balances increased and nominal interest rates decreased in the period before the financial crisis, inflation did not accelerate at all. This has led some analysts to conclude that money growth might not be well-suited neither for predicting future inflation prospects nor for supporting policy decisions. To contribute to the debate, this paper investigates how strongly money and inflation are related and how good is the forecasting power of monetary indicators with respect to consumer price inflation by taking the period of the financial and economic crisis into account.

Monetary growth does not indicate future inflation per se. For that reason, money demand is crucial for monitoring the inflation process, at least as a long run reference (ECB, 2004). The money demand function links the monetary development to its fundamental determinants, such as real income and the opportunity costs of holding money. By comparing the actual money stock with the long run equilibrium according to money demand, measures of excess liquidity can be derived and might be used to forecast inflation (Dreger and Wolters, 2010b).

Excess liquidity measures are based on the assumption of a stable money demand function. However, recent evidence has cast serious doubts on the robustness of money demand, especially if data after the introduction of the euro as the common currency are used. See for example Gerlach (2004) and Carstensen (2006). However, as Dreger and Wolters (2010a and 2010b) have demonstrated, the instability problem can be resolved by an appropriate specification of the opportunity costs. An almost stable money demand function for M3 is obtained if inflation is included. There is still a minor permanent shift in the income elasticity from 2002 onwards indicating the higher relevance of wealth effects since then, see Fase and Winder (1998), Greiber and Setzer (2007), Beyer (2009) and Dreger and Wolters (2009). However, little is known when the most recent development is taken into account. As an exception, Beyer (2009) has reported evidence for a stable money demand function for M3 using preliminary data to the end of 2008. As in Dreger and Wolters (2010a, 2010b, 2011), the inclusion of inflation is decisive to achieve this result.

The first contribution of the paper is to examine whether money demand has remained stable over an extended period covering the financial and economic crisis. As a main finding, the demand for real money balances appears to be robust, if real house prices are included as a proxy of wealth. The parameters of the long run money demand function show only minor variation over time. The second contribution is to explore the forecasting properties of M3 indicators with respect to HICP inflation over the recent period. The importance of money growth and/or excess money measures for inflation has been discussed in various papers. Gerlach and Svensson (2003) found that both the output gap and the real money gap, i.e. the difference between the actual real M3 money stock and its equilibrium value derived from a long run money demand relation contains useful information with respect to one- and two-year ahead HICP inflation rates. In contrast, the nominal M3 annual growth rate provides no information regarding future inflation. Trecroci and Vega (2002) reported similar results for GDP inflation. Following

Nicoletti-Altimari (2001) the real M3 gap (overhang) is an important complement to monetary aggregates if inflation is predicted for a two year-period. Kaufmann and Kugler (2008) detected a robust cointegration relationship between money growth and inflation. Shocks in M3 growth account for a substantial part of the inflation forecast error variance. The effects of output gap and interest rate shocks on inflation are transitory and their forecasting variance shares seems to be negligible at the medium term horizons. Carstensen, Hagen, Hossfeld and Neaves (2009) reported evidence that an aggregated monetary overhang can predict country-specific inflation in the four largest euro area countries, but it does not encompass measures of the country-specific monetary overhang. According to Amisano and Fagan (2010), broad money growth corrected for trend velocity and potential output growth is a leading indicator for switches between inflation regimes.

While most of the papers are based on data ending at the very beginning of the ECB period, our analysis produces inflation forecasts for the period from 2003Q4 to 2010Q4, thus including the period of the financial and economic crisis. This period is chosen as the ECB changed its policy strategy in 2003 giving less weight to the monetary pillar. Due to the apparent success of monetary policy in stabilising inflation, the predictive power of monetary aggregates might have declined. The findings of Amisano and Fagan (2010) suggest that the inflation risk has fallen over the past years. Due to unconventional monetary measures, however, inflation could shift from the current benign regime of price stability to a higher inflation regime (Peersman, 2011). Our results indicate that models based on excess liquidity outperform the benchmark as well as money growth. At the longer forecasting horizons, standard alternatives such as the term structure of interest rates are also outperformed.

The rest of the paper is organized as follows. Section 2 reviews the specification of the money demand function. In section 3 the time series used in the analysis are discussed. The specification and estimation of money demand functions in error correction form has been the customary approach to capture the nonstationary behavior of the relevant data. A system cointegration analysis and conditional error correction models are provided in section 4. The forecasting exercise is performed in section 5. Finally, section 6 concludes.

2 Specification of money demand

A widely used specification of money demand is chosen as the starting point of the analysis, see Ericsson (1998) and Beyer (2009). This specification of money demand leads to a long run relationship of the form

(1) $$(m-p)_t = \delta_0 + \delta_1 y_t + \delta_2 w_t + \delta_3 R_t + \delta_4 r_t + \delta_5 \pi_t$$

where m denotes nominal money balances taken in logs, p is the log of the price level, y is log of real income, representing the transaction volume in the economy, and w is log of real financial wealth. Opportunity costs of holding money are proxied by nominal long (R) and short (r) term interest rates and the annualized inflation rate, i.e. $\pi=4\Delta p$, in case of quarterly data. The index t denotes time.

Price homogeneity is imposed as a long-run restriction to map the money demand analysis into a system of I(1) variables; see Holtemöller (2004). The income variable exerts a positive effect on nominal and real money balances. Often, its impact is restricted to unity on theoretical grounds, see Dreger and Wolters (2009) for a discussion. Money holdings are also related to portfolio allocation decisions. For example, a surge in asset prices may trigger a rise in demand for liquidity due to an increase in net household wealth. While the scale effect points to a positive impact of wealth, the substitution effect works in the opposite direction, as higher asset prices make assets more attractive relative to money holdings. If the opportunity costs of money holdings refer to earnings on alternative financial assets, relative to the own yield of money balances, their coefficients should enter with a negative sign. For the inclusion of the inflation rate see also Dreger and Wolters (2010a). The inflation rate is part of the opportunity costs as it represents the costs of holding money in preference to holding real assets. Its inclusion provides a convenient way to generalize the short run homogeneity restriction imposed between money and prices. Also, adjustment processes in nominal or real terms can be distinguished (Hwang, 1985).

The parameters $\delta_1>0$and δ_2 denote the elasticities of money demand with respect to the scale variables, income and wealth. The impact of the return of other financial assets and inflation is captured by the semielasticities $\delta_3<0$, δ_4 and δ_5, respectively. The parameter δ_4 should be positive when r is mainly a proxy for the own rate of interest of holding money balances, but negative otherwise. Due to the ambuigity in the interpretation of the wealth and inflation variables, the signs of their impact cannot be specified a priori on theoretical grounds.

3 Data and preliminary analysis

Since the introduction of the euro in 1999, the ECB is responsible for the monetary policy in the euro area. As the time series under the new institutional framework are too short to draw robust conclusions, they have to be extented by artificial data. Euro area series prior to 1999 are obtained by aggregating national time series (Artis and Beyer 2004). By comparing aggregation methods, Bosker (2006) and Beyer and Juselius (2010) have stressed that differences are substantial prior to 1983, especially for interest rates and inflation. But they are almost negligible from 1983 onwards. In addition, the European Monetary System started working in 1983 and financial markets have become more integrated since then. See Juselius (1998) for evidence on a change in the monetary transmission mechanism in European countries in March 1983. Thus, 1983Q1-2010Q4 is chosen as the observation period. To cover initial values, the data set already starts in 1981Q1. Quarterly seasonally adjusted series are used.

-Figures 1 and 2 about here-

Nominal money balances for M3 are taken from the ECB monthly bulletin database and quarterly data refer to end-of-period values[2]. The short and long term interest rates *r* and *R* come also from this source and are defined by the end-of-period 3-month Euribor and ten-year government bond rates, respectively. Nominal and real GDP, as a proxy for income, are taken from Eurostat, the latter defined as chain-linked volumes with 2000 as the reference year. The GDP deflator (2000=1) is constructed as the ratio of nominal to real GDP. The GDP data are available since 1991, first quarter. For periods prior to 1991, the Brand and Cassola (2004) data have been used, as these data yield stable and economically interpretable results. To derive real money balances, nominal money

[2] Data refer to the actual composition of the euro area. Up to 2006, 12 countries formed the euro area. In the enlargement process afterwards, several countries have joined the monetary union, but received a very small weight in the aggregate.

stocks are deflated with the GDP deflator. Real financial wealth is approximated by nominal house prices deflated by the GDP deflator, as recommended by Setzer, Van Den Noord and Wolff (2011). The nominal series is taken from the Bank of International Settlement (Borio and Lowe, 2002). Quarterly interpolated data has been taken from the NiGEM model (National Institute for Economic and Social Research, 2011). HICP inflation is obtained from the ECB monthly bulletin, as this measure is relevant for central banks to monitor inflation. The evolution of real money balances, real income and real house prices is shown in Figure 1. Figure 2 displays the development of nominal interest rates and inflation measures.

-Figure 3 about here-

Outliers are detected in the real money balances. The first one (1990Q2) is due to the German unification, while the other one (2001Q1) reflects the stock market turbulences in the aftermath of the new economy bubble (Kontolemis, 2002). Moreover, a permanent break in 2002.1 is apparent in the income elasticity (Figure 3), and shifts are visible during the crisis period. Despite monetary developments have been largely favourable, massive production losses occured. In the analysis, outliers are captured by two impulse dummies, which are equal to 1 in the respective period and 0 otherwise ($d902$ and $d011$). In line with Dreger and Wolters (2009), the shift in the income elasticity is modelled by the inclusion of real house prices (w^*), defined as the product of w and a step dummy s021, which is equal to 1 from 2002.1 onwards.

4 Cointegration analysis and error correction models

Since the variables entering the money demand function are nonstationary, the appropriate empirical design is based on a cointegration analysis, where several cointegration vectors might exist. Therefore, the starting point is a vectorautoregressive (VAR) model in levels which is equivalently rewritten as a vector error correction model

$$(2) \qquad \Delta \boldsymbol{Y}_t = \boldsymbol{\alpha\beta}'\boldsymbol{Y}_{t-1} + \sum_{j=1}^{p-1} \boldsymbol{\Gamma}_j \Delta \boldsymbol{Y}_{t-j} + \boldsymbol{D}_t + \boldsymbol{\varepsilon}_t$$

where $\boldsymbol{\alpha}$ denotes the matrix of feedback parameters, $\boldsymbol{\beta}$ the matrix of the cointegrating relations and $\boldsymbol{D}_t$ the deterministic terms. The cointegration properties of different sets of variables are explored by the Johansen (1995) trace test. The lag length p of the VAR in levels is determined by the Akaike criterion and equal to two throughout the analysis. As the sample period is not very large both the standard trace test (Johansen 1995) and the small sample Bartlett corrected trace statistics (Johansen, 2000) are presented. An unrestricted constant and a linear time trend restricted to the cointegrating space allow for possible changes in the long run relations over the sample period.

-Table 1 about here-

The basic specification comprises real money balances, real income and the inflation rate, as in Dreger and Wolters (2010a). These variables are cointegrated, with a cointegrating rank equal to one, see Table 1. Although the cointegration property can be established even in this small system, the long run parameters are not very convincing, according to economic theory. Because of the break in the income elasticity from 2002Q1 onwards, they are quite unstable.

Thus, the system is enlarged by the w^* variable to account for the presence of wealth effects in money demand. In the extended specification, the cointegration rank rises by one, i.e. it is equal to two. To estimate the long run parameters with higher precision, the model can be further enlarged by the term structure of interest rates. The term structure can be interpreted as the net opportunity costs of holding money; i.e. the interest rate adjusted for the own rate of money holdings. In this case, the short rate approximates the own rate for M3. According to the trace test, its inclusion leads to a higher cointegration rank, but the result is less significant with the Bartlett corrected version. This additional cointegrating relationship may exist due to the stationarity of the term structure. Thus, the following analysis is based on the more interesting case of two non-trivial long run vectors.

-Table 2 about here-

Further analysis reveals that the system can be restricted to a money demand and an inflation equation, see Dreger and Wolters (2011) for the details. The restricted cointegration vectors and corresponding feedback mechanisms are exhibited in Table 2. The identifying null hypothesis for the long run relations cannot be rejected with a *p*-value of 0.175. The variables in the money demand function bear the theoretically expected signs, and the long run coefficients are plausible. For housing wealth, the scale effect dominates the substitution effect. The linear time trend in the inflation equation accounts for the secular decline of inflation, but it might be also interpreted as a rough indicator of potential output. In that case, inflation would depend on detrended output and real house prices. Thus, monetary policy should closely monitor the price evolution in asset markets, as it could have implications on the overall price development. The fact that real money balances can be excluded from a restricted inflation equation does not imply that money is irrelevant for inflation. Both real money balances and the inflation rate respond significantly to deviations from the two long run relationships, and the adjustment coefficients are well signed. In contrast, real income, real house prices and the term structure of interest rates do not adjust to equilibrium errors. The joint null hypothesis of weak exogeneity of these variables cannot be rejected with a *p*-value of 0.186.

-Table 3 about here-

From the perspective of policymakers, a single equation model is easier to handle than the bivariate system. Thus, the system is expressed as a conditional error correction model for money demand, where inflation enters as an endogeneous regressor (Johansen, 1995) [3]. The single equation is estimated in one step, where the long run parameters are obtained jointly with the short run dynamics (Stock, 1987). Initially, the contemporaneous and the first four lags of the changes of all variables, a constant and the two impulse dummies are included in addition to the one period lagged levels of the varia-

[3] Since inflation is endogeneous, we also estimated the conditional money demand equation using the instrumental variable approach with the first five lags of the short and long term interest rates as instruments for inflation. The estimated coefficients and test statistics are very similar and available from the autors upon request.

bles embedded in the money demand function. Then, the variables with the lowest and insignificant *t*-values are eliminated subsequently, where a 0.1 level is used. The final equations is exhibited in Table 3.

-Figures 3, 4 and 5 about here-

The cointegration vector for money demand is very similar to its counterpart obtained by the system approach, implying that the long run deviations show the same pattern (Figure 3). In fact, the correlation between the two series is 0.96. Furthermore, the residuals are well behaved, as they are normal, homoscedastic and do not show autocorrelation. Tests on the functional form do not display any problems. One step ahead forecast and Cusums of Squares tests do not indicate any problems with structural breaks (Figure 4). For example, from 102 recursive residuals, only 3 are outside of the 0.95 confidence band. All three occur before the ECB became in operation. Instability is not an issue at all at the end of the sample. This is also confirmed by a series of Chow forecast tests (Table 3), and the recursively estimated coeffecients, see Figure 5. To sum up, the model remains sensible even in the period of the financial and economic crisis. Acccording to this evidence, the further analysis can be safely conducted within the single equation approach.

5 Inflation forecasts

The evolution of monetary aggregates provides information on future inflation pressures if they can improve inflation forecasts. The policy debate is dominated by inflation of consumer prices, which is more important than the change in the GDP deflator. Forecast horizons of 1, 2 and 3 years are the most relevant targets for performing monetary policy. The different inflation rates are defined as follows:

$$(2) \qquad \pi^k_{c,t} = \frac{4}{k}\log(pc_t / pc_{t-k}) \quad , \quad k = 4,8,12.$$

In the out-of sample forecast experiment, the annual change of the consumer price index (*pc*), *k*=4 is used, as well as average cumulative inflation rates over the two and three years horizon (*k*=8, 12). They are also relevant for monetary authorities, as they reveal information on the inflation potential over the medium and long run. Temporary changes in high volatile prices are removed if these measures are selected. To mimic the actual forecasting situation a direct approach

$$(3) \qquad \pi^k_{c,t+k} = \alpha(L)\pi^1_{c,t} + \beta x_t + u_{t+k} \quad , \quad k = 4,8,12$$

is preferred, where $\alpha(L)$ is a lag polynomial, ensuring that the equations are balanced. Future inflation for *k*=4, 8 or 12 quarters ahead is predicted by including only current and lagged quarterly inflation up to order 3 and additional variables known at the time the forecast is made (*x*). Lagged values of *x* do not contribute significantly in the forecasting equation and have been excluded. Since the forecast error *u* follows a moving average process of order *k*-1, the autocorrelation and heteroscedasticity consistent covariance estimator proposed by Newey and West (1987) is used to evaluate the significance of the regression parameters.

To constitute a benchmark, future inflation is predicted by current and lagged inflation. Alternative models arise adding one further variable to the benchmark. Different variables are explored. While the first alternative is based on annual M3 growth, the second one includes the error correction term at period *t*, i.e. excess liquidity. This accounts for the fact that money is not an indicator for inflation per se. Instead excess liquidity matters. The term structure of interest rates serves as a further competitor, see e.g. Fama (1990), Mishkin (1990).

The forecasting performance is evaluated in an out-of-sample exercise. This mimics the actual situation the forecaster is confronted with. A real time analysis is not performed due to data availability and since revisions in monetary aggregates and interest rates are usually small. Due to the stability of the long run money demand equation, differences in error correction terms between the full sample and corresponding subsamples can be neglected.

In particular, the forecasts are obtained in a recursive manner. The first estimation subsample is 1983Q1-2002Q4 and the forecast subsample is 2003Q4-2010Q4 in case of annual inflation rates. After producing the forecast for 2003Q4, the estimation period is extended by one quarter (1983Q1-2003Q1) and the forecast for 2004Q1 is made. This process is repeated until the end of the sample is reached (2010Q4). For the multiyear forecasting horizons, the first estimation subsample is again 1983Q1-2002Q4. Overall, 29 annual, 25 biennial and 21 triennial forecasts are derived.

The forecast accuracy is evaluated by the root mean square forecast error, expressed relative to the benchmark model (Table 4). For robustness, the relative mean absolute forecast error is also considered. Ratios below (above) unity indicate an improvement (worsening) relative to the autoregressive process. To assess the significance of the difference, the *p*-values from the Diebold-Mariano (1995) test are reported. This test is applied in a one sided version, i.e. it explores the null hypothesis that competing forecasting models have equal predictive accuracy against the alternative that a particular method significantly outperforms the benchmark. Simulation results indicate that the Diebold-Mariano test statistic can be compared to critical values from the standard normal distribution, as long as forecasts are generated under rolling or recursive schemes (Giacomini and White, 2006). The Diebold-Mariano test is employed using the small-sample correction, as suggested by Harvey, Leybourne, and Newbold (1997). Furthermore, encompassing tests proposed by Harvey, Leybourne, and Newbold (1998) are carried out (Table 5). Eventually, the predictive accuracy can be improved by combining individual forecasting methods. Encompassing tests examine whether the information of one method is already embedded in a rival forecast, i.e. whether it can be excluded from the forecast combination.

-Tables 4 and 5 about here-

The average root mean square forecast error exceeds the mean absolute forecast error due to possible outliers. In general, the average forecast errors decline with the forecast horizon, as idiosyncratic shocks are smoothed out at the longer intervals. The predictive accuracy can be improved for all forecast horizons if the forecasting equation is extended by excess liquidity or the term structure. This means that fundamental information becomes more important. For example, the respective equation leads to a root mean square forecast error which is 30 percent below the one of the benchmark at the 3-year horizon. According to the Diebold-Mariano test, the gains are often significant, at least at the 0.1 level. In contrast, the forecasting performance for longer horizons worsens, if M3 growth is considered as the additional variable. It should be also noted, that the excess liquidity model consistently outperforms money growth as well as the term structure at all forecasting horizons. Nonetheless, the gains are not significant in case of the term structure.

According to the outcome of the encompassing tests, pooled forecasts might be useful to predict inflation. However, the components of the combined forecasts should be based on excess liquidity and the term structure of interest rates. Money growth can be excluded from the final forecasting equation, as it adds no further information, especially if excess liquidity is included. Especially at the longer horizons, excess liquidity measures can significantly improve the predictions resulting from the term structure of interest rates.

6 Conclusions

This paper investigates the forecasting performance of a broad monetary aggregate in predicting euro area HICP inflation by using nominal M3 growth as well as excess liquidity. The latter is the difference between the actual money stock and its fundamental value, derived from a long run money demand function. Their out-of sample forecasting performance is compared to a widely used alternative, the term structure of interest rates.

The results indicate that the evolution of M3 is still in line with the estimated money demand function even in the period of the financial and economic crisis, especially if real house prices are included as a proxy for financial wealth. The long run parameters appear to be very stable, and the error correction model passes all standard specification tests. Compared to the benchmark of an autoregressive process for inflation a payoff can be realized if additional variables are used as predictors, except of money growth. Both the excess liquidity and the term structure model can beat the benchmark, although the gains are often not significant at the conventional levels. But the results underpin the usefulness of monetary variables to predict inflation.

Despite the massive increase in the monetary base over the financial crisis period, the money stock did not show any noticeable increase. As the interbank market did not allow for a redistribution of liquidity between banks, central banks had to design unconventional measures (Freixas, 2009). While the interventions have been rather successful in avoiding a sudden meltdown of the financial system, many analysts have argued that these policies have laid the foundation to destabilise inflation expectations and generate future inflation pressures. If financial intermediation returns to normality, the precautionary demand for liquidity may decline, implying that the huge accumulation of reserve balances could result in a rapid increase in the money stock and excess liquidity. According to our forecasting results, this fact bears the danger of increasing inflation in it.

References

Amisano G, Fagan G (2010): Money growth and inflation. A regime switching approach, ECB Working Paper 1207.

Artis M, Beyer A (2004): Issues in money demand. The case of Europe. Journal of Common Market Studies 42, 717–736.

Beyer A (2009): A stable model for euro area money demand. Revisiting the role of wealth, ECB Working Paper 1111, European Central Bank.

Beyer A, Juselius K (2010): Does it matter how aggregates are measured? The case of monetary transmission mechanisms in the euro area, ECB Working Paper 1149, European Central Bank.

Borio C, Lowe P (2002): Asset prices, financial and monetary stability: Exploring the nexus, BIS Working Paper 114.

Bosker EM (2006): On the aggregation of eurozone data. Economics Letters, 90, 260–265.

Brand C, Cassola (2004): A money demand system for euro area M3. Applied Economics 8, 817–838.

Carstensen K (2006): Stock market downswing and the stability of European Monetary Union money demand. Journal of Business and Economic Statistics 24, 395–402.

Carstensen K, Hagen J, Hossfeld O, Neaves, AS (2009): Money demand stability and inflation prediction in the four largest EMU countries, Scottish Journal of Political Economy 56, 73-93.

Diebold FX, Mariano RS (1995): Comparing predictive accuracy, Journal of Business and Economic Statistics 13, 253-263.

Dreger C, Wolters J (2009): M3 velocity and asset prices in the euro area, Empirica 36, 51-63.

Dreger C, Wolters J (2010a): Investigating M3 money demand in the euro area, Journal of International Money and Finance 29, 111-122.

Dreger C, Wolters J (2010b): M3 money demand and excess liquidity in the euro area, Public Choice 144, 459-472.

Dreger C, Wolters J (2011): Money and inflation in the euro area during the financial crisis, DIW Discussion Paper 1131.

Ericsson NR (1998): Empirical modelling of money demand. Empirical Economics, 23, 295–315. Reprinted in Lütkepohl H, Wolters J (eds): Money demand in Europe, Physica 1999, 29-49.

European Central Bank (2004): The monetary policy of the ECB. ECB 2nd ed.

Fama E (1990): Term structure forecasts of interest rates, inflation and real returns, Journal of Monetary Economics 25, 59-76.

Fase MMG, Winder CCA (1998): Wealth and the demand for money in the European Union. Empirical Economics, 23, 507–524. Reprinted in Lütkepohl H, Wolters J (eds): Money demand in Europe, Physica 1999, 241-58.

Fischer B, Lenza M, Pill H Reichlin L (2009): Monetary analysis and monetary policy in the euro area, 1999-2006, Journal of International Money and Finance 28, 1138-1164.

Freixas X (2009): Monetary policy in a systemic crisis, Oxford Review of Economic Policy 25, 630-653.

Gerlach S (2004): The two pillars of the European Central Bank. Economic Policy 19, 389–439.

Gerlach S, Svensson LOE (2003): Money and Inflation in the euro area: A case for monetary indicators? Journal of Monetary Economics 50, 1649–1672.

Giacomini R, White H (2006): Tests of conditional predictive ability, Econometrica 74, 1545-1578.

Greiber C, Setzer R (2007): Money and housing: Evidence for the euro area and the US. Deutsche Bundesbank, Research Center, Discussion Paper Series 1, Economic Studies 2007-12.

Harvey D, Leybourne S, Newbold P (1997): Testing the equality of prediction mean squared errors, International Journal of Forecasting 13, 281-291.

Harvey D, Leybourne S, Newbold P (1998): Tests for forecast encompassing. Journal of Business & Economic Statistics 16, 254-259.

Holtemöller O (2004): A monetary vector error correction model of the euro area and implications for monetary policy. Empirical Economics 29, 553–574.

Hwang, H.-S. (1985): Test of the adjustment process and linear homogeneity in a stock adjustment model of money demand, Review of Economics and Statistics 67, 689-692.

Johansen S (1995): Likelihood based inference in cointegrated vector autoregressive models. Oxford: Oxford University Press.

Johansen S (2000): A Bartlett correction factor for tests on the cointegrating relations. Econometric Theory 16, 740-778.

Juselius K (1998): Changing monetary transmission mechanisms within the EU. Empirical Economics 23, 455-481. Reprinted in Lütkepohl H, Wolters J (eds): Money demand in Europe, Physica 1999, 189-215.

Kaufmann S, Kugler P (2008): Does money matter for inflation in the euro area? Contemporary Economic Policy 26, 590-606.

Kontolemis, Z.G. (2002). Money demand in the euro area. Where do we stand?, IMF Working Paper WP 02/185.

Mishkin FS (1990): What does the term structure tell us about future inflation? Journal of Monetary Economics 20, 77-95.

National Institute for Economic and Social Research (2011): The NiGEM model, http://www.niesr.ac.uk/pdf/nigem2.pdf.

Newey WK, West KD (1987): A simple positive definite heteroscedasticity and autocorrelation consistent covariance matrix, Econometrica 55, 703-708.

Nicoletti-Altimari S (2001): Does money lead inflation in the euro area? ECB Working Paper 63, European Central Bank.

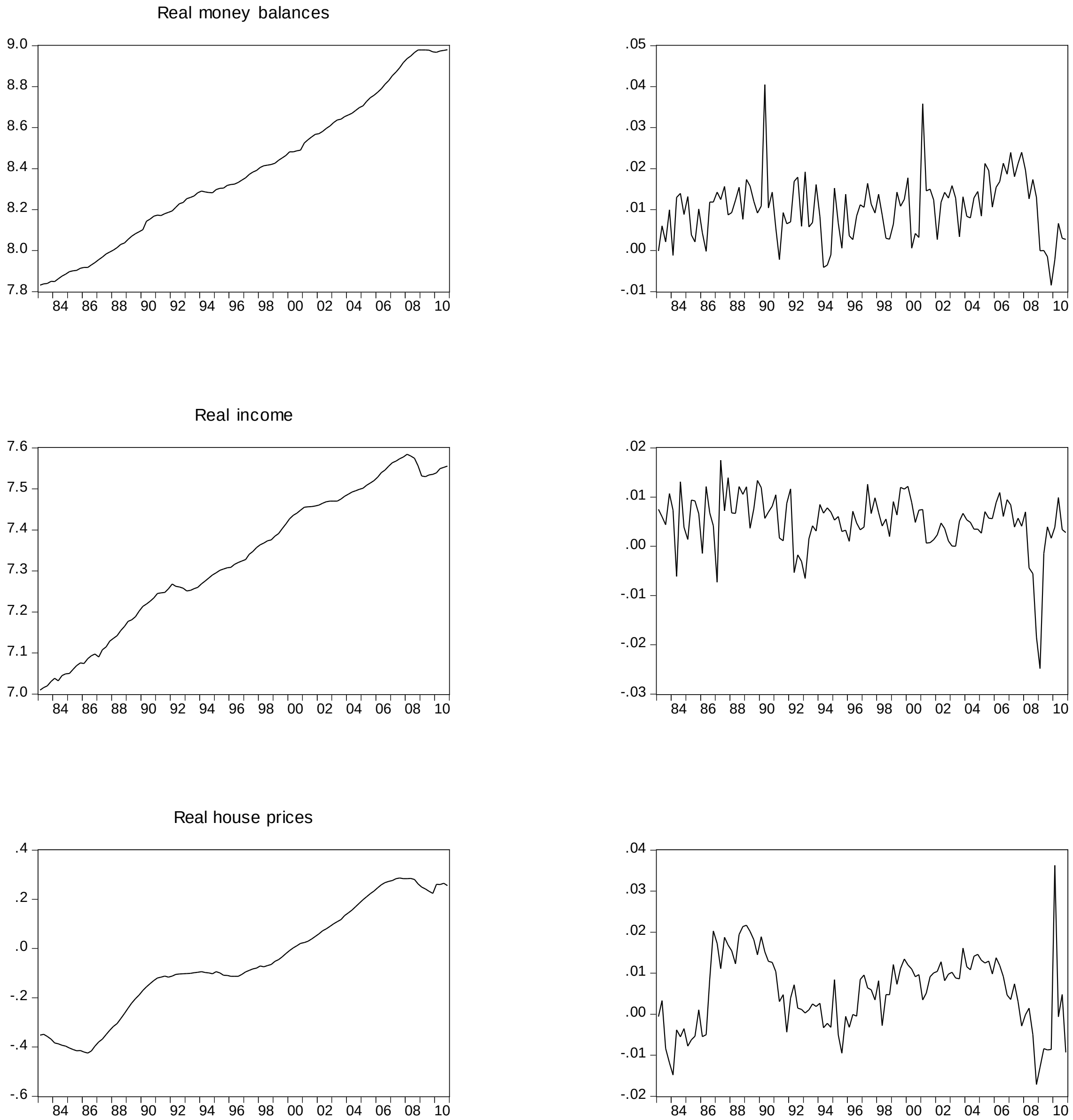
Peersman G (2011): Macroeconomic effects of unconventional monetary policy in the euro area, ECB Working Paper 1397.

Setzer R, Van Den Noord P, Wolff GB (2011): Heterogeneity in money holdings across euro area countries: The role of housing, European Journal of Political Economy, DOI 10.1016/j.ejpoleco.2011.04.003.

Stock JH (1987): Asymptotic properties of least-squares estimators of cointegrating vectors, Econometrica 55, 1035-1056.

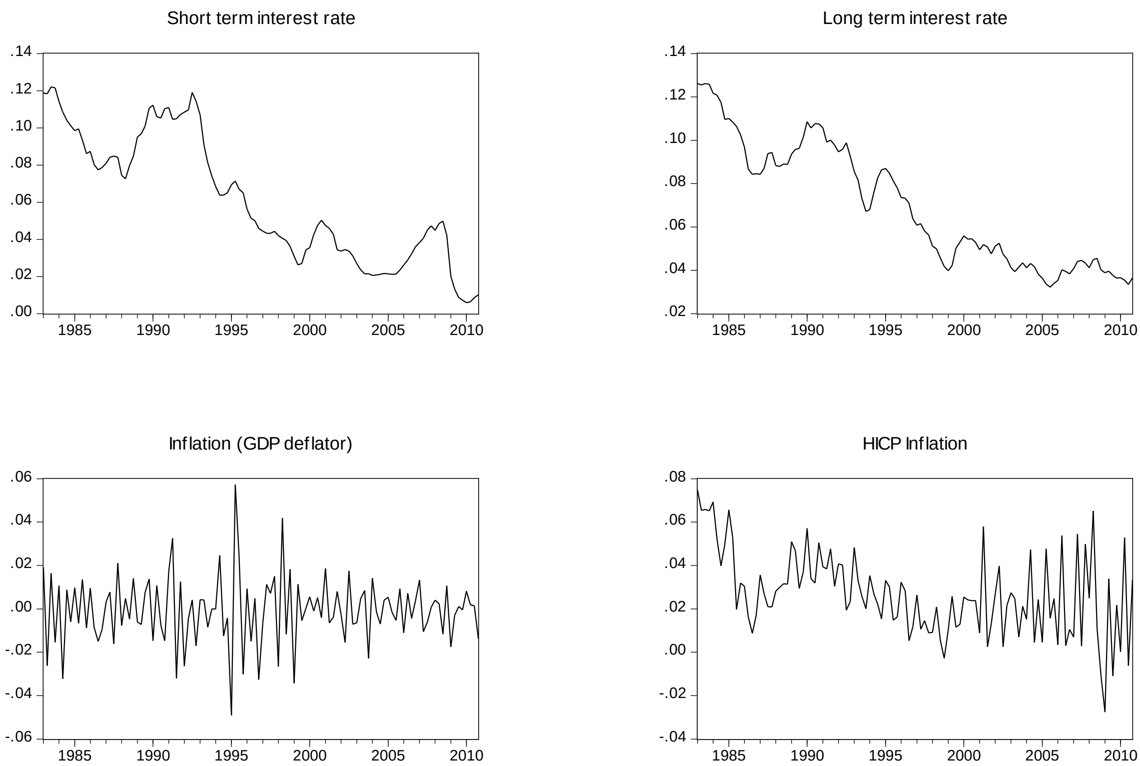
Trecroci C, Vega JL (2002): The information content of M3 for future inflation in the euro area, Weltwirtschaftliches Archiv 138, 22-53.

Figure 1: Money balances, income and housing prices



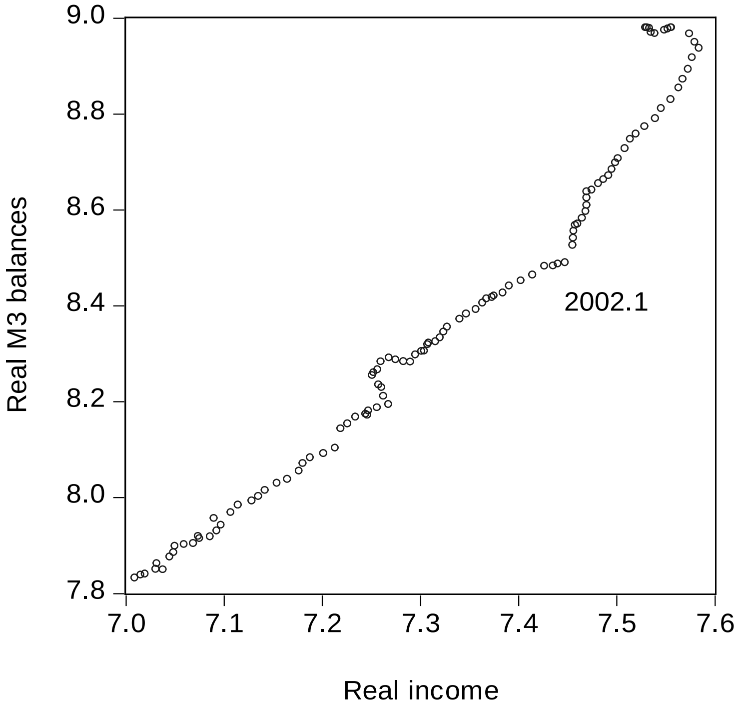
Note: Sample period 1983.1-2010.4. Variables in logs. Levels (left) and first differences (right scale).

Figure 2: Nominal interest rates and inflation



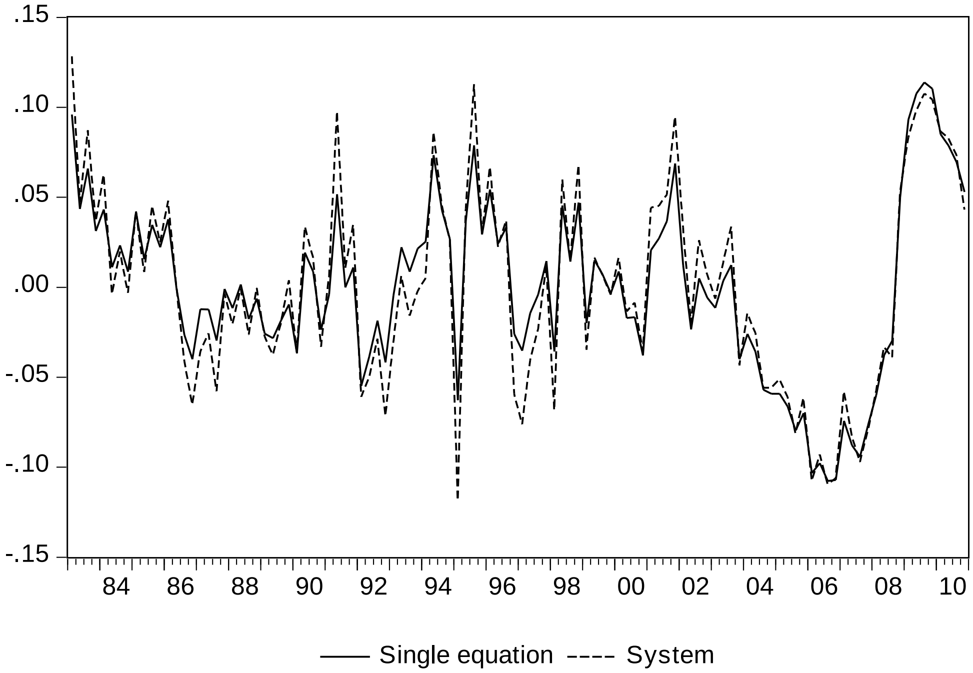
Note: Sample period 1983.1-2010.4. Inflation rates refer to the first differences of the GDP deflator (2000=1) and the HICP, respectively.

Figure 3 Structural break in the income elasticity



Note: Sample period 1983.1-2010.4.

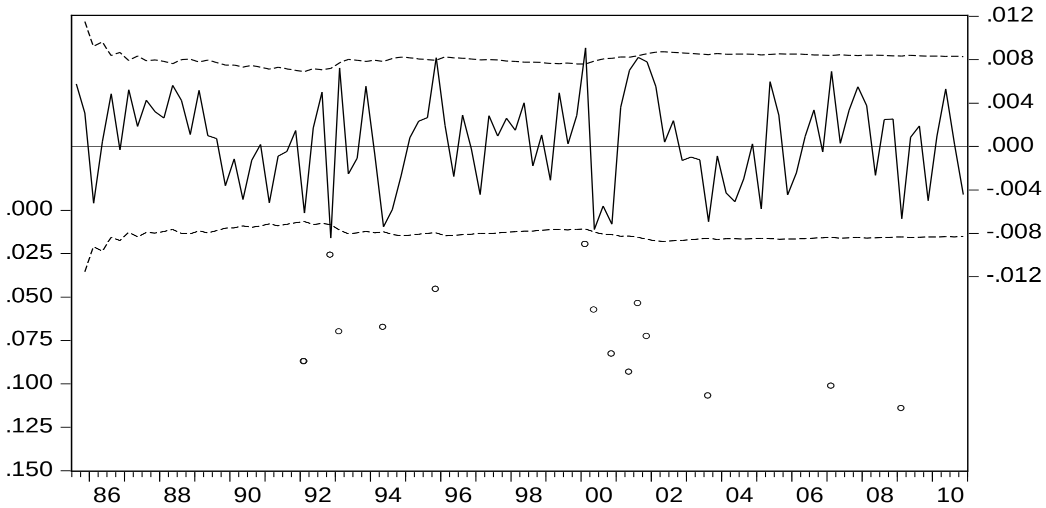
Figure 3 Excess liquidity measures



Note: Sample period 1983.1-2010.4. Error correction terms in the system and conditional single equation model.

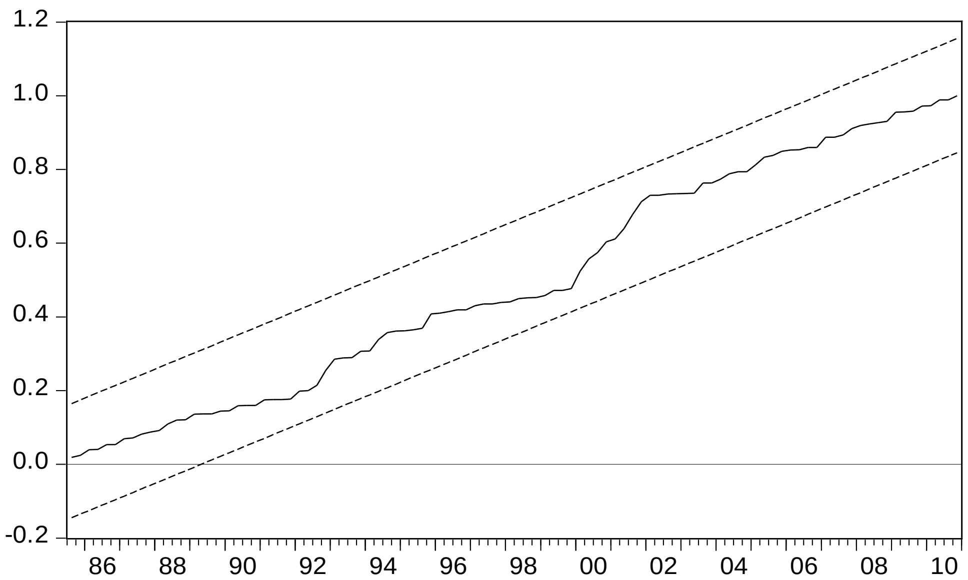
Figure 4 Parameter stability tests

A One step forecast test



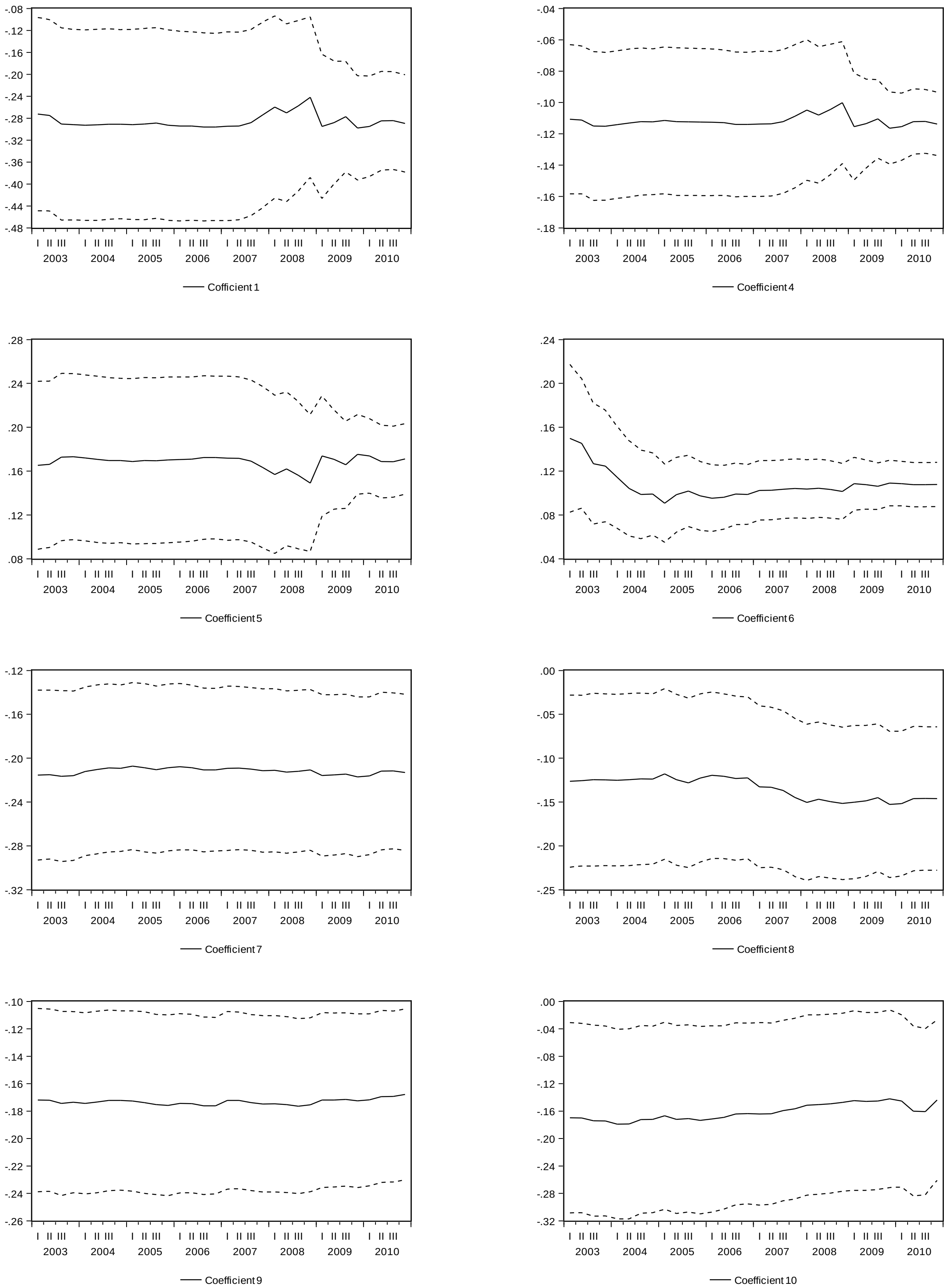
Upper part shows recursive residuals and two standard error bands (right axis). Lower part plots *p*-values for points where the hypothesis of parameter constancy is most likely rejected. Corresponding significance levels are shown on the left axis.

B Cusums of Squares test



Dashed lines represent 0.05 significance levels.

Figure 5 Recursive regression coefficients



Note: Ordering of coefficients according to conditional error correction model. Dotted lines represent 2-standard-error bands.

Table 1 Cointegration rank of subsets of variables

Variables	Rank null hypothesis	Trace test	Trace test (Bartlett correction)	Rank decision
m-p, y, π	0	44.53 (0.032)	42.02 (0.060)	1
	1	22.77 (0.116)	21.49 (0.161)	
	2	5.81 (0.496)	4.85 (0.624)	
m-p, y, w^*, π	0	106.21 (0.000)	98.00 (0.000)	2
	1	53.38 (0.003)	47.05 (0.017)	
	2	21.46 (0.163)	17.83 (0.363)	
	3	6.32 (0.432)	5.95 (0.477)	
m-p, y, w^*, π, rl-rs	0	136.40 (0.000)	123.86 (0.000)	2-3
	1	84.71 (0.000)	71.50 (0.009)	
	2	45.89 (0.023)	38.87 (0.120)	
	3	21.93 (0.144)	18.75 (0.302)	
	4	6.29 (0.435)	5.90 (0.484)	

Note: Sample period 1983Q1-2010Q4, p values in parantheses. All models include the impulse dummies d902 and d011, an unrestricted constant and a linear time trend which is restricted to the cointegration relationship. The lag order of the VAR in levels is determined by the Akaike criterion and equal to 2 throughout the analysis.

Table 2: Restricted feedback parameters and cointegrating vectors

	$\boldsymbol{\alpha}_1$	$\boldsymbol{\alpha}_2$
$\Delta(m\text{-}p)$	-0.158 (0.022)	0.403 (0.084)
$\Delta\pi$	0.225 (0.057)	-1.213 (0.217)

	$\boldsymbol{\beta}_1$	$\boldsymbol{\beta}_2$
m-p	1.000	0.000
y	-1.397 (0.053)	-0.339 (0.065)
*w**	-1.017 (0.075)	-0.178 (0.027)
π	2.982 (0.261)	1.000
rl-rs	1.694 (0.391)	0.000
trend	0.000	0.003 (0.001)

Note: Sample period 1983Q1-2010Q4. Feedback and cointegrating vectors in the bivariate error correction model for real money balances and inflation, treating real income, real house prices, and the term structure of interest rates and a linear time trend as exogenous. Standard errors in parantheses.

Table 3 Conditional error correction model

Dependent variable $\Delta(m\text{-}p)$

Con	$d902$	$d011$	$(m\text{-}p)_{t\text{-}1}$	$y_{t\text{-}1}$	$w^*_{t\text{-}1}$	$\pi_{t\text{-}1}$	$(R\text{-}r)_{t\text{-}1}$
-0.290 (6.531)	0.029 (6.924)	0.026 (6.047)	-0.114 (11.27)	0.171 (10.64)	0.108 (10.67)	-0.213 (5.984)	-0.146 (3.574)

$\Delta\pi_t$	$\Delta(m\text{-}p)_{t\text{-}4}$
-0.168 (5.387)	-0.144 (2.459)

Long run: $m - p = 1.504y + 0.947w^* - 1.873\pi_t - 1.285(R - r)$

R2=0.705, SE=0.004

JB=2.96 (0.23)	ARCH(1)=1.96 (0.16)	ARCH(2)=1.14 (0.32)	LM(1)=1.20 (0.28)
LM(2)=0.63 (0.54)	LM(4)=1.70 (0.16)	RESET(1)=0.40 (0.53)	RESET(2)=0.38 (0.68)
CF(03.1)=0.79 (0.76)	CF(04.1)=0.82 (0.72)	CF(05.1)=0.85 (0.67)	CF(06.1)=0.73 (0.79)
CF(07.1)=0.88 (0.60)	CF(08.1)=0.73 (0.72)	CF(09.1)=0.88 (0.54)	CF(10.1)=0.70 (0.59)

Note: Sample period 1983.1-2010.4. One-step estimation of the error correction model in the upper part, standard specification tests in the lower part of each subtable. R2=R squared adjusted, SE=standard error of regression, JB=Jarque-Bera test, LM(k)=Lagrange multiplier test for no autocorrelation in the residuals up to order k, ARCH(k)=LM test for conditional heteroscedasticity up to order k, RESET=Ramsey specification test, CF=Chow forecast test. Upper (lower) part: t-values (p-values) in parantheses.

Table 4 Out-of-sample forecasting performance of different models

A Root mean squared forecast error

Horizon	Benchmark	Money growth	Excess liquidity	Term structure
4	1.372	1.000 (0.500)	0.911 (0.067)	0.942 (0.037)
8	1.015	1.149 (0.763)	0.912 (0.071)	0.924 (0.003)
12	0.740	1.204 (0.710)	0.699 (0.056)	0.838 (0.002)

B Mean absolute forecast error

Horizon	Benchmark	Money growth	Excess liquidity	Term structure
4	1.018	0.950 (0.337)	0.843 (0.029)	0.911 (0.016)
8	0.760	1.069 (0.606)	0.873 (0.059)	0.911 (0.002)
12	0.638	1.054 (0.557)	0.617 (0.026)	0.807 (0.002)

Note: The root mean squared forecast error (RMSFE) and mean absolute forecast error (MAFE) are taken from the benchmark and expressed in percent. The three colums on the right report the RMSFE or MAFE relative to that of the benchmark. The *p*-values of the Diebold-Mariano (1995) test statistic on equal predictive accuracy are shown in parantheses. The Harvey, Leybourne and Newbold (1997) correction for small samples is applied.

Table 5 Encompassing tests

Annual forecasting horizon

	Money growth	Excess liquidity	Term structure
Money growth		0.773	0.421
Excess liquidity	0.060		0.137
Term structure	0.132	0.528	

Biennial forecasting horizon

	Money growth	Excess liquidity	Term structure
Money growth		0.914	0.359
Excess liquidity	0.005		0.113
Term structure	0.012	0.164	

Triennial forecasting horizon

	Money growth	Excess liquidity	Term structure
Money growth		0.989	0.016
Excess liquidity	0.000		0.001
Term structure	0.000	0.022	

Note: Entries denote *p*-values for the null hypothesis that the forecasting method in the row does not add information to the forecasting method in the column.