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A portfolio demand approach for broad money in the euro area

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Abstract

The aim of the paper is to reassess the issue of money demand stability by estimating a portfolio demand approach for broad money M3 in the euro area covering the sample 1999 to 2013. The question is relevant, since in view of the massive shocks observed since the start of the financial crisis in 2007 relationships may have changed. Overall, the paper finds that the main components of euro area M3 are largely stable and can be explained by fundamental factors such as a transaction variable and opportunity costs. Nevertheless, the analysis detects some instabilities originating from the demand for currency in circulation linked to the euro cash changeover and for marketable instruments in an environment of very low interest rates.

JEL Codes: C22, C52, E41

Keywords: Cointegration analysis, financial crisis, money demand stability, components of M3.

Non-technical abstract

From the start, the European Central Bank (ECB) has emphasised the importance of analysing monetary developments when assessing the monetary policy stance. This has helped the Governing Council of the ECB to better understand the risks to price stability in the euro area over the medium term and to make more robust monetary policy decisions. Within its monetary analysis, the ECB regularly monitors a broad set of monetary and credit aggregates, which may contain useful information about the likely future development of inflation and output. Given the presence of massive shocks in the aftermath of the financial crisis and the long period of exceptionally low interest rates, it is likely that the demand for these financial instruments has changed.

The empirical properties of money demand in the euro area are therefore of key importance to policy-makers. Money demand models provide a framework which link monetary developments to its fundamental driving factors, such as economic activity, prices and interest rates. (Long-run) money demand stability is an important condition for the validity of these models. Despite intensive research, there is no consensus concerning the stability (or instability) of money demand functions in general. While assessments on the stability of money demand functions have differed across time and country, most studies on money demand stability have been favourable for the euro area.

This paper reassesses the issue of money demand stability for the euro area. It does so by covering the sample 1999 to 2013 that is extending the sample used by Calza et al. (2000) by another 13 years and using genuine monetary union data. During this sample events such as the structural shift of the cash changeover as well as the financial crisis episode have challenged the stability of the money demand behaviour. It focuses on the four main components of M3 (currency in circulation, overnight deposits, short-term deposits, marketable instruments), thus taking the perspective of looking what is inside the broad monetary aggregate M3. Allowing for known structural breaks, the paper finds that the main components of euro area M3 can be largely explained by fundamental factors such as a transaction variable and opportunity costs, but there has been some measurable deterioration during the financial crisis. Consistent with the literature, currency demand is found to be rather insensitive to changes in interest rates and mainly driven by the transaction variable, while its share in M3 has remained broadly stable. Despite the finding of long-run stability for most components of M3, the empirical analysis detects some instabilities in the demand for currency in circulation, mainly originating from the euro cash changeover, and for marketable instruments related to the very low interest rates during the financial crisis. This environment has given investors strong incentives to sell these instruments and to buy other financial instruments outside of M3 with higher remuneration.

The approach of the paper is to estimate both individual demand functions and a portfolio demand approach for euro area M3. The approach to estimate individual demand functions based on fundamental determinants is fairly conventional, but most studies do not take the disaggregated perspective of explaining

the main components of M3. In this context, the portfolio demand approach has the advantage of better capturing substitution relationships between financial instruments included in M3. The empirical part of the paper uses a cointegration approach, which tests for the existence of a stable long-run relationship between the components of M3 and its fundamental determinants. To this end, it applies both the Johansen test and the t-ECM test for cointegration, thus providing checks for robustness of the results. The sample covers the monetary union in Europe from the start, i.e., 1999 to 2013. Given several breaks in the relationships, in particular the start of the financial crisis in 2007-08, the empirical test procedures test for cointegration in the presence of structural breaks and make the necessary adjustments to the econometric tests.

The results of this paper support the ECB's monetary analysis in times of structural change. Despite massive distortions of the euro area monetary policy transmission mechanism during the financial crisis, the components included in the narrow monetary aggregate M1 and the intermediate monetary aggregate M2 were stable. It means that these monetary aggregates can be used as compasses in the regular assessment underlying the ECB's monetary analysis. For the broader aggregate M3, which enjoys prominence in the ECB's monetary analysis, a word of caution is necessary, because the demand for marketable instruments, which represents the smallest component of M3, appears to have been distorted during the financial crisis. It is therefore likely that the empirical properties of the broad monetary aggregate M3 have deteriorated. In order to derive a robust signal from monetary analysis, it is therefore advisable to look into the signals of a broad set of monetary aggregates and not to overemphasise a single monetary aggregate, such as M3.

A PORTFOLIO DEMAND APPROACH FOR BROAD MONEY IN THE EURO AREA

1. Introduction

Owing to financial innovation, greater financial integration and the introduction of banknotes, the monetary policy transmission mechanism in the euro area has likely changed throughout monetary union (Angeloni, Kashyap & Mojon, 2012). In fact, financial innovation has influenced the transmission mechanism and may have distorted the information content of monetary aggregates. In addition, large shocks in the aftermath of the financial crisis and the long period of exceptionally low interest rates have had an impact on the demand for financial instruments and therefore on the substitution relationships among the components of M3.

In the presence of institutional changes, financial innovation and a severe financial crisis, the analysis of the behaviour of the individual components of M3 can contribute to a better understanding of the driving forces of their dynamics. Previous studies have estimated the demand for M3 examining whether broad money demand is stable (e.g., Carstensen, 2004; Dreger & Wolters, 2006 and 2010; Beyer, 2009). To the author's knowledge no recent study has examined the stability of euro area M3 with emphasis on the substitution relationships of its components. In this context, a previous study (Calza, Jung & Stracca, 2000) using data on M3 for the period prior to the start of monetary union in Europe found that the main components of M3 may be subject to temporary disturbances, which in the past did not affect the overall stability of euro area M3. In view of the massive shocks observed since the start of the financial crisis in 2007 and the extraordinary responses of central banks, it is of broader interest to analyse whether these findings still hold.

The aim of the paper is to reassess the issue of money demand stability by estimating a portfolio demand approach for broad money M3 in the euro area. It does so by covering the sample 1999 to 2013 that is extending the sample used by Calza et al. (2000) by another 13 years and using genuine monetary union data. During this sample events such as the structural shift of the cash changeover as well as the financial crisis episode have challenged the stability of the money demand behaviour. The approach applies cointegration analysis to the demand functions for the components of M3. Like most workhorse models, it provides a structural explanation of the demand for the components of M3 using drivers such as a transaction variable and opportunity costs. For example, the approach captures to what extent velocity shocks have impacted on the demand for the components. Relative to conventional money demand models, the present approach allows examining whether, owing to shocks during monetary union, substitution relationships within M3 have changed and whether this had an impact on the stability properties of M3.

The paper is organised as follows. Section 2 provides a brief review of the literature. Section 3 explains the data used for this study. Section 4 presents the econometric approach and the results from the empirical analysis. Section 5 concludes.

2. Brief review of the literature

Since the European Central Bank (ECB) has emphasised the importance of analysing monetary developments, the empirical properties of money demand in the euro area are of key importance to policy-makers and to market observers. The literature has shown that a monetary policy assessment aimed at price stability can benefit from the valuable information contained in monetary aggregates (e.g., Papademos and Stark, 2010; Masuch, Nicoletti-Altimari, Rostagno and Pill, 2003). In addition to the leading indicator properties of monetary aggregates, money demand models are of key importance to policy-makers. Such models provide a framework in which monetary developments can be explained by developments in other macro variables, such as economic activity, prices and interest rates.

Despite intensive research, there is no consensus concerning the stability (or instability) of money demand functions in general. Assessments on the stability of money demand functions have differed across time and country (Kahn & Benolkin, 2007; Calza & Sousa, 2003). In the euro area this relationship has been subject to intensive research. Prior to the financial crisis, several studies examining the empirical properties of euro area money found (long-run) money demand stability for the broad aggregate M3 (e.g., Fagan & Henry, 1998; Calza, Gerdesmeier & Levy, 2001; Bruggemann, Donati & Warne, 2003; Brand & Cassola, 2004).

When assessing the stability of money demand it is necessary to consider other factors such as an increase in macroeconomic uncertainty, which can lead to a strong increase in the demand for narrow money. In the euro area, between mid-2001 and mid-2004, massive portfolio shifts occurred into safe and liquid monetary assets in an environment of heightened economic and financial uncertainty that followed the global stock market correction and the terrorist attacks of 11 September 2001 (Fischer, Lenza, Pill & Reichlin, 2009). As a result of heightened financial uncertainty and portfolio shifts into M3, the stability of the relationship between the money stock and its fundamental determinants were questioned (Greiber and Lemke, 2005; Carstensen, 2006). Both the presence of portfolio shifts and the strong correlation between the money stock and wealth, which was observed between 2004 and 2009, support the idea to model money demand in the form of a portfolio demand approach.

Around the start of the financial crisis some signs of instability emerged in the conventional money demand functions. But, it could be shown that money demand stability remained favourable in money demand functions incorporating household wealth, thereby capturing the development of real money balances (Beyer, 2009). Approaches explaining cross border international portfolio allocations have been also in favour of money demand stability for euro area M3 (de Santis, Favero & Roffia, 2013). In addition, approaches based on panel cointegration provide evidence in favour of a stable long-run money demand function for M3, suggesting that findings of instability in conventional functions could be attributable to an omitted variable (Nautz & Rondorf, 2011; Jung, 2015). A further point is that as a result of a wide range of distortions in the transmission mechanism in the aftermath of the financial crisis and the adoption of non-standard measures, this relationship may have been affected. But, a recent study (Dreger & Wolters, 2014) finds that the ECB's extraordinary measures did not introduce instability in the broad money demand relationships in the euro area.

While the intermediate monetary aggregate M2 enjoys particular prominence in the United States and some authors find it to be a better monetary aggregate than M3, empirical research for that aggregate in the euro area is scarce (Reynard, 2007). Some studies have examined the properties of narrow money M1 and found evidence in favour of money demand stability (e.g., Stracca, 2003). Likewise, only few authors have looked into the demand for currency in circulation for which some signs of instability were detected around the cash changeover of the euro, which took place in 2002 (Fischer, Köhler & Seitz, 2004). Although the ECB is regularly providing an analysis of the components of M3 in its official publications (currency in circulation, overnight deposits, short-term deposits, marketable instruments), research on the main components of M3 in the euro area is scant (Calza, Jung & Stracca, 2000; Jung, 2015).

In terms of methodology, linear models embodying error-correction mechanisms have become the standard macroeconometric tool in the empirical literature on money demand (Duca & von Hoose, 2004; Belke & Czudaj, 2010). In an environment with interest rates close to the zero lower nominal bound, non-linearities in the demand for money may occur. Non-linear specifications are in particular suitable to explain changes in the speed of the error-correction adjustment. Available evidence suggests that non-linearities may in particular be relevant for modelling the narrow monetary aggregate M1 (Calza & Zaghini, 2009), but less so for the broader aggregate M3 (Dreger & Wolters, 2006).

3. Data

This paper uses monthly data for the components of M3 for the euro area, the corresponding interest rates and quarterly data for nominal GDP for the euro area. It covers the period since the start of monetary union (i.e., 1999 to 2013). Measures of end-of-month outstanding amounts denominated in euro (source: ECB) are used for the four main components of M3 for the euro area (changing composition): currency in circulation (CC); overnight deposits (OD); short-term deposits (SD); marketable instruments (MI) (see Chart 1) and for M3. The data is working day and seasonally adjusted. In addition, as proxy for liquidity, we included a series for the euro area monetary base (MB) denominated in euro (changing composition, source: ECB). When estimating the demand functions, we use a series for both OD and SD, which adjusts for a statistical break owing to a reclassification by the ECB. It classified certain deposits redeemable at notice up to 3 months in Spain as overnight deposits as of June 2005 in order to ensure conceptual consistency. Nominal GDP for the euro area (changing composition) denominated in euro is the series reported by Eurostat which is compliant with ESA95 National Accounts. The quarterly GDP series has been converted into monthly frequency using a cubic spline technique. The data has been seasonally adjusted using the Census X-12 procedure.

Chart 2 shows various interest rate measures which can be used as proxies for the own interest rate and the alternative rate of interest for each component of M3. This paper uses interest rates for the euro area, since the focus of the analysis is on the euro area-wide transmission. In the euro area a capital markets union has not yet been accomplished. Unlike for other monetary unions no liquid markets for Eurobonds exist so far in the euro area. From a conceptual perspective, it would be preferable to model the demand for the components of M3 in relation to a risk-free rate on government bonds. In this context, a weighted average for all euro area countries has the disadvantage that during the financial crisis the interest rates on government bonds in some euro area countries accelerated, while the rating for domestic government bonds was downgraded. In some euro area countries high risk premia were priced in reflecting increased uncertainty about the state of public finances. As proxy for the long-term market interest rate (LT) the rate of return on euro area government bonds with a maturity of 10 years is used, i.e., yields on government bonds from all issuers whose rating is triple A (source: ECB). The series has been calculated using GDP weights. For medium-term market interest rate (MT) the rate of return on euro area government bonds with a maturity of 5 years is used, i.e., yields on government bonds from all issuers whose rating is triple A (source: ECB). The series has been calculated using GDP weights (source: ECB). For short-term market interest rates (ST) EURIBOR three month rates (source: Reuters) are used for the euro area (changing composition) as a proxy for the own rate of return on marketable instruments. Moreover, the rate of return on overnight deposits (ROD) for the euro area (changing composition) is the series for new business applying to non-financial corporations (source: ECB MFI interest rate statistics).

For the short-term deposits the own rate (RSD) is computed as a composite rate which is a weighted average of the interest rate on deposits with agreed maturity of up to two years and deposits redeemable at notice of three months. The rates of return on these instruments for the euro area (changing composition) are the series for new business applying to non-financial corporations (source: ECB MFI interest rate statistics). Both interest rates are weighted according to the relative weights of each instrument in the component other short term deposits. Finally, the composite rate of return on M3 (RM3) is calculated as the weighted average of the own rates of return on the components of M3, using time-varying weights based on the respective shares in M3 (see Chart 4) using the formula:

RM3 = OD/M3*ROD + SD/M3*RSD + MI/M3*ST. (1)

Based on these interest rates it is possible to construct several interest rate spreads (see Chart 3), which can be used to proxy the opportunity costs in the money demand function (see next section). Visual inspection shows that for several interest rates a clear break has occurred during the financial crisis, which started in 2007-08. In economic terms, this was related to the strong policy response of the ECB (and of other leading central banks) driving down policy rates to very low levels in order to counter a massive shock related to the outbreak of a severe (global) financial crisis. In this context, it should be noted that our analysis uses measures for opportunity costs, i.e., the spreads between interest rates at two different maturities (see Chart 3).

Visual inspection suggests that the structural break related to the financial crisis may not only have affected the interest rates, but to a lesser extent the spreads as well. In the econometric analysis, we therefore include a financial crisis dummy (FINDUM) related to the collapse of Lehman Brothers on September 15, 2008. The dummy takes the value zero until August 2008 and from September 2008 it takes the value 1. In addition, we included two further dummies reflecting other known breaks. A dummy (EURODUM) was calculated to capture the impact of the euro cash changeover on the demand for currency in circulation. The dummy takes the value 1 until December 2001 and from January 2002 it takes the value zero. With the intensification of the financial crisis, repurchase agreements conducted by central counterparts gained popularity (ECB, 2012). Since these holdings are no genuine MFI holdings of repos, the ECB corrected its monetary statistics (i.e., the series M3, marketable instruments, and repos) for the impact of those instruments back to June 2010. In order to capture this statistical break, we include a dummy (MARKETDUM) in the regressions. The dummy takes the value zero until May 2010 and from June 2010 it takes the value 1.

4. An empirical analysis of the components of M3 in the euro area

This section examines the behaviour of the components of M3 using two complementary approaches: (i) individual demand functions for the euro area components (in levels); and (ii) a portfolio demand approach for the components of M3 (in shares of M3). The first approach explains the individual components of M3 without imposing a restriction on the coefficients, while the portfolio demand approach estimates the components in terms of shares of M3, thereby ensuring the stock-flow consistency of the model. In this context, the portfolio demand approach has the advantage that it models more explicitly the substitution processes within M3. Therefore, it can provide better indications about whether a common shock, which is not captured by a fundamental factor, explains a substitution process between two components of M3.

Section 4.1 explains the econometric approach of this paper and Section 4.2 discusses the empirical results for the euro area.

4.1 Econometric approach:

For the present analysis the following caveats apply. First, this paper focuses on specifications in nominal terms. Hence, it is not necessary to test whether price homogeneity holds for each individual component of M3. Second, the individual demand functions for the components of M3 disregard the presence of wealth effects, whereas the portfolio demand approach defines portfolio wealth by the stock of M3.[2] Moreover, the portfolio demand approach captures changes in trend velocity, since the transaction variable is specified in terms of a ratio between nominal GDP and M3. Third, both approaches in this paper treat the effects originating from international capital flows on the demand for money as exogenous, and hence do not include other potentially relevant factors in the analysis, such as global liquidity and exchange rates (Chung, Lee, Loukoianova, Park & Shin, 2014).

A further point is that, during the financial crisis, factors such as the massive liquidity provision by central banks may have gained relevance as driving factors of money demand in the euro area. In this context, Dreger & Wolters (2010) find that, before the financial crisis, excess liquidity has not created an issue for money demand stability in the euro area. In order to analyse the separate effect of excess liquidity in the present framework, two possibilities have been proposed in the literature. First, excess liquidity is modelled as the difference between observed and equilibrium money balances (Masuch, Pill & Willeke, 2001). Then the error correction term (ECT) captures the impact of a monetary overhang or shortfall of a component on its

[2] In this context, Friedman (1988) suggests that, when analysing real money demand, the wealth effect dominates the substitution effect. The wealth effect also implies decreases in money velocity, since it leads to higher money-to-income ratios. Moreover, Meltzer & Rasche (1995) suggest that the omission of a separate variable for private sector wealth could bias the analysis towards a systematic rejection of the hypothesis of a stable money demand relationship.

demand, since it can be understood as a measure of excess liquidity. Second, a separate liquidity variable can be included in the error correction model (ECM) and it can be tested whether this variable helps to improve the explanation of the components of M3.

Individual demand functions for the components of M3

In general, the demand for M3 can be explained by a set of fundamental determinants, which comprise a transaction variable, an opportunity cost variable and possibly other variables such as returns on stocks (e.g., Ericsson, 1998; de Santis, Favero & Roffia, 2013; Landesberger, 2007). Calza et al. (2000) point out that a similar reasoning can be applied to the components of M3. In the absence of special factors, the demand for the component M^i (in nominal terms) can be explained by its fundamental determinants:

$$M^i = \Phi(Y , R - r^i) \qquad (2)$$

with Y denoting a transaction variable (nominal GDP), r^i is the own rate of return on the component, and R the rate of return on a representative "*alternative*" asset. The transaction variable should exert a positive influence on the component M^i, whereas the opportunity cost variable (spread between the rate on an alternative asset and the own rate) negatively influences the demand for the component.

A conventional way to estimate individual demand functions is to specify an error-correction model. Since this specification allows testing for the existence of a cointegration relationship between the variables, it can be used to test for (long-run) stability of the individual demand functions. The error correction term is lagged by one year, since we are using year-on-year growth rates of the levels. A further lag was included to make the ECM more robust in the presence of structural change (Escribano & Arranz, 2000). The extended ECM for year-on-year growth rates of monthly data for component m_i is given by (Calza et al., 2000):[3]

$$\Delta m_t^i = \alpha_i + \beta_i\, \Delta y_t + \gamma_i\, \Delta(R_t - r_t^i) + \lambda_i ECT_{t-12} + \mu_i ECT_{-13} + \rho_i\, \Delta m_{t-1}^i + \omega_t \qquad (3)$$

[3] According to Kremers et al. (1992) the t-ratio for the coefficient on the error-correction term in the dynamic equation has a lot of power. The t-ratio approach relies on the assumption of weak exogeneity of the regressors and is only valid, if there is exactly one cointegration relationship between the variables. Additional tests, not reported here for reasons of brevity, show that weak exogeneity is satisfied in all cases considered, both for nominal GDP (or velocity) and for interest rates.

where Δ denotes the 12-month difference operator, m_i is the log of component i, y_i is the log of nominal GDP, R is the interest rate on the "typical" alternative investment and r^i is the own rate of return of component i, ECT is the residual of the long-run cointegration regression in levels with the regressors nominal GDP growth and the corresponding opportunity costs and with break dummies and ω_i is an error term.

For cointegration analysis to produce valid results it is important to include longer runs of data. In this regard the use of monthly observations gives about 167 observations and contributes to enlarging the degrees of freedom, but adds new information only to the extent that genuine monthly data are included. Clearly, a weakness of using annual growth rates in the above specification is that these may display a highly autoregressive behaviour. A drawback of month-on-month changes is that they typically display a considerable degree of noise without adding new information, given that genuine GDP data are only available at the quarterly periodicity. In that respect using quarterly data could provide better test statistics. Nevertheless, from a policy-oriented perspective an examination of the components of M3 using annual changes seems appropriate, since the ECB monitors monetary developments in its monetary analysis on the basis of annual growth rates for monetary aggregates (and loans). We made checks for robustness of the results using a quarterly version of the above specification. This specification largely confirms our results of the Johansen cointegration tests. However, in terms of the error correction model the use of quarter-on-quarter growth rates deteriorates the results. Using year-on-year growth rates of quarterly data instead leads to largely similar results, as reported, but such estimations, which use about 50 observations, may still suffer from a small sample bias.

A portfolio demand approach for the components of M3

The portfolio demand approach explicitly models the substitution process within M3, while the behaviour of M3 as a whole is exogenous to the model employed. This approach assumes weak separability between instruments included and excluded from M3. It imposes the constraint that the sum of the various components adds up to M3. Structural portfolio demand equations can be specified for the shares of the components of M3 (with the latter representing a proxy for portfolio wealth). Equations are specified for the share (M^i/M3) of each component i in M3 (in logs) using a transaction variable and the rate of return on M3

(RM3). The ratio of nominal GDP to M3 (in logs) is used as a transaction variable in the demand functions, and the composite rate of return on M3 measures the substitution effect owing to changes in underlying interest rates. This gives the following general specification:

$$M^i/M3 = \theta(Y/M3, RM3) \quad (4)$$

where Y/M3 denotes a standardised transaction variable and RM3 denotes the return on M3, which is the opportunity cost variable in this framework. The standardisation shall facilitate a comparison of the effect from the transaction variable on the demand for (the share of) the individual components. Moreover, given the quantity identity (M3·V≡Y), the transaction variable can be interpreted as velocity of broad money M3.

The "theoretical" signs of the explanatory variables may differ from the first approach, since the portfolio demand approach explains the development of the individual components of M3 *relative to each other*. Therefore, for certain components the coefficients will have an opposite sign from those estimated for the individual demand functions above. Since the portfolio demand model estimates the portfolio shares of the components, it applies a restriction on the coefficients. A desirable condition is that the income and (semi-) interest rate elasticities of all components *i* weighted by their share in M3 add up to zero respectively. This follows from the definition of M3 as the sum of the individual components.

As before, a further lag of the ECT was included in the ECM to better capture the presence of structural breaks. The extended ECM for year-on-year growth rates of monthly data for the share of component m^i underlying our estimations is given by:

$$\Delta sm_t^i = \alpha_i + \beta_i \, \Delta sy_t + \gamma_i \, \Delta RM3_t + \lambda_i ECT_{t-12} + \mu_i ECT_{-13} + \rho_i \, \Delta sm_{t-1}^i + \nu_t \quad (5)$$

where Δ denotes the 12-month difference operator, sm^i denotes the log of the share of component i ($m^i/m3$), *sy* the log of the share of nominal GDP in M3 (y/m3) or velocity of M3, *RM3* is the composite rate of return on M3, ECT denotes the residual of the long-run cointegration regression in levels and with break dummies and υ_t is an error term. The error correction term is lagged by one year, since we are using year-on-year growth rates of the shares.

4.2 *Econometric results*

This section reports the econometric results for the demand functions applying the approaches outlined above. Individual demand functions for the main components of M3 in levels are estimated using OLS, whereas the portfolio demand functions are estimated applying a Seemingly Unrelated Regression (SUR) technique (Zellner, 1962 and 1963). This method provides consistent and unbiased estimates in the presence of correlation across the individual demand functions and yields efficiency gains relative to Ordinary Least Squares (OLS). The SUR method applies Generalised Least Squares (GLS) estimation, which allows taking into account the correlation of the residuals of a set of unrestricted equations. Moreover, for the chosen demand functions, regressors are not identical across equations, and the cross-equation covariance is not identically zero. In this case, it has been shown that this method increases the efficiency of the estimation (Driwedi & Srivastava, 1978).

Before estimating the empirical demand functions, it may be useful to briefly review some basic time series properties of the data and to check for the existence of cointegration relationships. Prior to conducting a cointegration analysis, conventional unit root tests serve to check the integration properties of the euro area variables. The results of the ADF-tests (see Table 1) on the components of M3 (in logs), the interest rates and the corresponding spreads (in levels), and the transaction variables (in logs) indicate that these variables are all integrated of order one, but M3 appears to be integrated of order two. In addition, these tests confirm that the shares of M3 and the corresponding transaction variable are integrated of order one.

Taking into account that the power of unit root tests is generally low, we made checks for robustness of the results by applying the Phillips Perron (1998) tests on these variables for the identical sample. These tests confirm that the variables considered are all integrated of order one.[4] When comparing the results of the monetary union sample with those obtained for a sample of 20 years prior to monetary union (Calza et al., 2000, p. 685), it turns out that the results are robust. A weakness of the conventional unit root tests is their potential confusion of structural breaks in the series as evidence of non-stationarity. They may be biased towards a false unit root null when the data are trend stationary with a structural break, i.e., for the series that

[4] For brevity of the analysis results of the Phillips Perron tests are not shown here, but are available from the author. An earlier study on the components of M3 for the euro area by Calza et al. (2000) using ADF tests found that the variables

are found to be I(1), there may be a possibility that they are in fact stationary around the structural break(s), I(0), but are erroneously classified as I(1). We therefore conducted additional unit root tests with a breakpoint. In these tests, the null hypothesis is that the series has a unit root with a structural break against the alternative hypothesis that they are stationary with break. These tests show that the results are generally robust, but M3 appears to be a borderline case, since they suggest M3 to be integrated of order one. While the Phillips Perron test and the breakpoint unit root test point for M3 to an I(1) variable, the ADF-test for M3 suggests it to be an I(2) process.

In the literature, it is widely assumed that broad money M3 in nominal terms is integrated of order two, whereas in real terms it is often found to be integrated of order one based on a long-run cointegration relationship between money and prices (e.g., Holtemöller, 2004). Regarding the components of M3, their time series properties can differ from the overall aggregate, which is obtained by summing up the components. Their shares could be constant over time and hence stationary, but visual inspection (Chart 4) suggests some time-variation. With M3 as an I(2) variable, this could better explain why the shares of the components in M3 are empirically found to be I(1). In this context, it is important to note that M3 does not enter the cointegration analysis in levels.

Compared to other cointegration tests, the Johansen (1991) test has the advantage that it reports information about the number of cointegrating vectors (cointegration rank r). A further advantage of the Johansen cointegration test for applied analysis is that its indications can be used as a rough specification test. It is, however, somewhat sensitive to the lag structure and requires longer runs of data to provide robust results. Since the sample is characterised by important structural breaks, it is necessary to take known breaks into account, such as the euro cash changeover and the financial crisis. A structural break does affect the power of cointegration tests when the process generating the data does not have a common factor. We follow the approach proposed by Johansen, Mosconi & Nielsen (2000), who propose to conduct the tests in a cointegration model with piecewise linear trend and known break points, and use critical values as computed by Giles & Godwin (2012). These critical values capture whether one or more breaks are included in the cointegration regression.

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tested are integrated of order one for the sample 1990 to 1999 prior to monetary union.

Table 2 shows the results of Johansen cointegration tests of the demand functions for the main components of M3 and their fundamental drivers. All demand functions, except currency in circulation in levels, contain a break for the financial crisis (FINDUM). For currency in circulation a break for the euro cash changeover (EURODUM) has been included and for marketable instruments a second break for the ECB's correction of holdings of repurchase agreements by central counterparts (MARKETDUM) needs to be considered. With the exception of marketable instruments in levels, these tests confirm the existence of exactly one long-term relationship between the respective components (both in levels and in shares) and their drivers economic growth and the respective opportunity cost variable (at the 5% significance level), thereby indicating the presence of a stable (long-run) relationship between these variables. In this context, it can be observed that in the case of currency circulation an interest rate variable does not significantly enter the long-term relationship, neither in levels nor in shares of M3. Consistent with the literature, this means that currency demand in the euro area is rather insensitive to changes in interest rates and mainly driven by the transaction variable.

In order to check for robustness of the results and to provide further insights on the dynamics of the relationships, we estimate error-correction models of the demand functions. These may also include indications on cointegration based on the t-ECM test (Kremers, Ericsson & Dolado, 1992). Since this test efficiently exploits information contained in the error-correction model, it is more powerful than the conventional Engle-Granger (1987) procedure. A potential weakness of the t-ECM test is that in the presence of structural breaks these conventional critical values may no longer hold. In this framework it is possible to take into account structural breaks by using an extended error-correction model, which includes an extra lag of the ECT. For large samples of around 200 observations, Escribano & Arranz (2000) show that the conventional critical values still hold, if the extended error-correction model is specified. However, for smaller samples than considered here it would be necessary to adjust the conventional critical values.

In the error-correction models, a highly significant negative coefficient of the ECT is required to indicate cointegration. According to Ericsson & MacKinnon (2002, p. 304), using the table for 100 observations with one (two) variable(s) and a constant term, an estimated t-value of -2.86 (-3.21) for the coefficient of the ECM-term is required to indicate cointegration at the 5% significance level (the critical value is -3.43 (-3.79) for the 1% significance level). Since we are effectively using 167 observations, these critical values have to be adjusted; this gives critical values of -2.88 (-3.23) for the 5% significance level and -3.47 (-3.84) for the 1% significance level.

Results for individual demand functions for the components of M3

Table 3 reports the estimation results for equation (3) for the full sample (1999 to 2013). For convenience, the normalised coefficients of the (long-run) cointegration regression, which were obtained applying the Johansen approach, are reported separately from those of the error-correction models. Despite the massive distortions during the financial crisis, the results show that, for all components of M3, the long-run coefficients for output are significant with the theoretically expected sign. With the exception of overnight deposits, which have been strongly influenced by the ECB's non-standard measures, the income elasticity is close to one. Based on the Johansen test, the opportunity cost variable (short-term interest rate) is not part of the long-run relationship for currency in circulation, whose demand is largely insensitive to interest rate changes. Moreover, for the other main components of M3 the effect from the respective opportunity cost variable is not significant, and may even display the wrong sign. This finding appears to be attributable to the observed changes in the transmission mechanism and the environment of very low interest rates, since at the start of monetary union these elasticities were all significant with a negative sign (Calza et al., 2000).

Overall, the estimates of the ECMs show the existence of a positive relationship between the dependent variable and its lagged value, and a negative relationship between the dependent variable and the error correction term. Like the Johansen test, the results of the t-ECM test for the full sample (see Table 3) suggest that the hypothesis of no cointegration can be rejected in favour of cointegration, and hence long-run stability of the demand functions, for currency in circulation, overnight deposits and short-term deposits (at a significance level of 1%). Since the Johansen test is indicative of two cointegration relationships for marketable instruments, the t-ECM test may not be valid in this case. In this context, the coefficient of the ECT for marketable instruments has a positive sign (instead of a negative one), which may signal instabilities in the demand for this component during the financial crisis episode, when interest rates were approaching the zero lower bound. In addition, currency in circulation displays other signs of instability, since the lagged endogenous in that demand function is close to unity. For the other components of M3, coefficients describing the dynamic adjustment are significant and their signs are consistent with the theoretical priors. In terms of statistical properties, the dynamic specifications of the individual demand functions display a high explanatory power (adjusted R^2), but autocorrelation is detected for the demand functions, while separate ARCH-tests show the absence of heteroscedasticity.

Further diagnosis of the residuals of the ECMs (see Chart 5) shows that most movements of the components are explained within a confidence band of 95%. Nevertheless, these tests detect episodes characterised by strong disturbances of the individual demand functions. First, currency in circulation was affected by the euro cash changeover which ended in January 2002, and the distortions on the demand for currency in circulation continued throughout 2003. Second, the individual demand functions for both overnight and short-term deposits display more sizeable distortions, and potentially offsetting movements, during the financial crisis than before it. Third, sizeable distortions in the demand for marketable instruments have occurred during the financial crisis episode, in particular since the beginning of 2010.

When comparing the results of the monetary union sample with those obtained for a sample of 20 years prior to monetary union (Calza et al., 2000, p. 694), it turns out that the results of the t-ECM test are robust in terms of the existence of a cointegration relationship and broadly similar in terms of the estimated adjustment speed. However, marketable instruments for which a cointegration relationship was confirmed prior to monetary union are an exception, since during monetary union cointegration is no longer confirmed. This finding may be related to the monetary policy response during the financial crisis, which implied a shift of short-term interest rates to unprecedented low levels, thereby making it unattractive for investors to hold money market funds. In terms of the long-run coefficients it can be observed that the components respond in a significant and measurable manner to the transaction variable, but by contrast to the evidence prior to monetary union, there is no longer a significant response to the opportunity cost measure. While this is plausible for the demand of currency in circulation, it seems to suggest for the other components of M3 that a change in the relationship has occurred.

In order to explicitly test for structural breaks in the relationships, we apply the Quandt-Andrews test (for unknown structural breaks). This test helps to locate the most likely structural breaks in the demand for the components of M3 (Andrews, 1993). In addition to the breaks that have been taken into account in the estimations, the test indicates two breaks. One break is detected in the relationship for overnight deposits in 2008, which corresponds to an early phase of the financial crisis that was characterised by elevated uncertainty. A second break is detected for short-term deposits in September 2009 broadly coinciding with the adoption of the ECB's first Covered Bond Purchase Programme. Nevertheless, it is still possible that the detected structural breaks refer to portfolio substitutions between overnight deposits and short-term deposits, which can be better accounted for in the portfolio demand approach.

In this context, the massive liquidity provision by central banks during the financial crisis, may explain changes in the transmission mechanism as well. In order to find out whether there is a missing variable, we estimate equation (3) again and include a separate proxy for excess liquidity (i.e., the monetary base for the euro area). Its inclusion, however, does not help to improve the stability of the money demand functions for the components for the full sample. This is, however, not surprising, since the initial specification already captures excess liquidity by means of the ECT term (as discussed above).

Results for the portfolio demand approach for the components of M3

Since the portfolio demand approach includes the fundamental determinants relative to M3 trends, it ensures a consistent structure of the ECMs across shares and captures substitution processes within M3. Table 4 reports the results of the normalised coefficients of the (long-run) cointegration regression for the shares, which were obtained applying the Johansen approach. It also reports results of the portfolio demand system based on equation (5) for the shares of the main components of M3 for the full sample. In the long-run, changes in M3 velocity have a significant impact on all main components of M3. Given the results of the Johansen cointegration test, we did not include the composite rate of return on M3 in the long-run relationship for currency in circulation, but only in the dynamics. The share of currency in circulation is broadly stable, and does not respond to changes in the composite return on M3. Moreover, with the exception of short-term deposits, the long-run elasticities for the opportunity costs are significant at the 1% level, and display the correct sign.

Like the Johansen test for the shares (see Table 2), this approach confirms long-run stability for the shares of currency in circulation, overnight deposits and short-term deposits. Applying the above adjusted critical values (Ericsson & MacKinnon, 2002) to the extended error-correction model, the t-statistics for the ECTs are consistent with the existence of a cointegration relationship for the M3 shares of currency in circulation, overnight deposits, short-term deposits and their fundamental determinants respectively (at the 1%-level; for short-term deposits at the 5%-level). Unlike the Johansen test, the results of the portfolio demand system do not confirm long-run stability for the demand for marketable instruments in shares. For the M3 share of marketable instruments the t-statistics of the ECT suggests the absence of a cointegration relationship (at the 1%-level), which could be related to the behaviour of investors searching for yield in an environment of very low interest rates.

Overall, the estimates of the extended ECMs show the existence of a positive relationship between the dependent variable and its lagged value, and a negative relationship between the dependent variable and the error correction term. By contrast, for marketable instruments the coefficient of the ECT has a positive sign. In the short-term, M3 velocity has no significant impact on the components, but the composite rate of return on M3 is significant thus driving some of the dynamics in the portfolio substitutions between overnight deposits and short-term deposits. Overall, the dynamic adjustment of the portfolio demand functions mainly rests on the ECT and the lagged endogenous variable. Moreover, the dynamic specifications of the demand functions for the shares are well behaved with satisfactory statistical properties (high adjusted R^2; absence of heteroskedasticity), but the Portmanteau test indicates the presence of autocorrelation.

When comparing the results of the monetary union sample with those obtained for a sample of 20 years prior to monetary union (Calza et al., 2000, p. 696), it turns out that the results of the t-ECM test are robust in terms of the existence of a cointegration relationship and broadly similar in terms of the estimated adjustment speed. However, the share of marketable instruments for which a cointegration relationship was confirmed prior to monetary union is an exception, since during monetary union cointegration is no longer confirmed. As before for the individual demand functions, this finding is a reflection of the monetary policy response during the financial crisis, which implied a shift of short-term interest rates to unprecedented low levels, thereby making it unattractive for investors to hold money market funds. In terms of the long-run coefficients it can be observed that the shares of the components respond in a significant and measurable manner to the transaction variable, but by contrast to the evidence prior to monetary union, there is only a significant response to the opportunity cost measure for the share of overnight deposits and of marketable instruments. Again, it is plausible that the demand of currency in circulation responds to the transaction variable and not to the interest rate variable. However, the results seem to suggest that for the share of short-term deposits in M3 a change in the relationship has occurred.

Furthermore, the residuals for the portfolio demand system (see Chart 6) suggests that the stability properties for the demand functions using the shares of M3 have been affected by important shocks. While recursive estimates on the residuals of the ECMs indicate that most movements of the shares are explained within a confidence band of 95%, certain distortions stand out. In line with the above results for the individual functions, changes in the transmission mechanism linked to the cash changeover appear to have distorted the demand for cash, which remained broadly stable during the financial crisis. Other distortions refer to dysfunctionalities of markets during the financial crisis and the environment of very low interest rates. For example, marketable instruments were strongly affected by the very low interest rates. The distortions for overnight deposits and short-term deposits during the financial crisis episode appear to reflect portfolio substitutions between these components. Those instruments were subject to massive shocks during the financial crisis reflecting both an unprecedented high degree of uncertainty and a shift of policy rates towards the zero lower bound of interest rates.

5. Conclusions

In the literature, the existence of a stable money demand function is widely seen as a prerequisite for the conduct of a meaningful monetary analysis. The European Central Bank (ECB) assigns a prominent role to money in its monetary policy strategy, thereby emphasising how important it is for central banks to analyse monetary developments (ECB, 1999; Papademos & Stark 2010). For these reasons, the empirical properties of money demand in the euro area should be of key importance to policy-makers, academics and financial market observers.

This paper contributes to the empirical literature examining the stability of broad money M3 in the euro area. It reassesses the issue of money demand stability by estimating a portfolio demand approach for broad money M3 in the euro area covering the sample 1999 to 2013. During this sample events such as the structural shift of the cash changeover as well as the financial crisis episode have challenged the stability of the money demand behaviour. The paper finds that the main components of euro area M3 can be largely explained by fundamental factors such as a transaction variable and opportunity costs, with some measurable deterioration during the financial crisis. Overall, Johansen cointegration tests of the demand functions for the main components of M3 allowing for important structural breaks confirm the existence of a long-run relationship between the main components and their drivers economic growth and the respective opportunity cost variable, thereby confirming the overall stability of the (long-run) relationships. Consistent with the literature, currency demand is found to be rather insensitive to changes in interest rates and mainly driven by the transaction variable, while its share in M3 has remained broadly stable. Nevertheless, the paper detects some instabilities in the demand for currency in circulation linked to the euro cash changeover and in the demand for marketable instruments in an environment of very low interest rates.

These findings may have important implications for monetary analysis. First, those components included in the narrow monetary aggregate M1 and the intermediate monetary aggregate M2 robustly display long-run stability. Despite massive distortions of the euro area monetary policy transmission mechanism during the financial crisis, these aggregates likely have continued to perform as valid compasses. Second, the stability of the demand for marketable instruments, which represent the smallest component in M3, appears to have been distorted during the financial crisis, as investors who were searching for yield switched to other instruments. This behaviour has likely led to a deterioration of the empirical properties of the broad monetary aggregate M3, i.e. the monetary aggregate which enjoys prominence in the ECB's monetary analysis. Against this background, further research focusing on headline M3 in the euro area is needed to demonstrate that the long-run stability of M3 still holds empirically.

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Table 1: Results of ADF tests for unit roots

	test statistics			*test statistics*	
	Level of series	*Series in first difference*		*Level of series*	*Series in first difference*
Components of M3			**Interest rates and spreads**		
CC	-0.35	-6.12**	***LT***	-0.64	-13.31**
OD	-1.90	-12.78**	***MT***	-0.59	-11.24**
SD	-1.22	-3.10*	***ST***	-1.44	-5.99**
MI	-1.91	-11.12**	***RM3***	-2.03	-3.95**
MB	-0.72	-10.82**	***ROD***	-1.64	-5.16**
M3	2.51	-1.65			
SCC	-0.99	-6.09**			
SOD	-0.61	-10.91**	***RSD***	*-1.52*	-4.83**
SSD	-2.12	-10.80**	***RSD - ROD***	-1.87	-4.25**
SMI	-0.11	-13.32**	***MT – RSD***	*-2.87*	-10.82**
			LT-ST	*-2.86*	-10.04**
Transaction variables					
Y	-0.14	-9.15**			
SY	-0.51	-9.12**			

*Notes: the null hypothesis is that the series contains a unit root versus the alternative of no unit root; tests performed over full sample of each variable (1999:3 – 2013:11; in addition to a constant, the ADF tests include a trend in the case of SMI and Y. ** indicates rejection of null at 1% significance; * indicates rejection of null at 5% significance. The abbreviations of the variables are explained in the data section of the main text. S[component i] denotes the share of component i.*

Table 2: Johansen cointegration tests for the main components of M3

System	*Rank r*	*Trace statistics*	*Critical values* 95%	*Result*
Currency in circulation				
CC, YN	= 0	66.98**	34.18	One cointegration vector
	≤ 1	11.90	17.22	
SCC, SYN	= 0	60.88**	43.25	One cointegration vector
	≤ 1	24.54	22.34	
Overnight deposits				
OD, YN, OC	= 0	64.46**	58.23	One cointegration vector
	≤ 1	33.90	36.70	
SOD, SYN, RM3	= 0	66.11**	58.23	One cointegration vector
	≤ 1	26.21	36.70	
Short-term deposits				
SD, YN, OC	= 0	63.83**	58.23	One cointegration vector
	≤ 1	34.97	36.70	
SSD, SYN, RM3	= 0	61.11**	58.23	One cointegration vector
	≤ 1	27.24	36.70	
Marketable instruments				
MI, YN, OC	= 0	72.85**	66.95	Two cointegration vectors
	≤ 1	44.94**	42.52	
	≤ 2	21.67	21.93	
SMI, SYN, RM3	= 0	95.19**	66.95	One cointegration vector
	≤ 1	39.55	42.52	

*Notes: Johansen cointegration test for rank r with four lags; sample 1999.1 to 2013.11, ** denotes significance at the 5% level (eigenvalue statistics provide similar indications), critical values by Giles & Godwin (2012) were used with one break: q=2, v1=0.2 for currency in circulation in levels, with two breaks for the shares: q=3, v1=0.2, v2=0.35; for overnight deposits and short-term deposits one break: q=2, v1=0.35, and for marketable instruments with two breaks: q=3, v1=0.35, v2=0.25. Currency in circulation in levels includes EURODUM, in shares FINDUM is added; overnight deposits and short-term deposits include FINDUM, marketable instruments contain FINDUM and MARKETDUM as break dummies. The abbreviations of the variables are explained in the data section of the main text. S[component i] denotes the share of component I; Opportunity costs (OC) for CC: return on short-term deposits (RSD); for OD: spread between RSD and ROD; for SD: spread between MT and RSD; for MI: spread between LT and ST.*

Table 3: Individual demand functions,

(OLS estimation)

1999 to 2013 (monthly data)

Dependent variable	*Long-run demand functions*			*Dynamic demand equations*							
	Regressors			*Regressors*					*Diagnostics tests*		
	Constant	*Nominal GDP*	*Interest rates*(1)	*Constant*	*Lagged endogenous*	*Nominal GDP*	*Interest rates*(1)	*ECT*	*Adj.* R^2	*LM(1-12)-test*	*Quandt-Andrews breakpoint test*
CC(3)	0	0.94** (0.00)	-	0.01 (0.00)	0.99** (0.02)	-0.14 (0.13)	0.93* (0.37)	**-0.56**** **(0.05) [12.41]**	*0.97*	*2.81* *[0.00]*	-
OD(2,4,5)	-17.19 (1.92)	2.19** (0.30)	-2.02 (4.29)	0.01** (0.00)	0.83** (0.04)	0.17* (0.07)	-2.50** (0.51)	**-0.27**** **(0.07) [3.85]**	*0.94*	*2.29* *[0.01]*	*2008.1*
SD(2,4,5)	0.60 (5.62)	0.99** (0.39)	4.63 (5.39)	-0.00** (0.00)	0.96** (0.01)	0.16** (0.03)	-0.30** (0.09)	**-0.20**** **(0.05) [4.10]**	*0.99*	*4.18* *[0.00]*	*2009.9*
MI(2,5)	0	0.84** (0.05)	69.32 (36.42)	-0.01** (0.00)	0.92** (0.02)	0.46** (0.15)	-0.08 (0.23)	0.17 (0.07) [2.40]	*0.96*	*3.48* *[0.00]*	-

Notes: * indicates significance at 5%; ** at 1%; standard error in parenthesis; t-value in square brackets; ECT is the residual from the (long-run) cointegration regression (the second lag of the ECT is included, but not shown above). (1) Opportunity costs for CC: return on short-term deposits (RSD); for OD: spread between RSD and ROD; for SD: spread between MT and RSD; for MI: spread between LT and ST. (2) A dummy for the financial crisis has been included for 2008.9. (3) A dummy for the euro cash changeover has been included for 2002.1. (4) Series adjusted for the break caused by a statistical reclassification between overnight deposits and short-term deposits in Spain in June 2005. (5) A dummy for the ECB's correction of holdings of repurchase agreements conducted by central counterparts has been included for 2010.6.

Table 4: Portfolio demand approach,

Seemingly Unrelated Regression (GLS estimation)

1999 –2013 (monthly data)

Dependent variable	*Long-run demand functions*			*Dynamic demand equations*							
	Regressors			*Regressors*					*Diagnostics tests*		
	Constant	*Nominal GDP/M3*	*RM3*	*Constant*	*Lagged endogenous*	*Nominal GDP/M3*	*RM3*	*ECT*	*Adj. R^2*	*PT test, p-val*	*Quandt-Andrews breakpoint test*
SCC(1,2)	0	2.01** (0.05)	-	-0.00* (0.00)	0.97** (0.01)	0.05 (0.05)	0.60* (0.23)	**-0.77** (0.04) [17.22]**	*0.98*	*<0.01*	-
SOD(2,3)	0	0.70** (0.04)	-12.20** (1.92)	0.00 (0.00)	0.88** (0.02)	0.05 (0.03)	-1.05** (0.12)	**-0.33** (0.07) [5.09]**	*0.98*		-
SSD(2,3)	0	0.84** (0.04)	3.31 (2.01)	0.00 (0.00)	0.90** (0.02)	0.00 (0.02)	0.67** (0.08)	**-0.13** (0.04) [3.50]**	*0.96*		-
SMI(2,4)	0	1.52** (0.09)	-17.62** (4.83)	-0.00 (0.00)	0.94** (0.02)	-0.02 (0.07)	0.74** (0.27)	0.09 (0.06) [1.50]	*0.95*		-

Notes: * indicate significance at 5%; ** at 1%; standard error in parenthesis; t-value in square brackets; ECT is the residual from the (long-run) cointegration regression (the second lag of the ECT is included, but not shown above), PT test, p-val: is the *p*-value for the Portmanteau Serial Correlation test for the SUR system (using one lag). S(component i) denotes share of component i in M3. The composite rate of return on M3 (RM3) is calculated as the weighted average of the own rates of return on the components of M3, using time-varying weights based on the respective shares in M3 using the formula: RM3 = OD/M3*ROD + SD/M3*RSD + MI/M3*ST. (1) A dummy for the euro cash changeover has been included for 2002.1. (2) A dummy for the financial crisis has been included for 2008.9. (3) Series adjusted for the break caused by a statistical reclassification between overnight deposits and short-term deposits in Spain in June 2005. (4) A dummy for the ECB's correction of holdings of repurchase agreements conducted by central counterparts has been included for 2010.6.

Chart 1: Development of the main components of M3 (EUR billions)

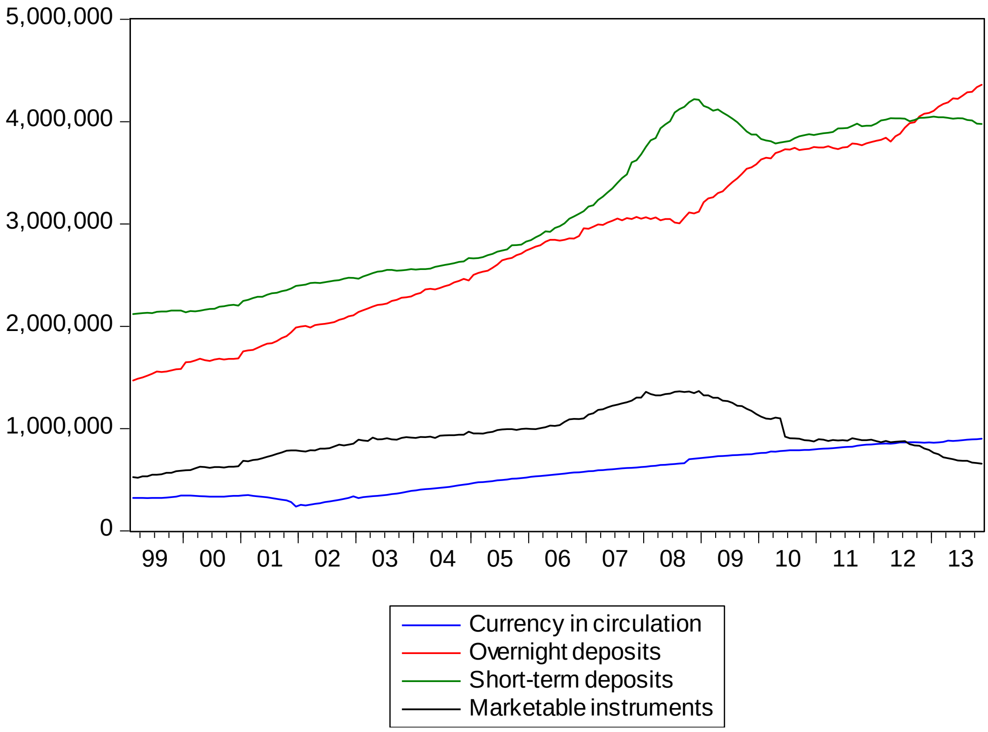


Chart 2: Development of alternative interest rate variables (in percent)

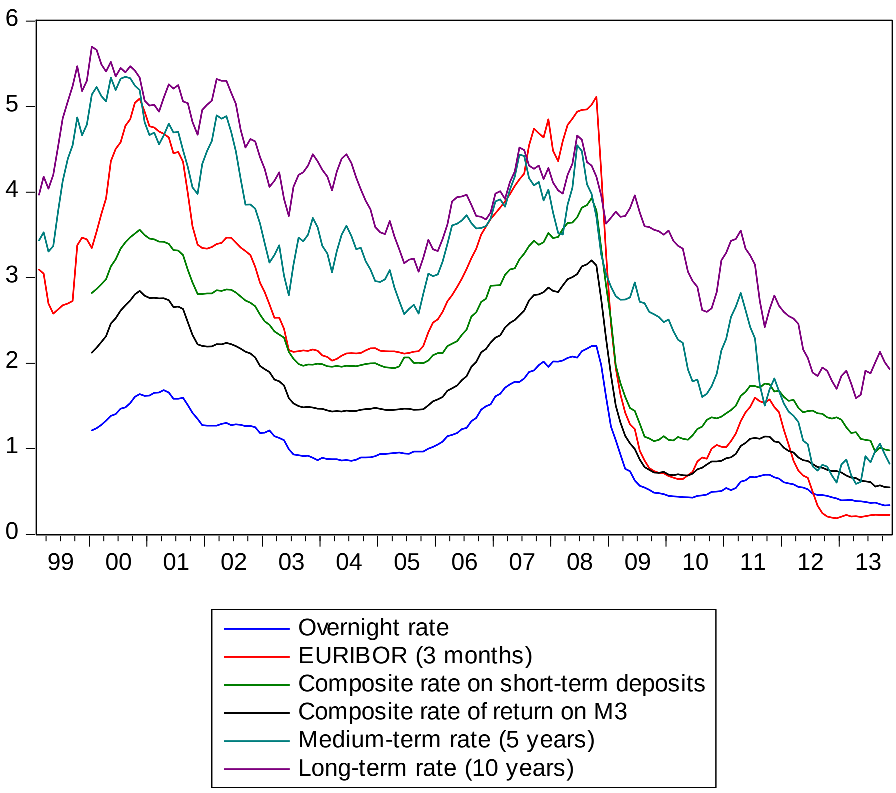


Chart 3: Development of alternative interest rate spreads (in percent)

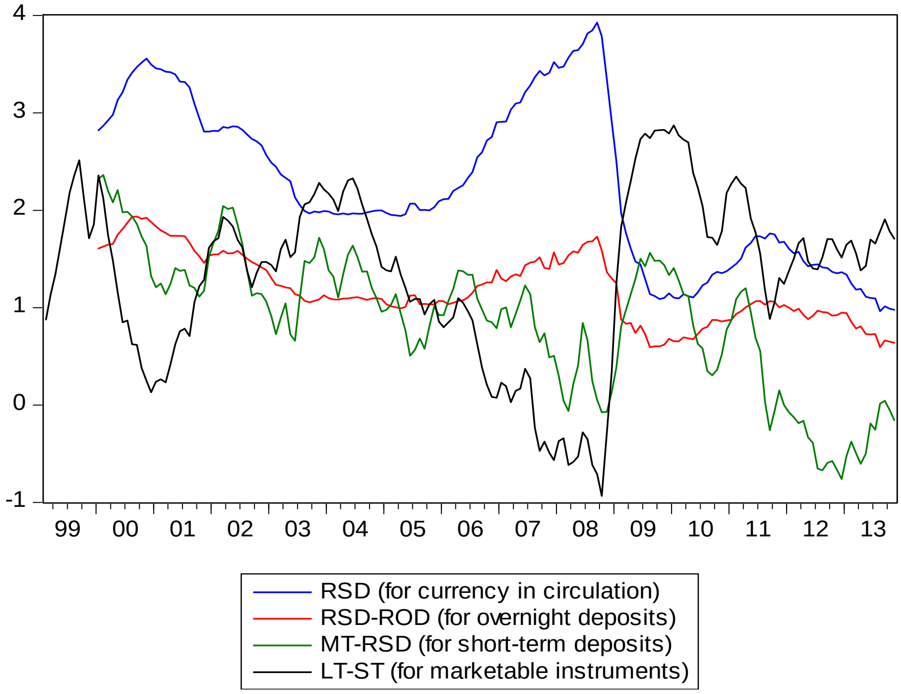


Chart 4: Development of the shares of the components in M3 (in percent of M3)

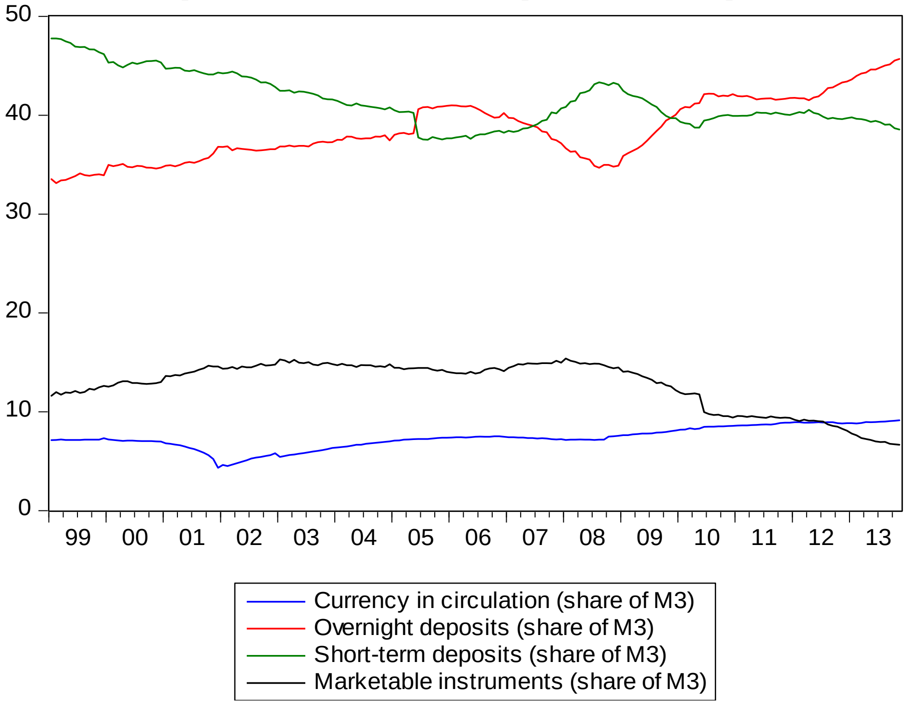


Chart 5: Residuals from the individual demand functions (sample 2000.4 to 2013.11)

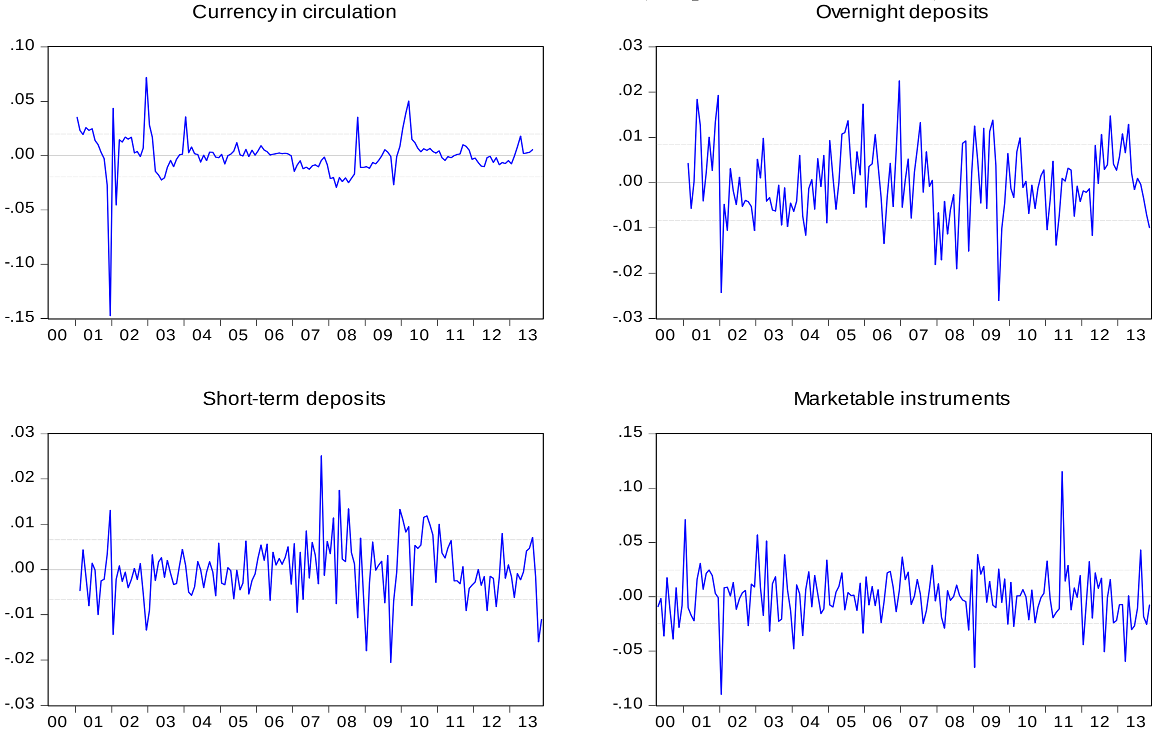
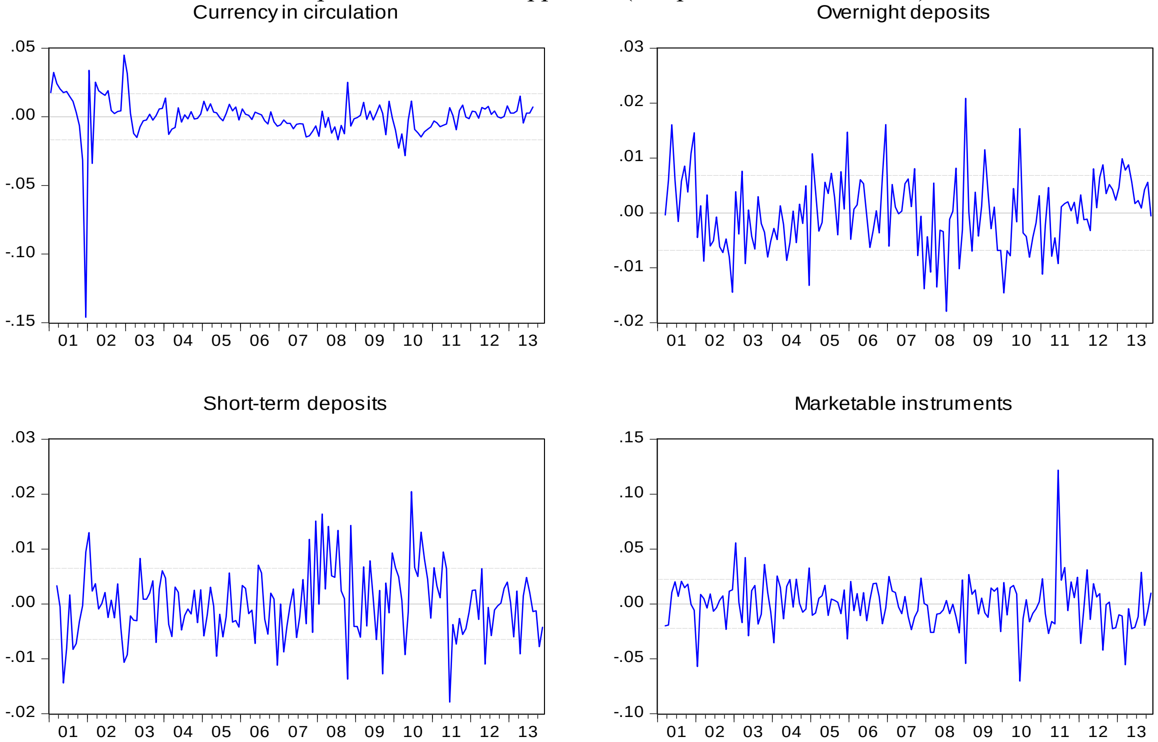


Chart 6: Residuals from the portfolio demand approach (sample 2001.2 to 2013.11)



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