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DOES MONEY MATTER IN THE EURO AREA? EVIDENCE FROM A NEW DIVISIA INDEX

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Highlights

- Standard simple-sum monetary aggregates, like M3, sum up monetary assets that are imperfect substitutes and provide different transaction and investment services. Divisia monetary aggregates, originated from Barnett (1980), are derived from economic aggregation and index number theory and aim to aggregate the money components by considering their transaction service.
- No Divisia monetary aggregates are published for the euro area, in contrast to the United Kingdom and United States. We derive and make available a dataset on euro-area Divisia money aggregates for January 2001 – September 2014 using monthly data. We plan to update the dataset in the future.
- Using structural vector-autoregressions (SVAR), we find that Divisia aggregates have a significant impact on output about 1.5 years after a shock and tend also to have an impact on prices and interest rates. The latter result suggests that the European Central Bank reacted to developments in monetary aggregates. Divisia aggregates reacted negatively to unexpected increases in the interest rates. None of these results are significant when we use simple-sum measures of money.
- Our findings complement the evidence from US data that Divisia monetary aggregates are useful in assessing the impacts of monetary policy and that they work better in SVAR models than simple-sum measures of money.

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1. Introduction

Measuring the impact of monetary policy on the economy at the zero lower bound is difficult. During the past six years, policy rates were cut close to zero in many advanced countries and central banks implemented various unconventional activities, such as large-scale asset purchase programmes in the United States, United Kingdom and Japan, or long-maturity lending to banks in the euro area. Such unconventional monetary policy measures are not reflected in central bank policy rates and therefore standard structural vector-autoregressions (SVAR) involving the policy rate, such as Christiano, Eichenbaum and Evans (1999), cannot be used in their original forms. At the zero lower bound other indicators of monetary policy are needed. A measure of money may be one such indicator, but measures of money have virtually disappeared from standard monetary models.

Beyond issues related to monetary policy at the zero lower bound, there are other more fundamental reasons for rethinking the design of monetary models and for incorporating a measure of money. One important reason for the disappearance of money from monetary models was empirical: estimated money demand functions were found to be unstable and measures of money proved to be less effective in predicting economic outcomes[1]. However, such empirical failures are challenged by the literature on aggregation-theoretic measurement of money, which was originated by Barnett (1980). The most widely used measures of money, such as M2 and M3 published by central banks, are simple sum measures. Simple sum aggregation implies that all components of the money stock are perfect substitutes, which is a very restrictive and improbable assumption. Correct aggregation can be obtained by using either aggregation theory or statistical index number theory, as first underlined by Barnett (1980), who suggested the discrete-time Törnquist-Theil approximation of the Divisia index (see details in the Appendix)[2].

Recent literature studying US data also underlines the usefulness of Divisia money indicators for monetary analysis. For example, within a cointegrated vector autoregression model, Hendrickson (2013) identifies a stable money demand equation using various measures of Divisia money indices and he also finds that Divisia indicators Granger-cause the growth and level of output as well as the level of prices. The same analysis with simple-sum money indicators led to weaker results. Keating, Kelly and Valcarel (2014) showed that a SVAR model with Divisia money worked as well as the model with the Federal funds rate before the crisis. It worked equally well in the sample that include the period of the zero lower bound when the Federal funds rate model could not be used. Using a different SVAR model, Belongia and Ireland (2014) found support for the inclusion of money in the US monetary policy rule. They also identified money demand and monetary system shocks which led to reasonable output and price responses.

[1] Other reasons, as emphasised by for example Leeper and Roush (2003), Belongia and Ireland (2014) and Keating, Kelly and Valcarel (2014), were policy shifts (the focus on interest rates by central banks) and the development of theories suggesting that money is redundant.

[2] As noted by Barnett and Chauvet (2011), the name Divisia is from François Divisia, who first proposed a formula for aggregating quantities of perishable consumer goods (see Divisia, 1925).

The purpose of this paper is to examine the possible role of money shocks on output and prices in the euro area. Since no Divisia monetary aggregates are available for the euro area, we first create and make available a database on euro-area Divisia monetary aggregates[3]. We plan to update the dataset in the future and keep it publicly available. Using different SVAR models, we find sensible and statistically significant responses to Divisia money shocks, while the responses to simple-sum measures of money and interest rates are not statistically significant, and sometimes even the point estimates are not sensible.

2. Data and models

No Divisia monetary aggregates are available for the euro area, in contrast to the US, UK and several other countries[4]. We therefore create and make available a database on euro-area Divisia monetary aggregates for January 2001-September 2014, as detailed in the Appendix. A particular issue with creating Divisia aggregates for the euro area relates to euro-area enlargement: after 2001, six additional countries joined the 12 existing members of the euro area, while Lithuania will join in January 2015. The headline monetary aggregates and their components published by the ECB relate to a changing composition euro-area aggregate and hence there was a level shift in these indicators whenever a new member joined. For economic analysis, such level shifts should be eliminated. We therefore created two versions of the Divisia index which do not suffer from enlargement-related level shifts: one considers only the first twelve members of the euro area, while the other is based on transactions data also published by the ECB. In our empirical work both versions led to very similar results.

We use standard structural vector-autoregressions (SVAR) to estimate the impact of a monetary shock on output and prices. The most commonly used measures of output and prices, GDP and the GDP deflator, are available quarterly, so we use quarterly data. Starting from the first quarter of 2001, from when our Divisia aggregates are available, our sample period includes 54 quarterly observations up to 2014Q2. This sample period is much shorter than sample periods available for the US and UK, so we are obliged to use relatively small-scale models, yet we can still estimate our models with a reasonable degrees of freedom[5].

[3] Our dataset is downloadable from the following website: http://www.bruegel.org/datasets/.

[4] For the US, the Center of Financial Stability (http://www.centerforfinancialstability.org) and the Federal Reserve Bank of St. Louis publish Divisia money aggregates, while the Bank of England publishes such series for the UK. A webpage at the Center of Financial Stability website lists the main works with Divisia money aggregates and available data sources.

[5] Since we use quarterly data, we allow four lags in the VARs, which can also capture any seasonal effect which may have not been properly removed by seasonal adjustment. The use of four lags reduces our effective sample period by 4 to 50. In our four-variable VARs we need to estimate 17 parameters per equation (four lags of each of the four variables plus an intercept), which leaves a reasonable degrees of freedom.

We therefore convert our monthly seasonally adjusted monetary aggregates to the quarterly frequency by using observations from the last month of the quarter. For GDP and the GDP deflator we use the seasonally adjusted euro-area twelve (ie constant country composition) aggregates published by Eurostat. For interest rate, we use two variants: the ECB's main refinancing operations rate (referred to hereafter as the policy rate) and a so-called shadow rate calculated by Wu and Xia (2014). Wu and Xia (2014) estimated shadow rates for the US, UK and the euro area using unobserved components models, using information from the term structure of interest rates. Their estimates are virtually the same as the policy rates when policy rates were well above zero, but their shadow rate estimates turned negative for certain periods when the policy rates were very close to zero[6].

We use two main variants of the SVAR model: one with three variables and one with four variables. In the three-variable VARs we include the standard measures of output and prices and one indicator of money or monetary policy: either an interest rate or a measure of the money stock. In such a simple three-variable SVAR, shocks to monetary policy, money demand and money supply cannot be separately identified, yet it is instructive to start with a simple model and as we will see, responses derived from larger models give similar results. In the four variable SVARs we include both a measure of interest rate and money, in addition to output and prices. Thereby, we are able to check the responses to the two key monetary variables when both are included in the model.

Output, prices and monetary aggregates enter the model in log-levels, while the interest rates are included in percent. Such a specification can lead to consistent estimation of the model parameters, irrespective of whether or not there is a cointegration relationship between the variables. Due to our small-scale models, we cannot adopt a complex identification technique. We therefore assume a standard recursive model and use the Cholesky-decomposition to identify structural shocks. Since the Cholesky-decomposition depends on the ordering of the variables, we tried different orderings, which did not change the main findings reported in the next section.

[6] See a graphical comparison of policy rates and shadow rates at Jing Cynthia Wu's website: http://faculty.chicagobooth.edu/jing.wu/research/data/WX.html

3. Results

Figure 1 presents the results from the three-variable VARs. The first two rows of the figure show responses to different measures of the interest rate. The estimated impact of a shock to the European Central Bank policy rate on output is negative, but it is not significantly different from zero in each quarter after the shock. The response of the price level is not significant either, yet the point estimate suggests a "price puzzle" during the first year after the shock, ie an increase in the price level following a monetary contraction. The shadow rate works better than the policy rate: the point estimate does not suggest a price puzzle and by about 7-10 quarters after the shock zero is at the boundary of the 95 percent confidence band of price responses, suggesting that it is significant (though the output response is not significant).

The results with different monetary aggregates are reported in rows 3-6 of Figure 1. Divisia monetary aggregates work better than simple-sum monetary aggregates. The response of output to a Divisia shock is positive and statistically significant about 5-7 quarters after the shock for both Divisia M2 and M3. This approximately 1.5 year horizon coincides perfectly with the horizon at which monetary policy it thought to have an effect on the economy. The output level response is temporary as the impulse-response function returns to zero, which is quite sensible because we would not expect a monetary shock to have a permanent impact on the level of output. While the shape of the responses to shocks to simple-sum monetary aggregates is similar, the impulse response function is never significant. The response of prices to a money shock is only significant for M2 Divisia about 9 quarters after the shock. For M3 Divisia and both M2 and M3 simple sum, the price response is not significant, but for M3 Divisia a larger fraction of the 95 percent confidence band lies above zero than in the case of the simple sum measures. The point estimates suggest that prices increase after an expansionary monetary shock, which is sensible, ie no price-puzzle arises.

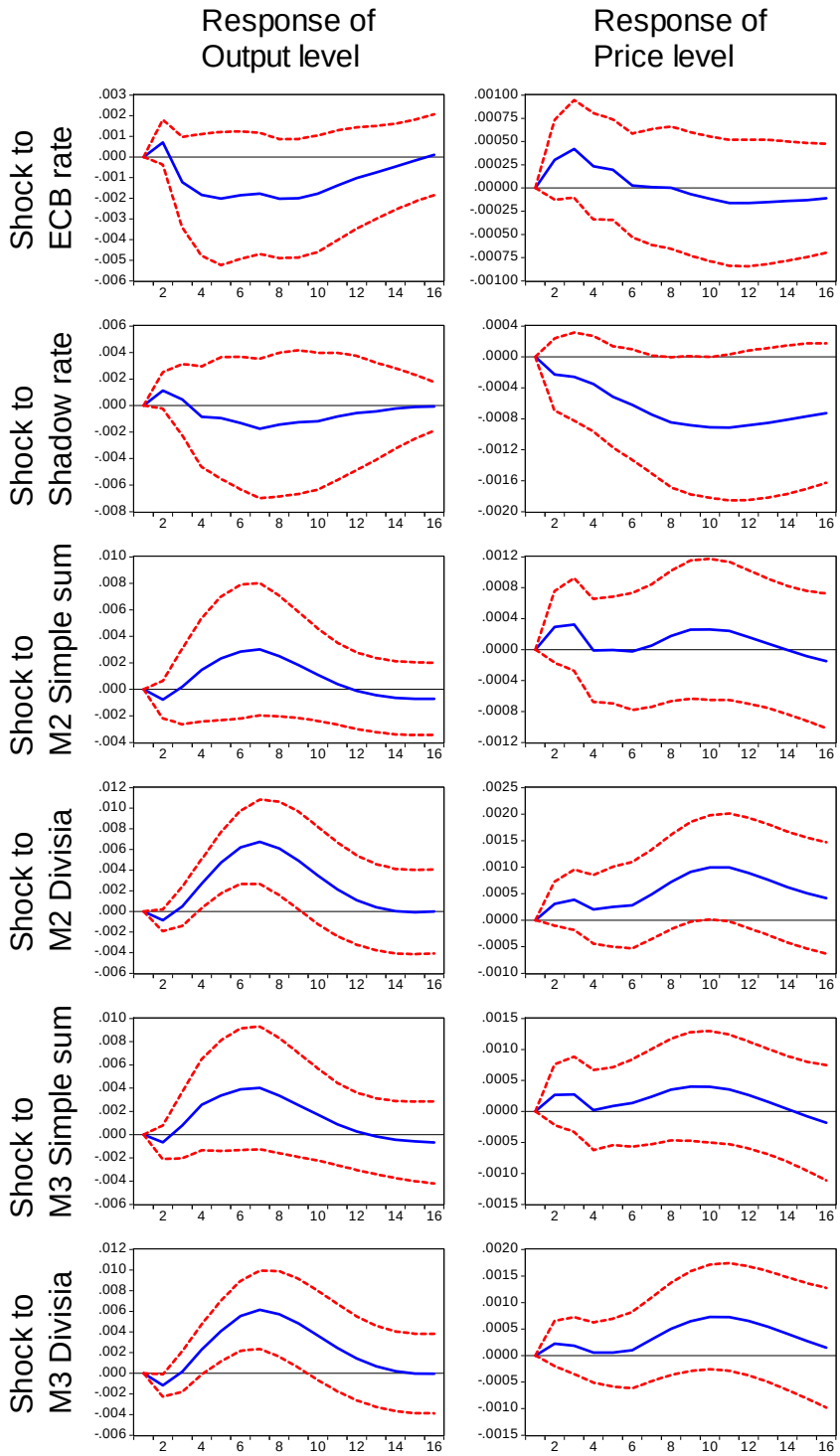
In the four-variable VARs both a measure of interest rate and money are included. We include only the shadow rate as the interest rate variable, because it is better indicator from the theoretical perspective when the policy rate reaches the zero lower bound, and also because it led to more sensible responses than the policy rate in the three-variable VARs. As a measure of money, we check the results with four different options: M2 or M3 and either simple-sum or Divisia.

Figure 2 shows the results, which clearly underline that Divisia monetary aggregates lead to more sensible responses than simple sum aggregates.

- The output response is significantly different from zero to about 5-7 quarters after a shock to Divisia aggregates, but it is not significant for shocks to simple-sum monetary aggregates.

- The price responses are not significant for any of the monetary aggregates, but a larger fraction of the confidence band lies above zero for the Divisia aggregates than for the simple-sum aggregates.
- The shadow rate increases significantly after a shock to Divisia money, which is sensible and suggests that the ECB reacted to monetary developments, eg by increasing the interest rate following an unexpected increase in money. With simple-sum measures the interest rate response is not significant.
- Finally, M2 Divisia reacts negatively to an interest-rate shock, which is significant about 10 quarters after the shock. This is again sensible and suggests that money growth can be tamed by interest-rate increases. The same impulse response is not significant for Divisia M3, however, a larger fraction of the confidence band lies below zero than in the cases of M2 and M3 simple-sum measures of money.

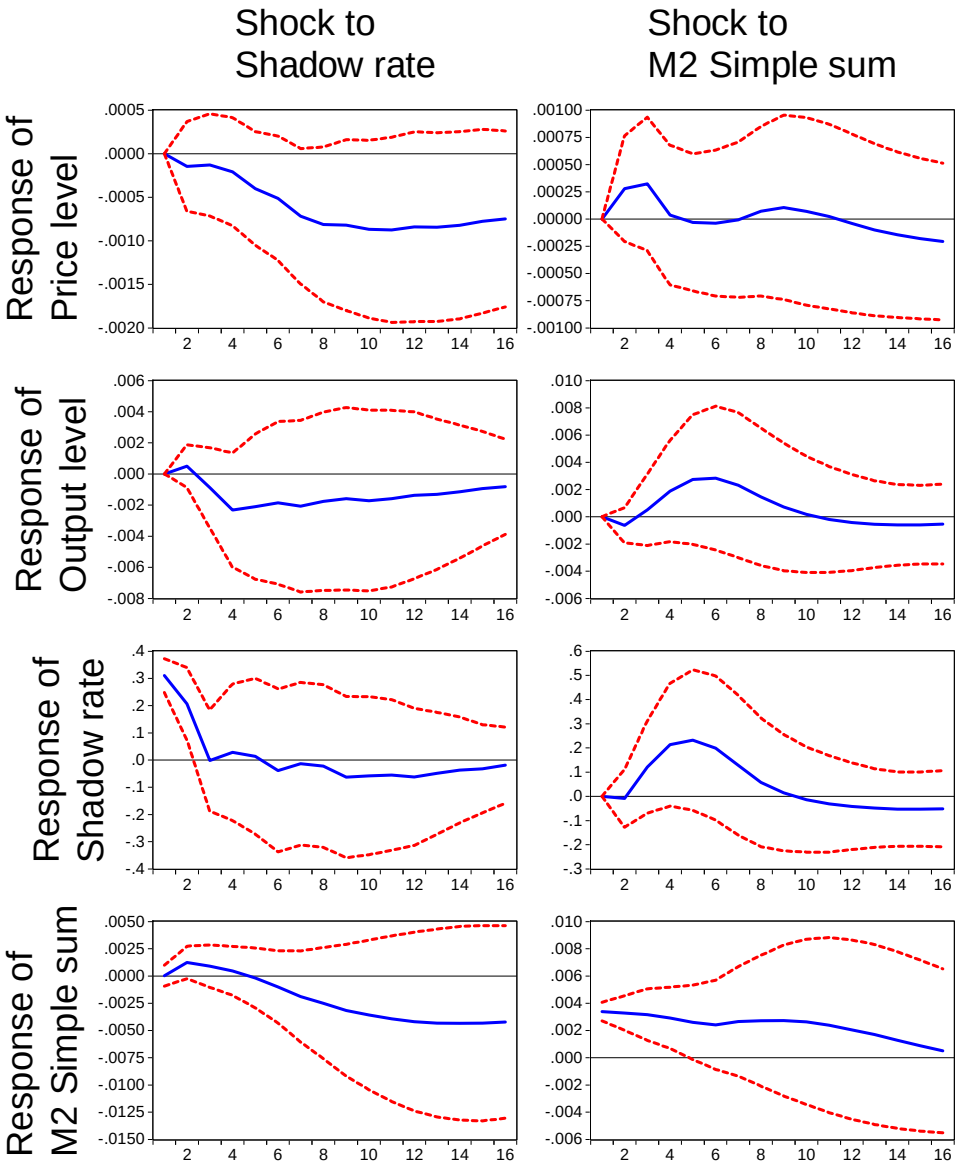
Figure 1: Response of output and price levels to a monetary shock derived from three-variable VARs



Note: The solid blue line indicates the point estimate of the impulse response function of the variable indicated on the top of the columns to a one standard deviation Cholesky shock indicated on the left, while the dashed red lines indicate the boundaries of the 95 percent confidence band. The horizontal axis indicates the number of quarters after the shock (with the shock occurring in quarter 1). We expect a negative response of output and prices to an interest rate shock and positive response of output and prices to a money shock. The responses were derived from three-variable VARs. Two variables are the same in each VAR: the log of GDP deflator and the log of constant price GDP. The third variable is indicated on the left of each line: interest rates are included in percent, while monetary aggregates are included as log-levels.

Figure 2A: Impulse responses to interest rate and money shocks derived from four-variable VARs

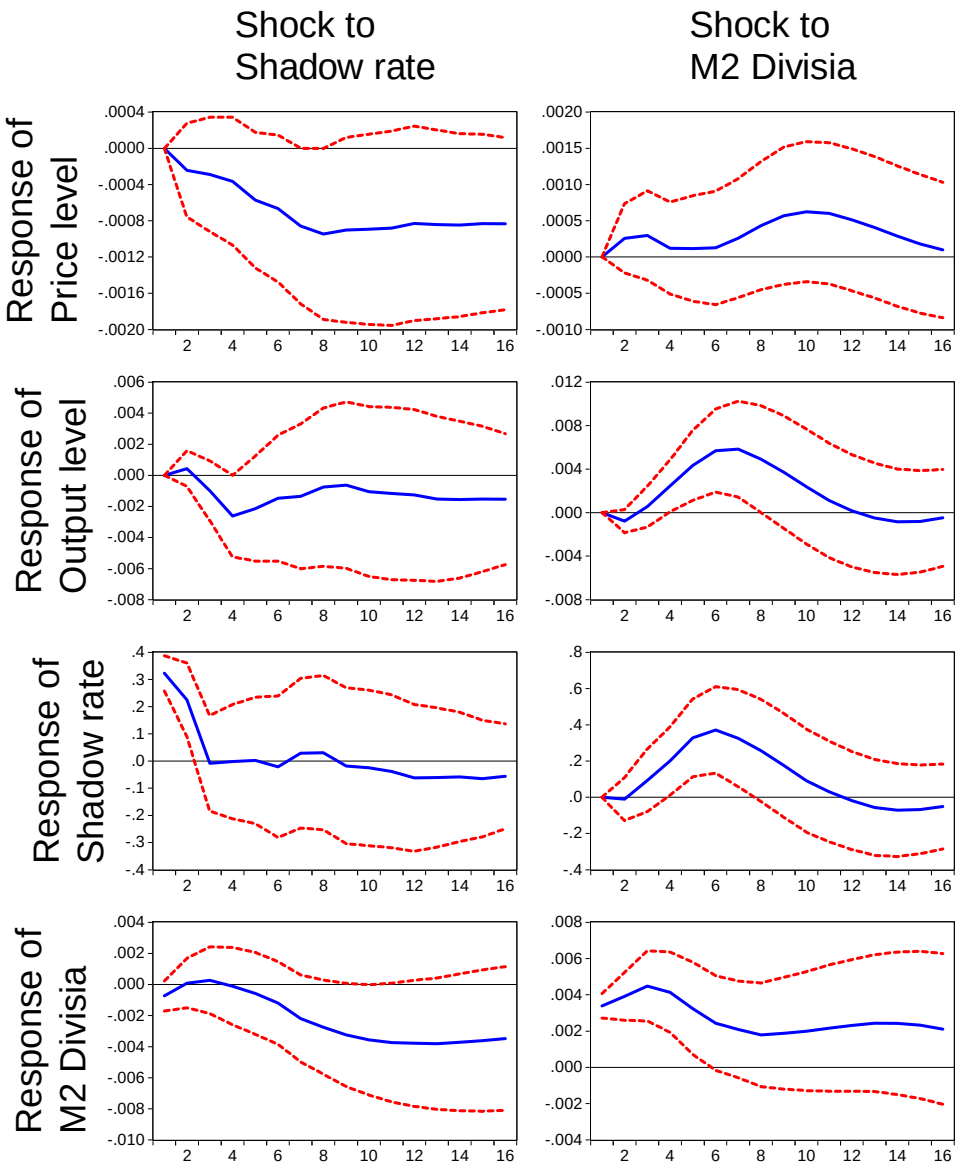
A: Using M2 simple sum



Note: The solid blue line indicates the point estimate of the impulse response function of the variable indicated on the left of each row to a one standard deviation Cholesky shock indicated on the top of each column, while the dashed red lines indicate the boundaries of the 95 percent confidence band. The horizontal axis indicates the number of quarters after the shock (with the shock occurring in quarter 1). The impulse-responses were derived from a four-variable VARs including the log of GDP deflator, the log of constant price GDP, the shadow rate (in percent) and the log of the monetary aggregate indicated in the subtitle.

Figure 2B: Impulse responses to interest rate and money shocks derived from four-variable VARs

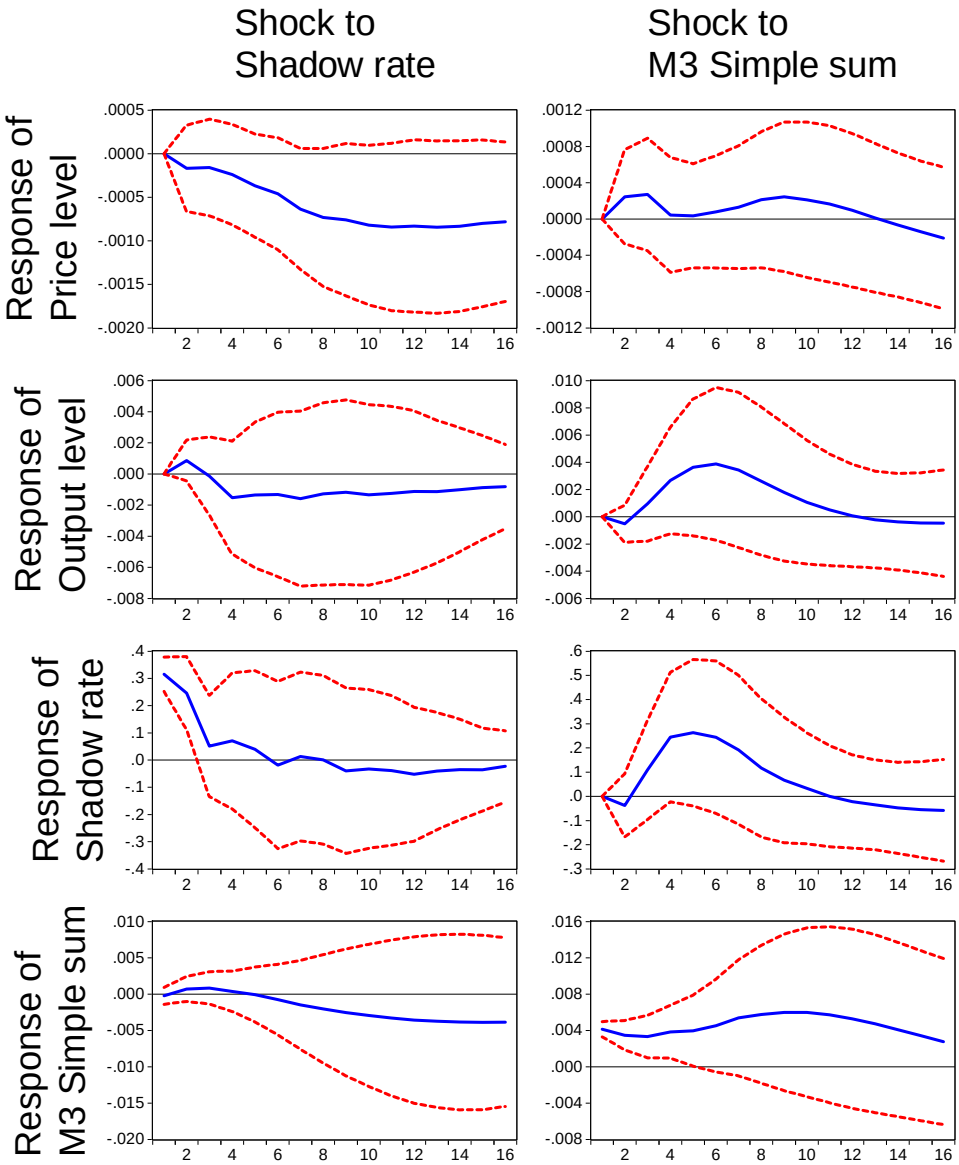
B: Using M2 Divisia



Note: see Figure 2A.

Figure 2C: Impulse responses to interest rate and money shocks derived from four-variable VARs

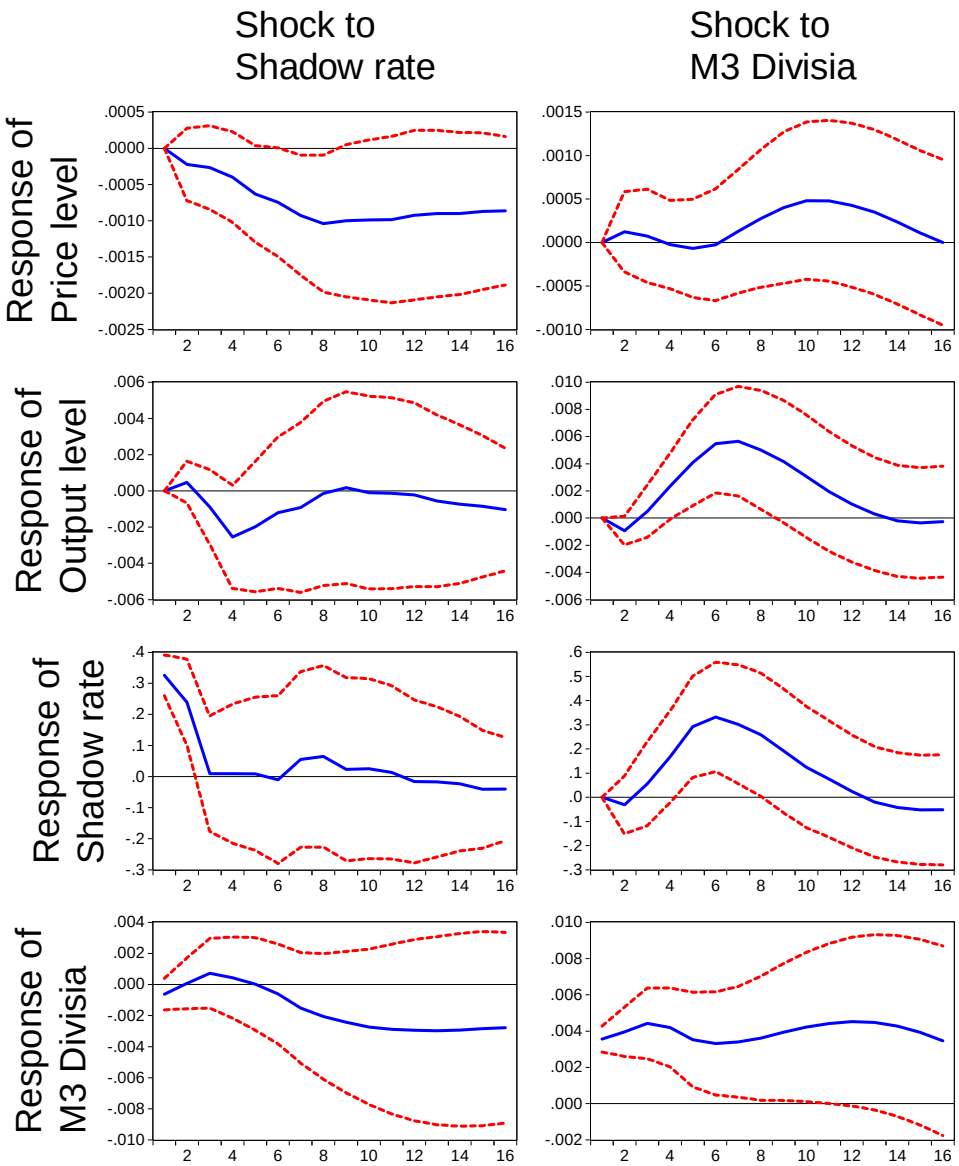
C: Using M3 Simple sum



Note: see Figure 2A.

Figure 2D: Impulse responses to interest rate and money shocks derived from four-variable VARs

D: Using M3 Divisia



Note: see Figure 2A.

4. Conclusions

We created a new database on euro-area Divisia monetary aggregates and used structural vector-autoregressions to analyse the impact of interest-rate and money shocks on euro-area output and prices. Our estimates demonstrate the usefulness of Divisia monetary aggregates for analysing monetary shocks in the euro area. We find that shocks to Divisia aggregates have a significant impact on output about 1.5 years after the shock, while shocks to simple-sum monetary aggregates and shocks to interest rates (measured by either the ECB policy rate or an estimated shadow rate) did not have significant impacts on output. We find a significant impact on prices only with one SVAR model using Divisa M2 aggregate and another SVAR using the shadow rate. Yet even in model variants in which Divisia indicators did not have a statistically significant impact on prices, the estimated price responses to Divisia shocks were as theoretically expected (the so-called "price puzzle" did not arise) and a large fraction of the confidence interval lay above zero. In contrast, when we used simple-sum measures of money, the confidence bands were broadly symmetrical around zero. We also found a statistically significant impact of shocks to Divisia on interest rates, suggesting that the ECB reacted to developments in monetary aggregates. With simple-sum measures the interest rate response was not significant. Finally, we also found that Divisia measures of money tend to react negatively to unexpected increases in interest rates, which is sensible, but the results with simple-sum monetary aggregates were much weaker in this regard too. Overall, our findings complement the evidence from US data that Divisia monetary aggregates are useful in assessing the impacts of monetary policy and that they work better in SVAR models than simple-sum measures of money.

Our findings open further research avenues. A key question with major policy relevance is the impact of unconventional monetary policy measures, such as unlimited liquidity provision to banks or the announcement of the ECB's Outright Monetary Transactions (OMT), on money demand and supply and on Divisia money developments. These issues are left for further research.

Appendix

1. Introduction

Standard simple-sum monetary aggregates, like M3, sum up monetary assets that are imperfect substitutes and provide different transaction and investment services. Divisia monetary aggregates, originated from Barnett (1980), are derived from economic aggregation and index number theory and aim to aggregate the money components by considering their transaction service. As noted by Barnett and Chauvet (2011), the name Divisia is from François Divisia, who first proposed a formula for aggregating quantities of perishable consumer goods (see Divisia, 1925).

No official Divisia monetary aggregates are published for the euro area, in contrast to the UK and US. Estimates for the euro area by academic researchers are scarce and we could not find any publicly available dataset. Earlier works on the euro area include Wesche (1997), Reimers (2002), Barnett (2003), Stracca (2004), Binner *et al* (2009), Jones and Stracca (2012) and Barnett and Gaekwad-Babulal (2014). Most of these papers aggregated country-specific data to obtain an aggregate for the euro area.

In our paper we derive and make available a dataset on euro-area Divisia monetary aggregates corresponding to the standard (simple sum) monetary aggregates published by the European Central Bank (ECB), ie M1, M2 and M3. Our sample period covers monthly data between January 2001 and September 2014 and we plan to update the dataset in the future. During our sample period, the euro area existed and data on (changing composition of) euro-area aggregates is also available. We therefore base our calculations on euro-area data instead of using country-specific data and aggregating them at the euro-area level.

For calculating Divisia indices, data on the components of the money stock and their interest rates are needed. Data on the stock of outstanding quantities of the components of M3, the broadest monetary aggregate published by the ECB, is available from September 1997 (on a changing country-composition basis). Interest rate data on all of these components is available from January 2003 onwards (for a few indicators, earlier data is available from other sources), implying that from this date, high-quality Divisia aggregates can be calculated for the euro area. Using country-specific data, we approximate the missing euro-area interest rates for January 2001-2002 with a good level of confidence.

The use of changing composition euro-area outstanding stocks for econometric analysis is inappropriate, because there is a level shift in the data when a new member joins. We therefore derive two versions of the Divisia index which do not suffer from enlargement-related level shifts: one considers only the first twelve members of the euro area, while the other is based on transactions data also published by the ECB.

This appendix details our methodology, data sources and adjustments made, and presents the resulting indicators.

2. The theory and methodology of calculating Divisia monetary aggregates

The simple-sum monetary aggregates published by many central banks simply add up the different components of money:

(1) $$S_t = \sum_{i=1}^{N} M_{i,t} \ ,$$

where S_t is the simple-sum monetary aggregate (like M3), $M_{i,t}$ is the level of the *i*-th money holding (like demand deposits) and *N* denotes the number of components considered (e.g. 7 for the ECB's M3 aggregate). We denote by $v_{i,t}$ the share of each component in the monetary aggregate, which is:

(2) $$v_{i,t} = \frac{M_{i,t}}{\sum_{j=1}^{N} M_{j,t}} \ .$$

As Barnett, Fisher and Serletis (1992) noted, the simple sum aggregation in equation (1) implies that all components are perfect substitutes, since all indifference curves and isoquants over those components must be linear with slopes of minus one, if this aggregate is to represent the actual quantity selected by economic agents. They also note that Irving Fisher found the simple-sum index to be the least useful of the hundreds of possible indices he studied. The perfect substitutability condition is very problematic, because eg cash differs so much from short maturity bank bills and bonds, which are part of the ECB's M3 indicator.

Better aggregation can be obtained by using either aggregation theory or statistical index number theory, as first underlined by Barnett (1980). In aggregation theory, aggregator functions are utility functions for consumers and production functions for firms. While aggregation theory is important in theory and in hypothesis testing, derived aggregators depend on unknown parameters, making them impractical for use by central banks and government agencies for calculating and publishing data. For this reason, Barnett (1980) proposed the use of index number theory, which does not depend on unknown parameters, but can depend on the prices of components (beyond the quantity of components). He also notes that the definition of exact[1] statistical index numbers does depend upon the maximising behaviour of economic agents and that Hulten (1973) has proved that in continuous time the Divisia index is always exact for any consistent (blockwise homothetically weakly separable) aggregator function.

In discrete time the Divisia index has to be approximated, for which different choices can be made. Barnett (1980) proposed the Törnquist-Theil Divisia index, which is:

(3) $$\frac{D_t}{D_{t-1}} = \prod_{i=1}^{N} \left(\frac{M_{i,t}}{M_{i,t-1}} \right)^{\left(\frac{1}{2}\right)\left(s_{i,t} + s_{i,t-1}\right)} \ ,$$

[1] An index number is called exact if it exactly equals the aggregator function whenever the data is consistent with microeconomic maximising behaviour. See Diewert (1976), who also defined a quantity (price) index as superlative if it is exact for a flexible aggregator (unit cost) function. An aggregator (unit cost) function is flexible if it can provide a second-order approximation to an arbitrary twice differentiable linearly homogeneous aggregator (unit cost) function. See Hill (2006) on the difficulties in selecting which superlative index should be used.

(4) $$s_{i,t} = \frac{\pi_{i,t} M_{i,t}}{\sum_{j=1}^{N} \pi_{j,t} M_{j,t}},$$

where D_t is the quantity of the Divisia index, $s_{i,t}$ is the share of the *i*-th component, $\pi_{i,t}$ is the rental price (or user cost) for good *i* in period *t*. The (nominal) user cost of money was derived by Barnett (1978):

(5) $$\pi_{i,t} = p_t^* \left(\frac{r_{B,t} - r_{i,t}}{1 + r_{B,t}} \right),$$

where p_t^* is the cost of living index, $r_{B,t}$ is the rate of return on the benchmark asset (which provides no liquidity or other monetary services and is solely used to transfer wealth intertemporally) and $r_{i,t}$ is the own rate of return on asset *i*. The real user cost ($\rho_{i,t}$) is obtained by taking away p_t^* from (5):

(6) $$\rho_{i,t} = \left(\frac{r_{B,t} - r_{i,t}}{1 + r_{B,t}} \right).$$

By taking logs of (3), it is easy to see that for the Divisia index the growth rate (log change) of the aggregate is the share-weighted average of the growth rates of component quantities, as highlighted by Barnett, Fisher and Serletis (1992):

(7) $$\log(D_t) - \log(D_{t-1}) = \sum_{i=1}^{N} s_{i,t}^* \left(\log(M_{i,t}) - \log(M_{i,t-1}) \right),$$

where $s_{i,t}^* = (1/2)(s_{i,t} - s_{i,t-1})$.

The Bank of England writes the expression in a different form (see Hancock, 2005)[2]:

(8) $$\frac{\Delta D_t}{D_{t-1}} = \sum_{i=1}^{N} \frac{1}{2} (w_{i,t} + w_{i,t-1}) \frac{\Delta M_{i,t}}{M_{i,t-1}},$$

where the weights, $w_{i,t}$, are defined as:

(9) $$w_{i,t} = \frac{(r_{B,t} - r_{i,t}) M_{i,t}}{\sum_{j=1}^{N} (r_{B,t} - r_{j,t}) M_{j,t}}$$

However, the only difference between (7) and (8) is that (7) uses log-changes while (8) uses percent changes. This is because in fact $s_{i,t} = w_{i,t}$, since the $p_t^* / (1 + r_{B,t})$ component of $\pi_{i,t}$ cancels out in (4). Log-changes are almost identical to percent changes for small changes and money components used not to change much

[2] According to Hancock (2005), the Bank of England uses a moving average of $\Delta M_{i,t}$ on the right hand side of equation (8), i.e. instead of $\Delta M_{i,t}$, they use $(\Delta M_{i,t} + \Delta M_{i,t-1})/2$, but we could not confirm this smoothing from other sources. In our calculation we use $\Delta M_{i,t}$ and not its moving average.

from one month to the other, so (7) and (8) should lead to virtually identical results. We calculate our Divisia indices according to (8).

In practice, calculations in the literature also used to differ whether the nominal stocks of money components ($M_{i,t}$) or their real stocks or per capita stocks are used in the aggregation. We use the simple nominal stock of money components.

3. The ECB's monetary aggregates

Using harmonised definitions of the money-issuing sector, the money-holding sector and monetary financial institutions' (MFI) liabilities categories, the ECB calculates and publishes three monetary aggregates for the euro area (on a changing country-composition basis): a narrow aggregate (M1), an "intermediate" aggregate (M2) and a broad aggregate (M3). Table 1, taken from the ECB website, presents the components of the monetary aggregates. These aggregates are calculated by simply adding the euro value of the components (ie these are simple sum measures).

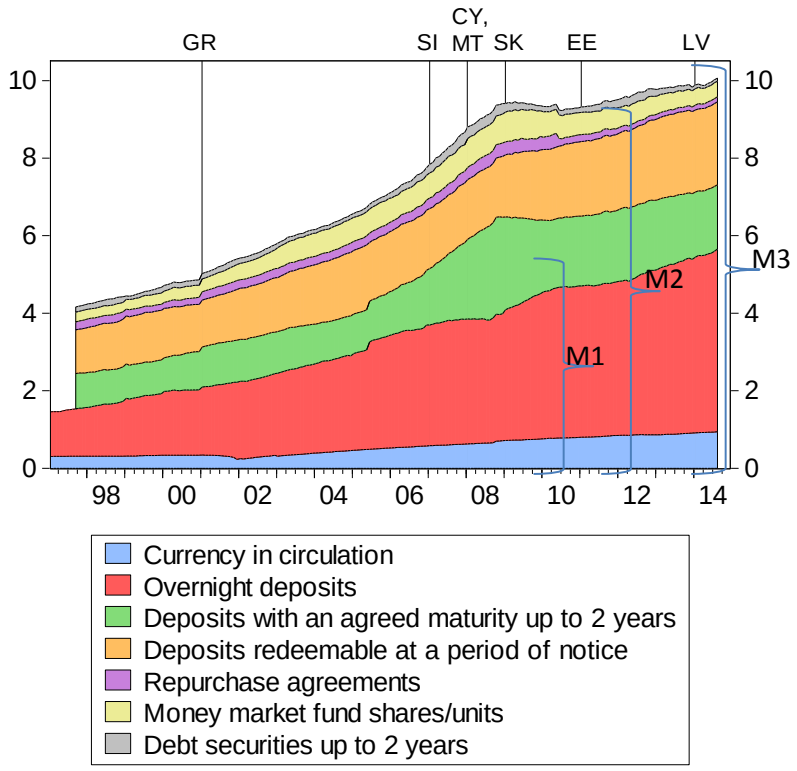
Table 1: ECB's definitions of euro area monetary aggregates

Liabilities °1°	M1	M2	M3
1. Currency in circulation	X	X	X
2. Overnight deposits	X	X	X
3. Deposits with an agreed maturity up to 2 years		X	X
4. Deposits redeemable at a period of notice up to 3 months		X	X
5. Repurchase agreements			X
6. Money market fund (MMF) shares/units			X
7. Debt securities up to 2 years			X

(1) Liabilities of the money-issuing sector and central government liabilities with a monetary character held by the money-holding sector. Source: http://www.ecb.europa.eu/stats/money/aggregates/aggr/html/hist.en.html

Figure 3 shows the importance of the seven components of M3, the broadest monetary aggregate (using the data sources to be detailed in the next section). Overnight deposits have the largest share in the simple sum M3, followed by deposits redeemable at notice.

Figure 3: Components of euro-area (changing composition) M3, seasonally adjusted, € trillions



Note: the vertical lines with the country-codes above indicate the dates when these countries joined the euro area. GR: Greece, SI: Slovenia, CY: Cyprus, MT: Malta, SK: Slovakia, EE: Estonia, LV: Latvia.

4. Data sources and adjustments

Our aim is to calculate Divisia monetary aggregates corresponding to the three monetary aggregates published by the ECB, both for the changing composition euro area and for the first twelve member states that joined the euro (constant composition). We also aim to calculate the user cost of the three aggregates.

4.1 Data sources

Most of our data is from the ECB's Statistical Data Warehouse. In addition,

- Data on currency issued was downloaded from the International Monetary Fund's International Financial Statistics (IFS);
- Some German deposit rates were collected form the website of the Bundesbank;
- The return on debt securities up to two years is approximated by the Bank of America Merrill Lynch 1-3 Year Euro Financial Index.

Table 2 on the next page presents a summary of the data availability.

Table 2: Summary of data availability

A: Monetary aggregates

	Euro area (changing composition)	Country-specific data
1. Currency in circulation	SA: January 1980, NSA: September 1997	No, but currency issued is available from the IMF IFS
2. Overnight deposits	SA: January 1980, NSA: September 1997	For a different reference sector*: September 1997, NSA, for the first 11 countries of the euro area; March 1998 for Greece; other six members: from about two years before their euro entry
3. Deposits with an agreed maturity up to two years	September 1997, both NSA and SA	same as for overnight deposits
4. Deposits redeemable at a period of notice	September 1997, both NSA and SA	same as for overnight deposits
5. Repurchase agreements excluding repos with central counterparties	September 1997, both NSA and SA	Only for total repos** and for a different reference sector: same as for overnight deposits; for some countries there are only zero values
6. Money market funds	September 1997, both NSA and SA	same as for overnight deposits; for some countries there are only zero values
7. Debt securities up to two years	September 1997, both NSA and SA	No***

Source: All data except currency issued by member states is from the ECB's Statistical Data Warehouse.

Note: NSA: Neither seasonally nor working day adjusted; SA: Working day and seasonally adjusted.

** The reference sector used by the ECB for calculating the three monetary aggregates is "MFIs, central government and post office giro institutions". Unfortunately, country-specific data is not available for this reference sector, but available for the reference sector "MFIs excluding ESCB". ECSB = European System of Central Banks. The difference between the data for the two reference sectors of the euro-area aggregates is generally small or even zero, see Section 4.4 in which we plot the differences.*

*** The exact definition of repurchase agreements included in the ECB's monetary aggregates is: "Repurchase agreements excluding repos with central counterparties". Unfortunately, country-specific data is not available for this component, but only for total repurchase agreements, and for the reference sector described in * above. As we detect in Section 4.4, central counterparties are excluded only from June 2010 onwards, causing a break in this component and also in M3.*

**** Data on short term debt securities issued by MFIs is available, but it has a very different level and dynamics compared to the component included in M3.*

B: Interest rates

	Euro area (changing composition)	Country-specific data
1. Currency in circulation	assumed to be zero	assumed to be zero
2. Overnight deposits	January 2003	Harmonised data: January 2003 for the first 12 members; from the date of euro entry (or a few months earlier) for the newer members. Non-harmonised data*: December 1995-June/September 2003 for six countries (Austria, Finland, Greece, Italy, Netherlands and Spain); German data from Bundesbank for January 2000-December 2002
3. Deposits with an agreed maturity up to two years	January 2003	Harmonised data: same as for overnight deposits. Non-harmonised data*: December 1995-June/September 2003 for ten countries (first twelve euro members except Ireland and Luxembourg), but for somewhat different maturities
4. Deposits redeemable at a period of notice	January 2003	Harmonised data:January 2003 for five countries (Germany, Spain, Finland, France, Ireland); from later dates for 10 other countries, but there are many gaps in the data; in September 2014 data was available for 9 countries. Non-harmonised data*: December 1995-June/September 2003 for four countries (Belgium, Germany, Greece and Ireland)
5. Repurchase agreements	January 2003	Harmonised data: January 2003 for the four countries (Spain, France, Greece, Italy), but the Greek data end in 2011
6. Money market funds	We use the Eonia rate; available from January 1995**	No
7. Debt securities up to two years	We use the Bank of America Merrill Lynch 1-3 Year Euro Financial Index; available from January 1996***	No

Source: All data except German overnight deposit rate in 2000-2002 and the Bank of America Merrill Lynch 1-3 Year Euro Financial Index is from the ECB's Statistical Data Warehouse.

Note:

** Some of the non-harmonised interest rate data must have very different definitions from the harmonised data and therefore cannot be used to proxy euro-area data for earlier years, as we discuss in the next section.*

*** Eonia, euro overnight index average, is a measure of the effective interest rate prevailing in the euro interbank overnight market. It is calculated as a weighted average of the interest rates on unsecured overnight lending transactions denominated in euro, as reported by a panel of contributing banks. See* https://www.ecb.europa.eu/home/glossary/html/glosse.en.html#189

****The BofA Merrill Lynch Euro Financial Index tracks the performance of EUR denominated investment grade debt publicly issued by financial institutions in the eurobond or euro member domestic markets. The BofA Merrill Lynch 1-3 Year Euro Financial Index is a subset of The BofA Merrill Lynch Euro Financial Index including all securities with a remaining term to final maturity less than 3 years. Qualifying securities must have at least one year remaining term to final maturity, at least 18 months to final maturity at point of issuance, a fixed coupon schedule and a minimum amount outstanding of EUR 250 million See:* http://www.mlindex.ml.com/gispublic/bin/getdoc.asp?fn=EB01&source=indexrules

In order to check the consistency of the money components with the simple sum aggregates M1, M2 and M3 published by the ECB, we calculated the sum of the components: the sums calculated by us were identical to the monetary aggregates published by the ECB, both for the unadjusted and the seasonally adjusted data.

In addition to monetary aggregates, the ECB publishes data on monthly transactions and the percent changes in a co-called index of notional stocks.

Transactions data are derived by adjusting the change in stocks with reclassification, revaluation and exchange rate adjustment of the components. Such changes and breaks in the series should be disregarded when growth rates of money stocks are calculated or when a time series is used for econometric analysis.

The index of notional stocks is calculated as a chain-index, by multiplying the previous period value of notional stock with the percent increased derived from transaction data, where the percent change is calculated by dividing the transaction in a given month with the outstanding amounts of the asset at the end of the period. See Section 4.2 and 4.3 of ECB (2012) for details.

4.2 Approximating non-available euro-area average interest rates for 2001-2002

Panel B of Table 2 shows that interest rates for four components of M3 are available for the euro area (changing composition) starting in January 2003. We approximate these four interest rate series for 2001-2002 using country-specific data and explain the data limitations that do not allow a proper approximation of two of these four interest rate series pre-2000 with a sufficient coverage. Approximating for 2000 would be possible, but we decided to start our sample in January 2001 because Greece joined the euro area in this month and our focus is on a constant composition euro-area aggregate for the first twelve members. Starting our sample period in January 2001 implied that no aggregation is needed for countries with different currencies. Also, in 2000 Greek interest rates behave very differently from those of euro-area members that joined in 1999, which would make it more difficult to interpret their aggregate in 2000.

Overnight deposit rate

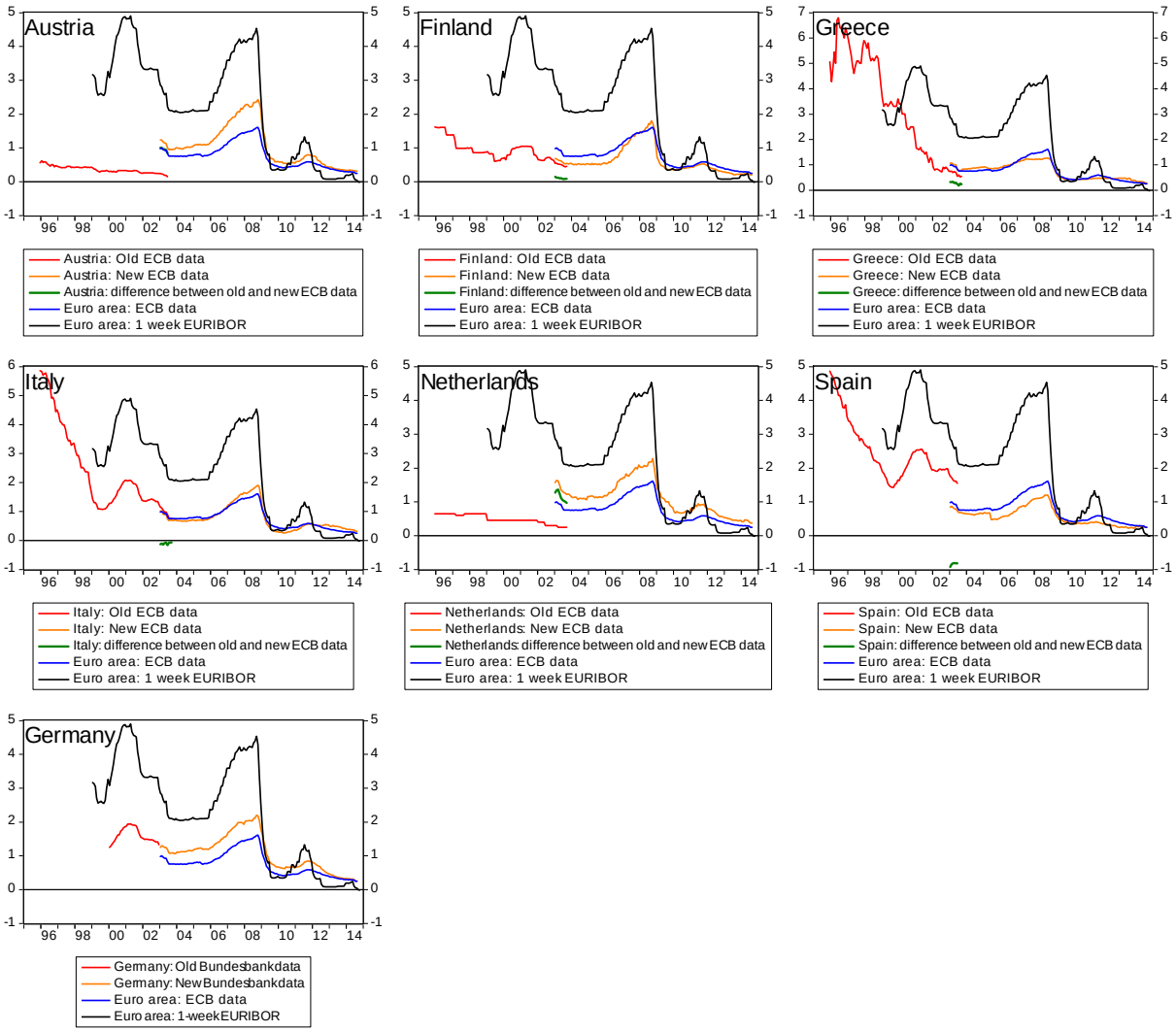
The ECB publishes country-specific interest rates on overnight deposits starting in January 2003 for all the euro-area countries at that time (data for newer euro-area members is available from later dates). The series are regularly updated (the latest data is for September 2014). For six of the first twelve members, separate series are available from the ECB for December 1995 – June or September 2003. We could find pre-2003 data only at the Bundesbank website for Germany, but not at the central bank websites of the other larger euro-area countries.

The first six panels of Figure 4 plot the new and the old ECB series for the six countries for which the ECB publishes pre-2003 data, along with the euro-area average overnight deposit rate and the 1-week EURIBOR. For Finland, Italy and Greece the old and new data match quite well. For Austria and the Netherlands the old series are very different from the new series and the old series are almost constant at a time when all other interest rate series (of these two countries and of other euro-area countries) exhibited an increasing trend in late 1999 and then a falling trend in mid-2001. Because of these discrepancies, we do not use the pre-2003 Austrian and Dutch time series. The old Spanish series are also different in levels from the new Spanish series, but its dynamics are quite plausible given the dynamics in other countries. Therefore, for Finland, Italy, Greece and Spain we make use of the old ECB series and chain them backwards to the new ECB series, by adding to the old series the average spread between the new and the old series in the period when both are available (ie in the first six or nine months of 2003; see the thick green lines on the charts).

For Germany, the Bundesbank publishes effective overnight interest rates separately for German households and non-financial corporations, for two sample periods: a 'new' one starting in January 2003, which is regularly updated, while the 'old' one is available for January 2000 – December 2002. We used the volume of

households' and non-financial corporations' overnight deposit outstanding quantities (available from January 2003) to calculate the average overnight deposit rate. The weighted average overnight deposit rate of the 'new' series calculated by us was identical to the German overnight deposit rate published by the ECB in each month during January 2003-September 2014. Lacking pre-2003 quantities on deposits, we used the January 2003 volume of deposits to weight the interest rates for the two sectors pre-2003. Since the shares of households and nonfinancial corporations in overnight deposits were relatively stable after 2003, using the January 2003 values for calculating a weighted average for 2000-2002 likely does not introduce any major distortion. As the last panel of Figure 4 shows, the old and new series are nicely connected and therefore we use the old series for 2000-2002.

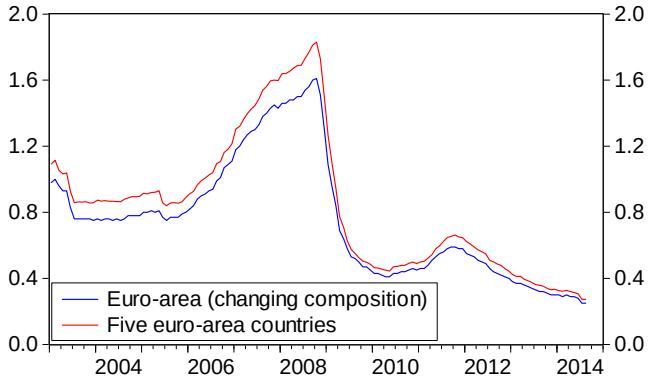
Figure 4: Overnight deposit rates for seven euro-area countries with available data before 2003



After these amendments, we have pre-2003 data on overnight deposits for five countries: Germany (from January 2000) and Finland, Italy, Greece and Spain (from December 1995). The group of the latter four countries is far from being sufficient to approximate a euro-area average before 2000. Greece, which joined the euro area in January 2001, exhibited very different interest rate developments relative to the other euro-area countries before joining the euro, and therefore mixing Greek data with the data of the other eleven members before Greece's entry to the euro area might lead to an aggregate that is difficult to interpret. We therefore approximate the missing data for the euro-area average for only 2001-2002.

While the five countries together account for about half of the euro area, calculating a weighted average of the data of the five countries (eg using weights from their shares in monetary aggregates) would be appropriate only if they are representative of the average. However, as Figure 4 shows, Germany, the euro area's largest country, used to have persistently higher overnight deposit rates than the euro-area average, while Finland and Spain used to have lower rates. Italian and Greek rates were the closest to the euro-area average. The 2005 drop in the euro-area average is mostly visible in Spain (see the right panel of Figure 6). Figure 5 shows that there was a non-constant and sizeable spread between the average of these five countries and the euro-area average.

Figure 5: Overnight deposit rates: euro area versus the average of the five countries



Note: the five countries are Finland, Germany, Greece, Italy and Spain. We weighted the deposit rates of these five countries with the shares of these countries in the aggregate outstanding volume of overnight deposit of the five countries.

We therefore decided not to weight the country-specific rates of the five countries using their shares in aggregate volume of the five countries, but we estimated a regression to determine the weights. Specifically, we regressed the euro-area average rate on the interest rates of the five countries as explanatory variables in the period 2003-2006 (a period that may have similarities to the 2001-2002 period for which we aim to approximate the euro-area average). We do not include an intercept in the regression and constrain the parameters to sum up to one.

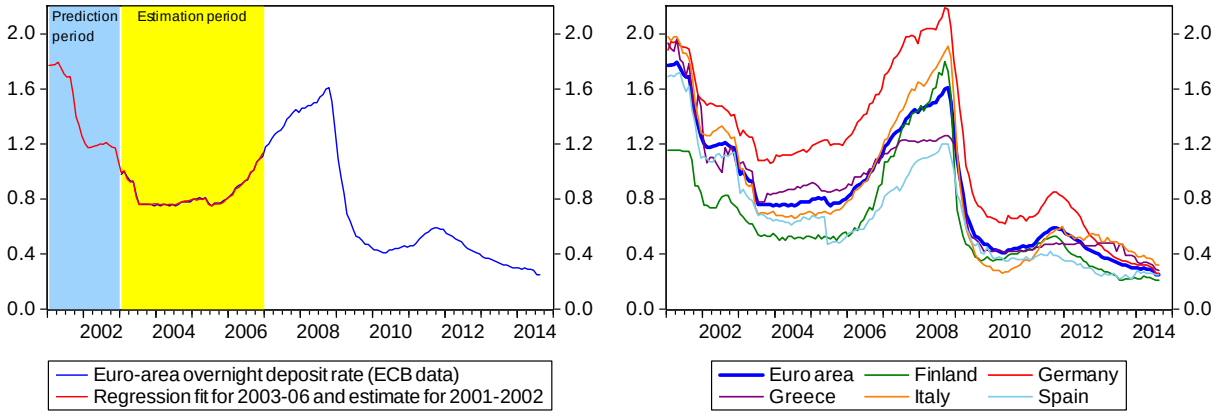
Table 3 shows the regression results. Italy has the largest estimated weight (32 percent), perhaps because Italian interest rates were the most similar to the interest rates of those euro-area countries which are omitted from the regression due to missing data. The left panel of Figure 6 shows the fitted values for 2003-2006 and the predicted values for 2001-2002. The right panel of Figure 6 compares the euro-area average to the data of the five counties.

Table 3: OLS regression of euro-area overnight deposit rate on the overnight deposit rates of five countries

	Coefficient	Std. Error	t-Statistic
Germany	0.216	0.016	13.4
Finland	0.153	0.021	7.3
Italy	0.321	0.026	12.2
Spain	0.190	0.017	10.9
Greece	0.121		

Note: estimated regression: $r_{EA,t} = \beta_1 r_{DE,t} + \beta_2 r_{FI,t} + \beta_3 r_{IT,t} + \beta_4 r_{ES,t} + (1 - \beta_1 - \beta_2 - \beta_3 - \beta_4)\beta_1 r_{GR,t} + u_t$. Since the parameter of the Greek interest rate is constrained, its standard error is not estimated. The sample period includes monthly data between January 2003 and December 2006. The coefficient of determination (R2) is 0.993.

Figure 6: Overnight deposit rates for the euro area and its approximation for 2001-2002



Deposits with an agreed maturity up to 2 years

Similarly to other deposit rates, the ECB publishes euro-area average (changing composition) and country-specific interest rates from January 2003 on deposits with an agreed maturity of up to 2 years. For the following ten countries, the ECB publishes separate times series from December 1995 to either June or September 2003:

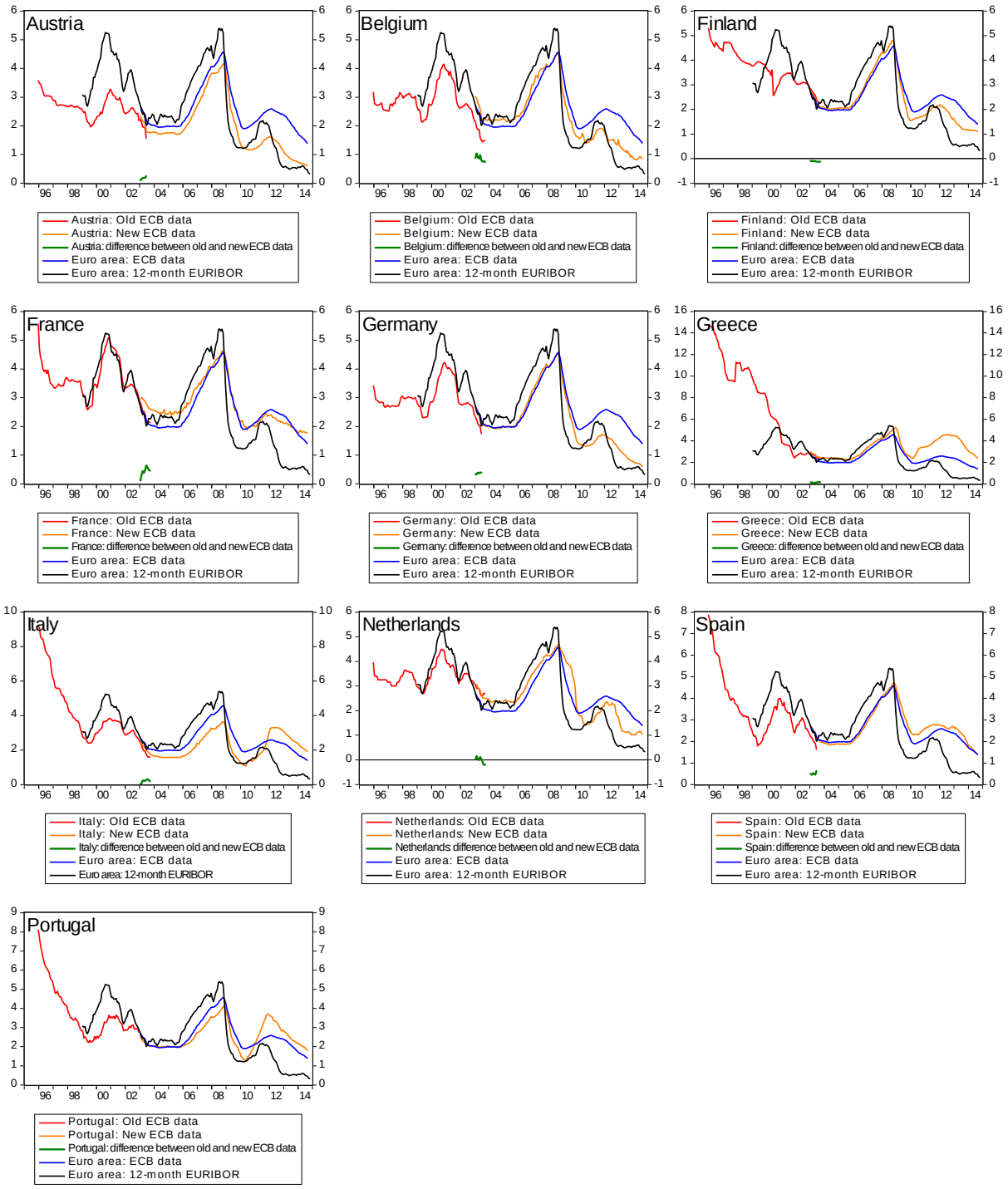
- Deposits with agreed maturity, up to 1 year: Austria, Belgium, Germany, Greece and Portugal;
- Deposits with agreed maturity, over 1 and up to 2 years: France, Italy, the Netherlands and Spain;
- Deposits with agreed maturity, total: Finland.

Presumably, deposit rates for these maturities should not differ much from the rates on deposits with maturity up to 2 years. Figure 7 shows that the difference between the old and the new series are indeed typically small with perhaps the exception of Belgium. Yet for Belgium the dynamics of the old and new series are very similar in the period when both rates are available. Therefore, we chain the old series to the new series similarly as we did with the overnight deposit rates, ie by adding to the old series the average spread between the new and old series in 2003.

Figure 7 also shows that the differences compared to the euro-area average interest rate (which is available from 2003) are typically smaller (at least up to the crisis) than in the cases of overnight deposits rates. For example, the German term deposit rate was practically identical to the euro-area average in 2003-08, while

Figure 4 showed that the overnight German deposit rate was higher than the euro-area average. Also, Figure 4 reports that Greek interest rates developed very differently from the rates in other euro-area countries before Greece joined the monetary union in 2001.

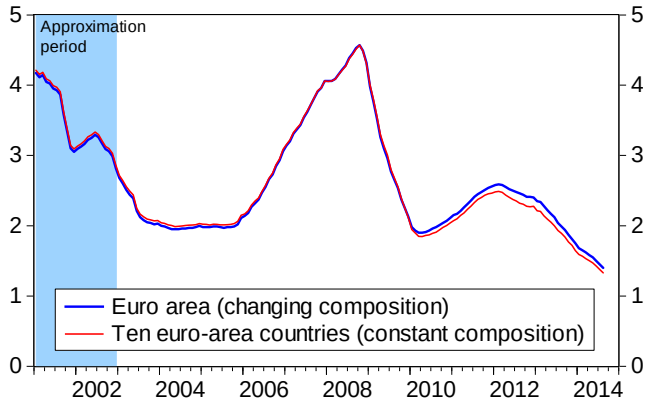
Figure 7: Rates on deposits with an agreed maturity up to 2 years* for ten euro-area countries with available data before 2003



** The new country-specific data (available from January 2003 onwards) and the euro-area average (also available from January 2003 onwards) refer to deposits with an agreed maturity up to 2 years. The old series available for December 1995-June/September 2003 refer to deposits with different maturities: up to 1 year (Austria, Belgium, Germany, Greece and Portugal), over 1 and up to 2 years (France, Italy, the Netherlands and Spain) and total (Finland).*

The group of ten countries for which we have pre-2003 interest rate data is likely representative for the euro area as a whole, which had 12 members that time. Since the outstanding stock of deposits is available, we weighted the interest rates of the 10 countries with weights derived from their combined stock of deposits. As Figure 8 shows, the gap between the changing composition euro-area average and the average for these 10 member states is very narrow indeed. In order to approximate the euro-area average in 2001-2002, we calculated the average spread between the two indicators in 2003-2005 and subtracted it from the euro-area 10 rate in 2001-2002 (this approximation is also indicated on Figure 8).

Figure 8: The approximation of euro area (changing composition) interest rates on deposits with an agreed maturity up to 2 years using the weighted average interest rate of ten euro-area countries



Note: the euro area (changing composition) data is available from the ECB from January 2003 onwards; the 2001-2002 values of this interest rate are our approximation.

Deposits redeemable at notice

Pre-2003 interest rates on deposits redeemable at notice are available from the ECB for only four countries: Belgium, Germany, Greece and Ireland. There is no new data for Belgium starting in 2003, while for Greece the new time series is available only for June 2010 – April 2013 and therefore there is no overlapping period between the old and new data to check their consistency, so we will not use the old data of these two countries to approximate the euro-area average before 2003. Moreover, the old and new German and Irish data should have very different definitions, as revealed by Figure 9. We therefore cannot use country-specific pre-2003 interest rates to approximate the euro-area average. Instead, we approximated pre-2003 euro-area average rates a different way. The spread between the interest rates on deposits redeemable at notice and the rates on overnight deposits was broadly stable (Figure 10), so we link the former to the latter by using the approximated value of the latter in 2001-2002.

Figure 9: Interest rates on deposits redeemable at notice for the two euro-area countries with available data both before and after 2003

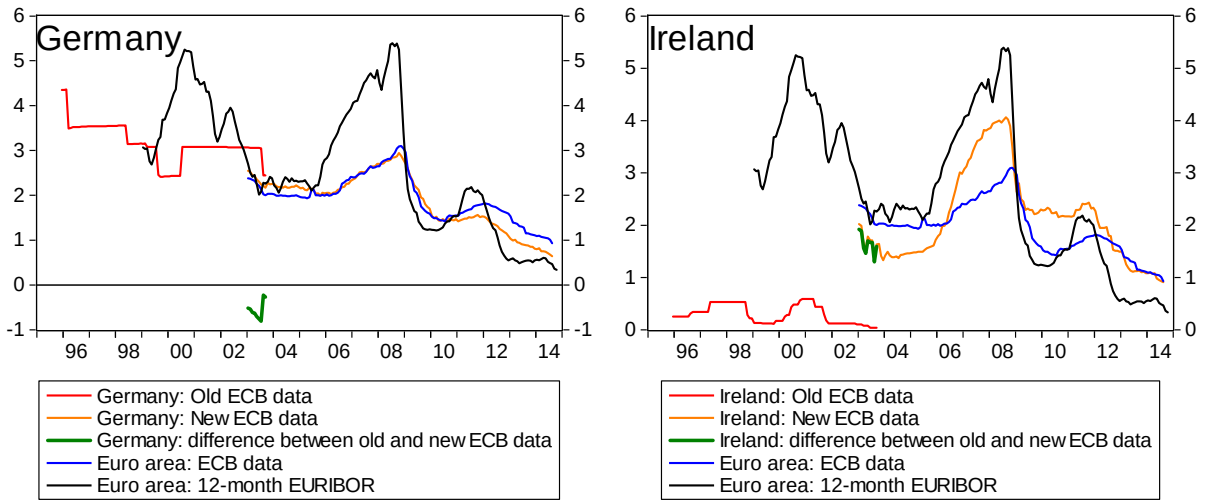
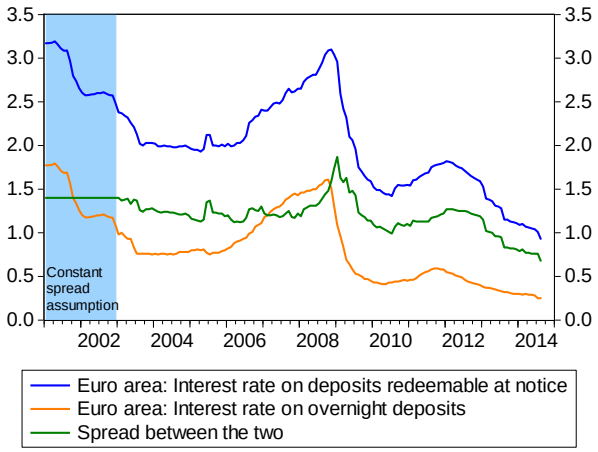


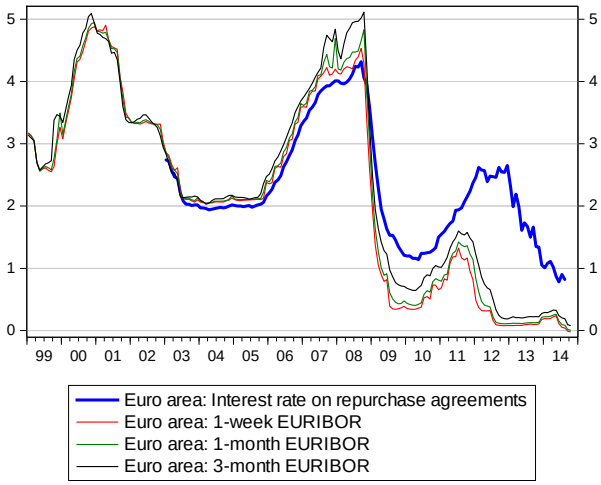
Figure 10: The spread between euro-area average interest rates on deposits redeemable at notice and overnight deposit rate



Repurchase agreements

Pre-2003 data on repurchase agreements is available only for Spain, which is not sufficient to approximate the euro-area average. We approximate the euro-area repo rate for 2001-2002 by observing that the spread between the repo rate and the EURIBOR was rather stable in 2003-2005 (Figure 11). We therefore subtract 10 basis points (the average difference between the 1-month EURIBOR and the repo rate in 2003-2005) from the 1-month EURIBOR to approximate the pre-2003 average euro-area repo rate.

Figure 11: Interest rates on repurchase agreements and the EURIBOR



4.3 The benchmark rate

The so-called benchmark rate is the rate of return on an asset that does not provide monetary service, only investment income. As Barnett (1978, 1980) proved, the benchmark rate is needed to derive the weights of the components for the Divisia monetary indices and to calculate the user cost of money.

Such a benchmark asset is hardly observable and therefore researchers/institutions adopted different approaches to approximate the benchmark rate. The most widely used assumption is to add a spread to the maximum return of some observed assets. The selection of the maximum return (at each point in time) is called the 'upper envelope' approach and in most cases the components of the money stock are considered. The spread which is added to the maximum return to get the benchmark rate is called the 'liquidity services premium'.

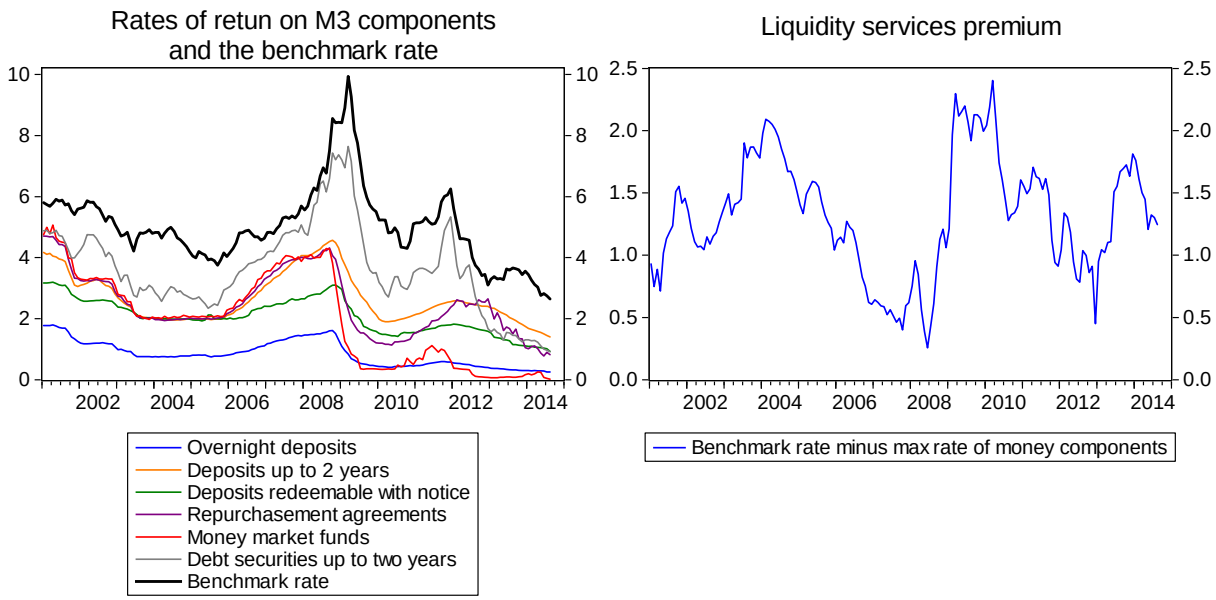
For example, Stracca (2004) proxies the benchmark rate by adding 60 basis points to the rate on marketable instruments (that he defined as the sum of three components that differentiate ECB's M2 and M3: repurchase agreements, money market funds and debt securities up to 2 years). Jones and Stracca (2012) adopted the same approach. El-Shagi and Kelly (2013) adopted two proxies: (1) adding 100 basis points to the return on the maximum return of the components of the money stock, (2) adding a variable premium to the maximum return of the components amounting to the spread between the ten-year and one-year government bond yields. Up to 2005, the Bank of England proxied the benchmark rate as the interest rate on three-month Local Government (LG) bills plus a 200 basis point spread, but then switched to an envelope approach, whereby the benchmark asset is the M4 component that pays the highest interest rate (see Hancock, 2005). The Center for Financial Stability (CFS) uses an envelope approach applied to all components of the money stock plus a loan rate[3] from 1997, the date from when this loan rate is available. For earlier years, 100 basis points are added to the yield on the highest yielding asset of M4 (see Barnett *et al*, 2013).

We find the fixed-spread assumption to be *ad hoc* and therefore we sought an alternative. Since only bank debt up to 2 years maturity is included in euro-area M3, we also considered the yield on bank debt for longer maturities. BofA Merrill Lynch Year Euro Bond Indices are also calculated for maturities 3-5 years, 5-7 years, 5-

[3] The loan rate considered is the "Weighted average effective loan rate, low risk, 31 to 365 days, all commercial banks". The reason for the use of this rate is that it acts as an upper limit to the interest rate a bank will offer on any deposit category, because a bank will not pay out to its depositors more than it earns in interest on the short-term loans it makes.

10 years and over 10 years. Bank debt with such a long maturity may have characteristics similar to the theoretical benchmark asset. Longer maturity bank debt had higher returns than the returns on the components of M3. The left panel of Figure 12 plots the benchmark rate and the own rate of six money components. The right panel of Figure 12 shows the difference between the benchmark rate and the maximum rate among the M3 components. This spread, which can be regarded as an estimate of the liquidity services premium, was quite variable both before and after the outbreak of the global financial and economic crisis.

Figure 12: The benchmark rate, rates on the components of M3 and the liquidity premium (percent per year)



Note: The own rate on currency is zero and is not shown on the left panel. The benchmark rate is the maximum of the rate on bank debt with the following maturities: 5-7 years, 5-10 years and over 10 years.

A drawback of our selection of the benchmark asset is that it should be risk-free in principle, while the longer-maturity bank debts we consider are not risk free. However, most components of the money stock involve risk, including the 2-year maturity bank debt and bank deposits[4]. The rate on any risk-free benchmark asset would likely be lower than the return on many components of the monetary aggregates. For example, the return on 10-year German government bonds, which is probably a safe asset, is only 0.8 percent per year at the time of writing this paper, which is below all but two interest rates indicated on the left panel of Figure 12. While Barnett, Liu and Jensen (1997) developed an aggregation formula for the case of risk by using the consumption capital asset pricing model (CCAPM), that model is not without problems and the available Divisia monetary aggregates for the EU and US are also not risk-adjusted. We therefore do not adjust our aggregation method to risk but leave this issue for further research.

[4] Note that in Denmark (a non-euro area EU country) and in Cyprus (a euro-area country) depositors having deposits over the €100,000 guaranteed amount suffered losses during the restructuring of some banks. Moreover, deposits were withdrawn to a significant level from several euro-area periphery countries and transferred to other (safer) euro-area countries. This suggests that even in the cases when depositors did not suffer any actual loss, many of them regarded their deposits as unsafe in euro-area periphery countries.

4.4 Approximating constant country composition monetary aggregates and interest rates

All euro-area data (components of monetary aggregates and average interest rate) obtained from the ECB refers to the changing composition euro-area aggregate, that is, the actual euro-area members are considered in each month. Whenever a new country joined the euro area, it was added to the monetary aggregates and from that point in time its interest rates were included in calculating the average interest rate for the euro area[5]. Such changes in composition obviously complicate monetary analysis, because at the time that each new country joins the euro area, the outstanding stock of money increases because of the inclusion of this new member, but this is not an increase in money stock. The use of aggregates which do not include level shift at the time of enlargement is therefore much preferable.

The countries that joined the euro area after 2001 (Slovenia, Cyprus, Malta, Slovakia, Estonia, Latvia) are rather small and therefore the impact of the composition change should be small too[6]. Nevertheless, we create two versions of the Divisia index which do not suffer from enlargement-related level shifts: one considers only the constant-composition aggregate comprising the first twelve members of the euro area (missing data does not allow the estimation of constant-composition aggregates for the current 18 members of the euro area), while the other is based on transactions data also published by the ECB.

The ECB's transactions data treat enlargement as a special case of reclassification and therefore the increase in the components of the monetary aggregates are not increased by the level shift related to enlargement (see Section 4.3.2 of ECB (2012)). However, after enlargement, transactions data include the new member states as well and therefore the country-composition of transactions data is changing with enlargement, which is a drawback. We calculate the stocks from transitions data by setting the January 2010 values of the seasonally adjusted outstanding stocks of all components as the starting point and adding monthly seasonally adjusted transactions data for later months and subtraction transactions data for earlier months. Thereby we calculate seasonally adjusted "notional outstanding volumes".

Our alternative approach is to calculate the outstanding stock to the first 12 members of the euro area, as we detail below. It has the advantage of an indicator that has a constant country composition. But it also has a main drawback that changes in stocks not related to transactions are also included, such as reclassification. For example, the last but one panel of Figure 13 shows that central counterparties were excluded from repo transactions only from June 2010 onwards, which has halved the outstanding stock of the indicator used as a component of M3. Arguably, such reclassifications should be excluded before analysing monetary aggregates, but our constant-country composition aggregate we have not removed this (nor other) cases of reclassification. A further drawback of our constant-country composition aggregate is that country-specific data has a slightly different reference sector than the euro-area aggregates, as we discuss below.

We therefore derived both versions of the Divisia index and compared empirical results. We also calculated the corresponding simple-sum aggregates. As it turned out, the impulse-response function estimates from SVAR models were almost identical for the two possible measures

The constant-country composition aggregates for the first 12 members of the euro were derived the following way.

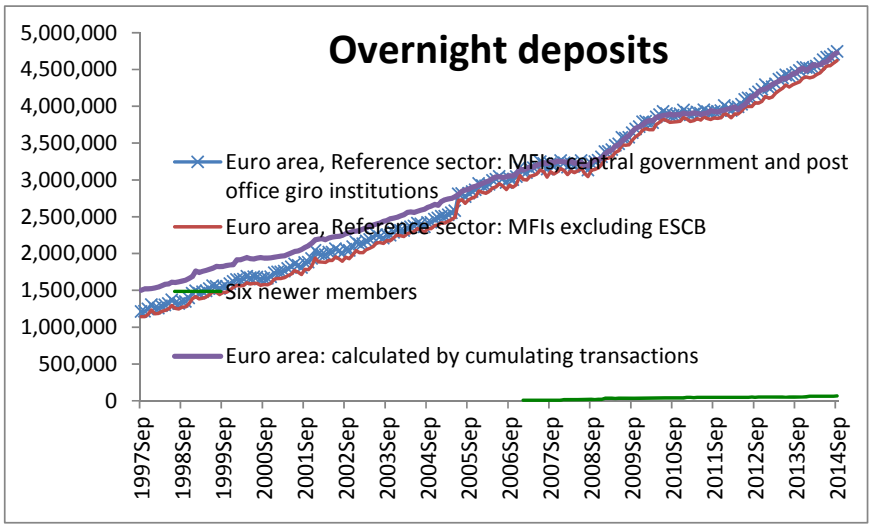
[5] Moreover, the positions of MFIs in the former euro-area countries are also reclassified, since the new member belongs to the euro area from the date of entry, while earlier it was classified as part of the rest of the world.

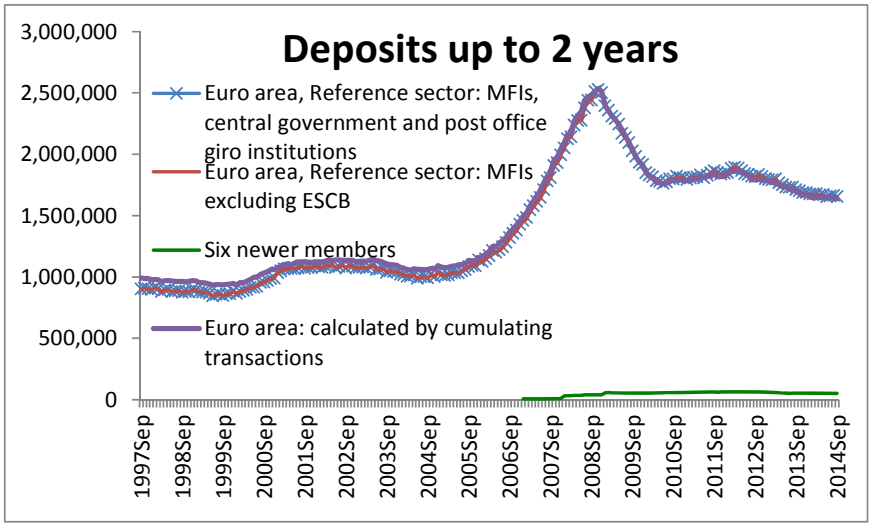
[6] Note that Greece joined the euro area in 2001 and we calculate our euro-area aggregates starting in 2001 and therefore Greece's entry does not lead to a compositional change in our aggregates.

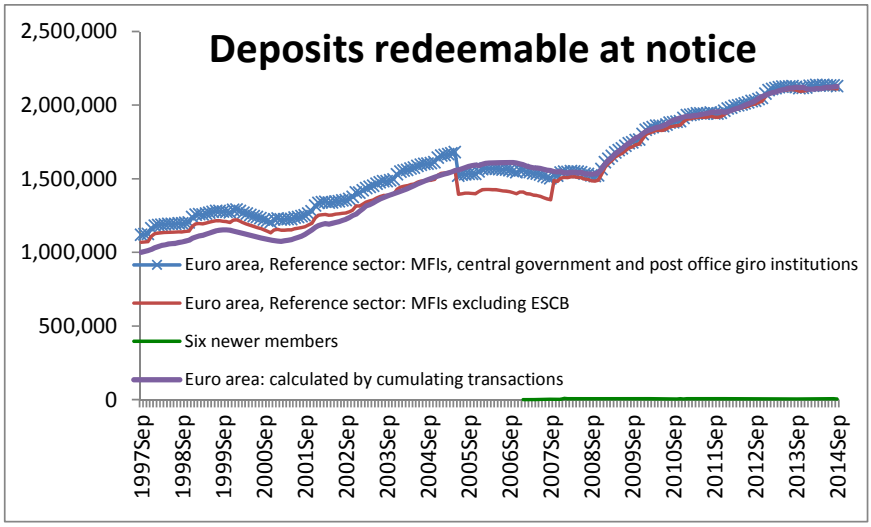
Five components

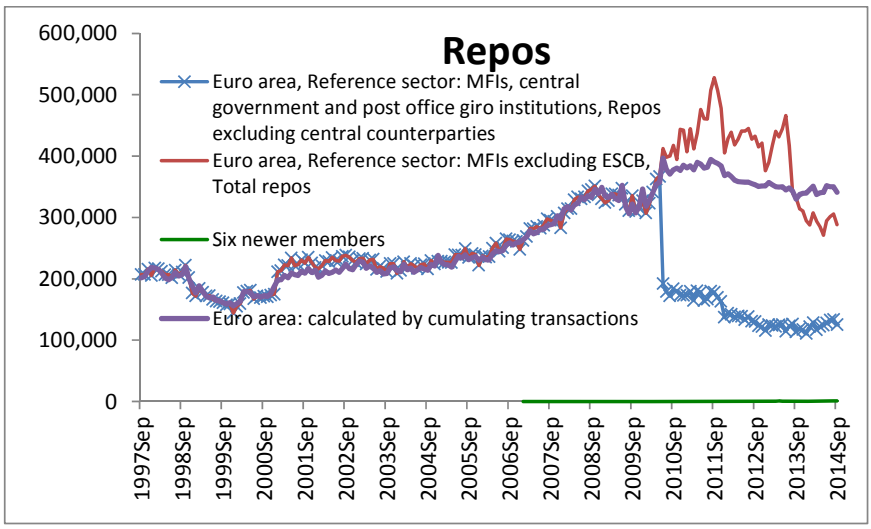
As documented in the notes to Panel A of Table 2, euro-area aggregate data on the components of the ECB's monetary aggregates considers the sector "*MFIs, central government and post office giro institutions*". Unfortunately, country-specific data is not available for this reference sector, but for the sector "*MFIs excluding ESCB*". For the repos "*Repurchase agreements excluding repos with central counterparties*" is included in the ECB's M3 indicator, but country-specific data is available only for total repos. Such differences may limit the accuracy of our constant country composition calculations, but luckily the difference between the data referring to the two reference sectors of the euro-area aggregates is generally small, except for repos from June 2010 onwards (Figure 13). For repos, Figure 13 suggests that data on central counterparties was excluded only from June 2010 onwards and therefore there seems to be a break in the series which is included in the ECB's M3 aggregate, and consequently there is a break in the M3 aggregate too. Figure 13 also includes the notional outstanding volumes as we calculated them. They are generally quite similar to the outstanding stock (except for repos after May 2010), suggesting that the various reclassifications were not too substantial. For repos there is a big difference from June 2010 onwards and the notional outstanding volume is much more sensible for economic analysis than the raw data with a huge break in it.

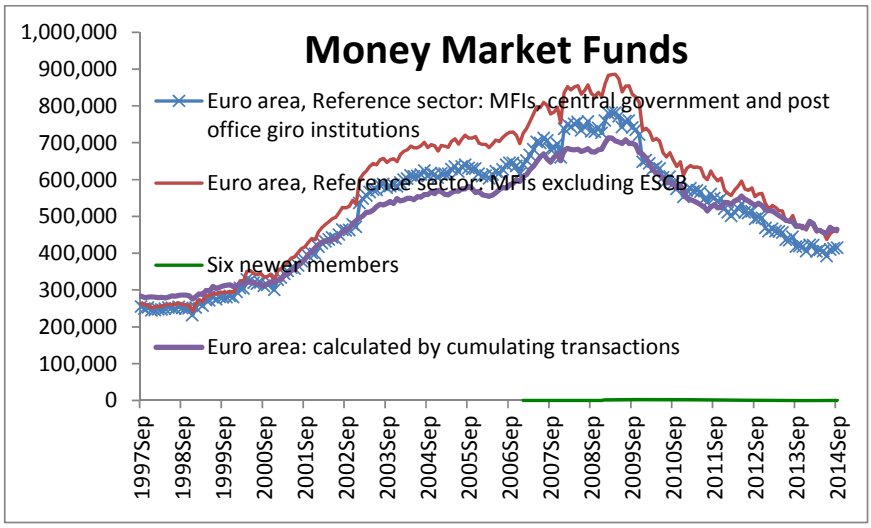
Figure 13: Comparison of euro area (changing composition) data regarding two reference sectors, and the combined stock of six newer members (in euros)











Note: the components indicated by blue lines are included in the ECB's monetary aggregates, while country-specific data is available for the aggregates corresponding to the red lines. The green lines, showing the aggregate data of six newer members, relate to the reference sector "MFIs excluding ECSB" and each of these newer members are included from the date of their euro entry onwards. ECSB = European System of Central Banks.

For the five components indicated in Figure 13, we calculated the constant-composition euro-area 12 aggregate by subtracting from the total euro-area values the values of the six countries starting from the date of their euro-area membership (ie we subtract the green lines from the blue lines of Figure 13). We first calculated the seasonally non-adjusted aggregates for the euro-area 12 and then adjusted the resulting series seasonally.

Currency in circulation

It is not possible to obtain country-specific data on currency in circulation, because cash flows freely within the monetary union. Yet using data on currency issued, we approximate the euro-area 12 by

combining IMF and ECB data to proxy country-specific values. The IMF International Financial Statistics (IFS) publishes data on "Currency issued" for 16 of the 18 euro-area members (not available for Slovakia and Latvia in the September 2014 version of the IFS), plus for the euro area[7].

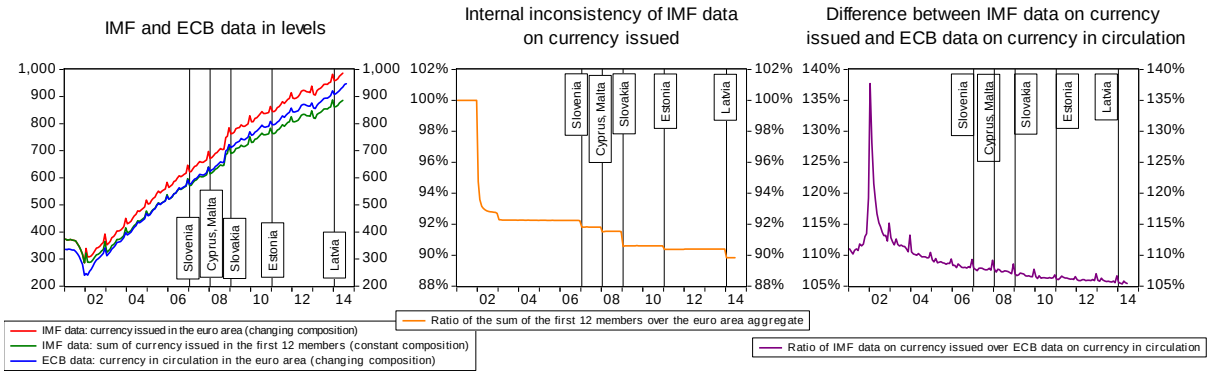
The left and middle panels of Figure 14 show that there is a consistency problem with the IMF data: in 2001-2006, the sum of the values of the first twelve members of the euro area should be equal to the euro-area aggregate, but this equality holds only in 2001. In 2002-2005 there is a sizeable gap. On the other hand, the middle panel also shows that from 2003 onwards, the share of the first twelve members in the overall euro-area aggregate was stable for periods when no new member joined and declined only when a new member joined. This observation suggests that the 2001-2002 data may be incorrect, but data from 2003 onwards may be correct apart from perhaps a level problem.

The right panel of Figure 14 shows that the data on currency issued is higher by about 5-10 percent than the data on currency is circulation in most years, which is sensible. This panel also reveals that in 2002 there seems to be an unusually large difference between the two indicators, suggesting that there may be a data issue in 2002.

Our aim is to estimate and separate out the volume of currency in circulation in the six newer euro-area members that joined between 2007-2014. To this end, we calculate the ratio of currency issued in Slovenia over the total currency issued in the euro area in each month of 2007-2014 (both are IMF data) and use this share to multiply the euro-area aggregate currency in circulation data of the ECB to get an estimate of the currency in circulation in Slovenia. We calculate the same (time-varying monthly) ratio for Cyprus, Malta and Estonia starting from the dates when they became members of the euro area. Lacking IMF data on Slovakia and Latvia, we cannot do the same exercise for these two countries. However, as the middle panel of Figure 14 reveals, the share of the first twelve members in total euro area declined at the time when Slovakia and Latvia joined, and using the magnitude of this decline, we can calculate the shares of these two countries too in total (changing composition) euro-area aggregate currency issued.

[7] The idea to use IMF data on currency issued originated in the work of El-Shagi and Kelly (2013), who calculated Divisia money indicators for six euro-area countries, though they did not combine the IMF data on currency issued and the ECB data on currency in circulation.

Figure 14: IMF data on currency issued in the euro area and ECB data on currency in circulation



Note: the vertical lines with country names indicate the dates when these countries joined the euro area. The left panel is in € billions, the middle and the right panel are in percent. All data are seasonally unadjusted.

Bank debt up to two years maturity

The ECB does not provide a country-specific breakdown of the 7th component of M3, bank debt up to two years maturity, while other data, such as short-term securities other than shares of banks (for which country-specific data is available) is not suitable[8]. Given that the share of the six newer members in the higher numbered components of M3 is minuscule (Table 4) and their share in bank debt could be similar, plus bank debt is anyway a small component in M3 (Figure 3), we use the total (changing composition) bank debt component of M3 in our constant-composition aggregates.

Results

Table 4 on the next page shows the shares of the first twelve and six more recent members in six components of M3 in September 2014. The combined share of the six newer members in currency was 2.6 percent, in overnight deposits it was 1.37 percent and in deposits up to two years it was 3.19 percent. Their combined share was negligible (ie between 0.09 percent and 0.76 percent) in items 4, 5 and 6.

[8] The ECB publishes country-specific data on short-term securities other than shares of monetary financial institutions (MFIs), which may be a reasonable proxy for bank debt up to two years. However, the bank debt indicator used as a component of M3 was 72 percent in September 1997 and only 14 percent in July 2014 of the aggregate of the country-specific data on short-term securities other than shares of MFIs, suggesting that both the level and the dynamics of these two variables are very different.

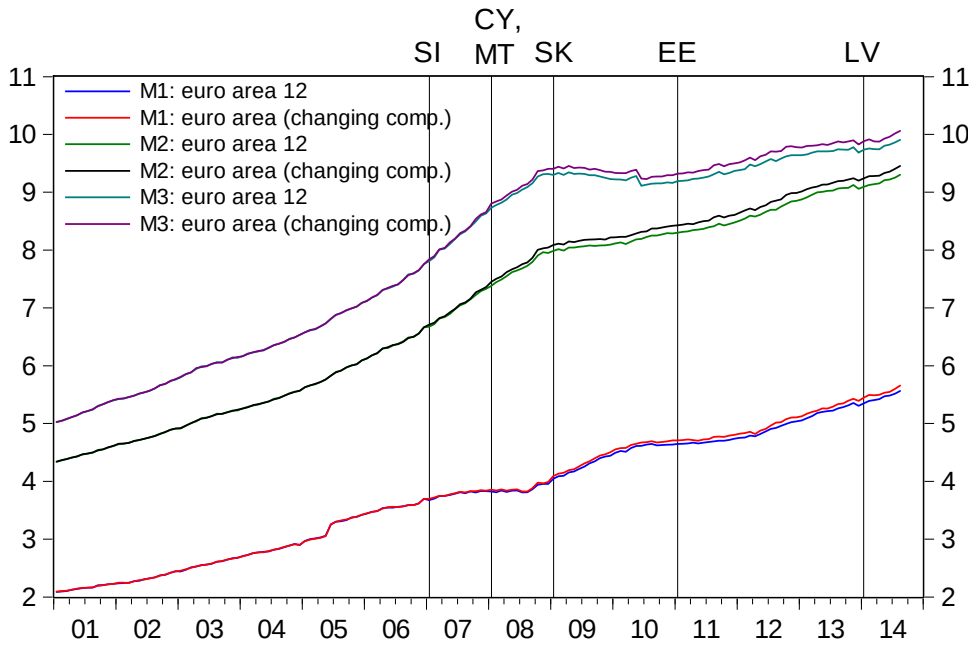
Table 4: The shares of the first twelve members of the euro area and more recent members in six of the seven components of M3 in September 2014 (using seasonally unadjusted data)

	Euro area 12	Slovenia	Cyprus	Malta	Slovakia	Estonia	Latvia	Total
1. Currency in circulation	97.40%	0.48%	0.22%	0.10%	1.02%	0.27%	0.51%	**100%**
2. Overnight Deposits	98.63%	0.22%	0.21%	0.15%	0.47%	0.17%	0.16%	**100%**
3. Deposits up to 2 years	96.91%	0.59%	1.26%	0.28%	0.73%	0.13%	0.10%	**100%**
4. Deposits redeemable at notice	99.76%	0.02%	0.08%	0.01%	0.07%	0.04%	0.03%	**100%**
5. Repurchase agreements	99.24%	0.00%	0.00%	0.76%	0.00%	0.00%	0.00%	**100%**
6. Money Market Funds	99.91%	0.01%	0.00%	0.04%	0.02%	0.00%	0.02%	**100%**

Note: the shares in "1. Currency in circulation" is our estimate using IMF data on currency issued and ECB data on currency in circulation, while for the other five items we used ECB country-specific data to calculate the shares.

Figure 15 shows the impact of compositional changes in the membership of the euro area on monetary aggregates. As expected, the admission of the six new members between 2007-2014 did not increase much the stock of euro-area monetary aggregates. By September 2014, their combined impact was about 1.5 percent.

Figure 15: The impact of compositional change on simple sum monetary aggregates, seasonally adjusted, € trillions



Note: the vertical lines with the country-codes above indicate the dates when these countries joined the euro area. SI: Slovenia, CY: Cyprus, MT: Malta, SK: Slovakia, EE: Estonia, LV: Latvia.

The impact of compositional changes on average euro-area interest rates is bound to be small for two reasons: interest rates in the newer member states did not differ much from the euro-area average and their shares in outstanding volumes of the money components are small. Yet we filtered out these six new member states from the three deposit categories for we have country-specific interest rate data [9]. For example, in 2007 the euro-area average can be written as:

$$r_t^{(EA)} = \frac{r_t^{(EA12)} \cdot M_t^{(EA12)} + r_t^{(SI)} \cdot M_t^{(SI)}}{M_t^{(EA12)} + M_t^{(SI)}},$$

where $r_t^{(j)}$ is the interest rate on deposits in country *j*; $M_t^{(j)}$ is the outstanding stock of deposits in country *j*; EA refers to the euro area (changing composition), EA12 refers to the first twelve members of the euro area and SI refers to Slovenia. From 2008, Cyprus and Malta are also included, from 2009 Slovakia is included, from 2011 Estonia is included and from 2014 Latvia is included.

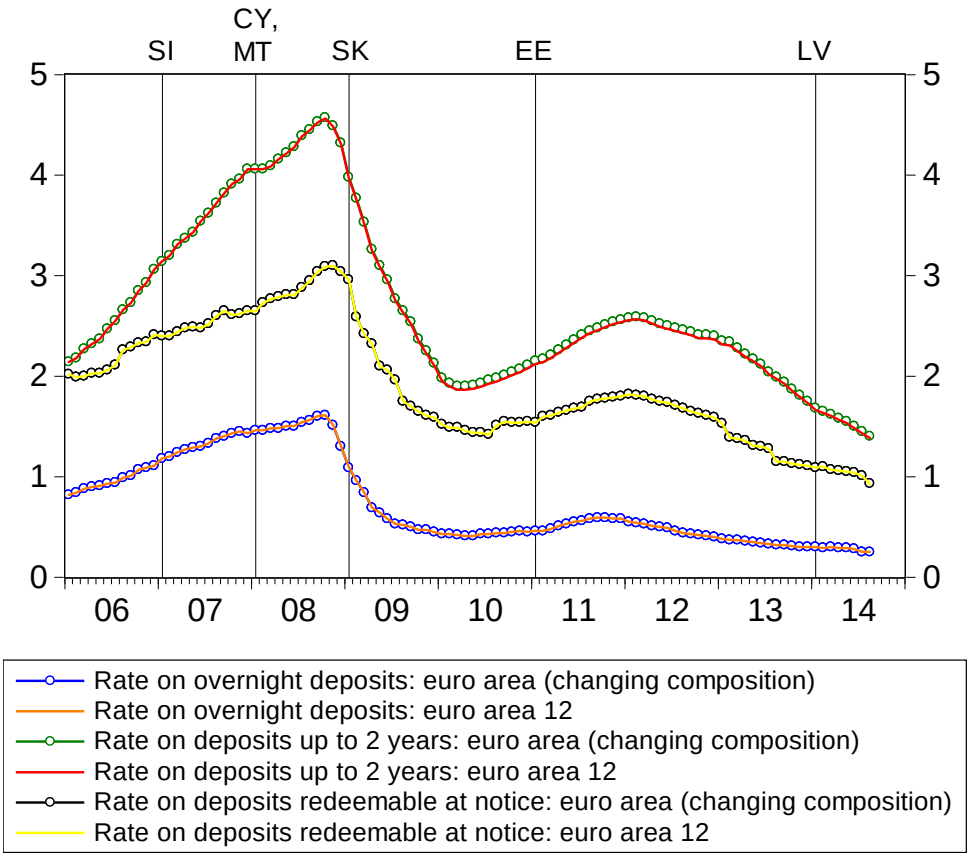
Figure 16 compares the fixed and changing composition euro-area average interest rates on the three deposit categories. They are so similar to each other that visually they can hardly be differentiated. The greatest difference in interest rates on deposits up to 2 years is below 4 basis points, while the greatest difference in interest rates on overnight deposits and in interest rates on deposits redeemable with notice is less than half a basis point.

Lacking country-specific interest rate data on repos, money market funds and bank debt does not allow filtering of the six newer members out from the euro-area average, but given that their share is negligible in outstanding volumes, the likely impact would be a small fraction of a basis point.

The own rate of return on currency is assumed to be zero for all countries and hence there is no need to filter the newer members out.

[9] Data on interest rates on overnight deposits and deposits with maturity up to two years is available for all six countries for the full period of their euro membership. For deposits redeemable with notice, Malta and Latvia are not considered because of missing interest rate values.

Figure 16: The impact of compositional change on deposit interest rates (percent per year)

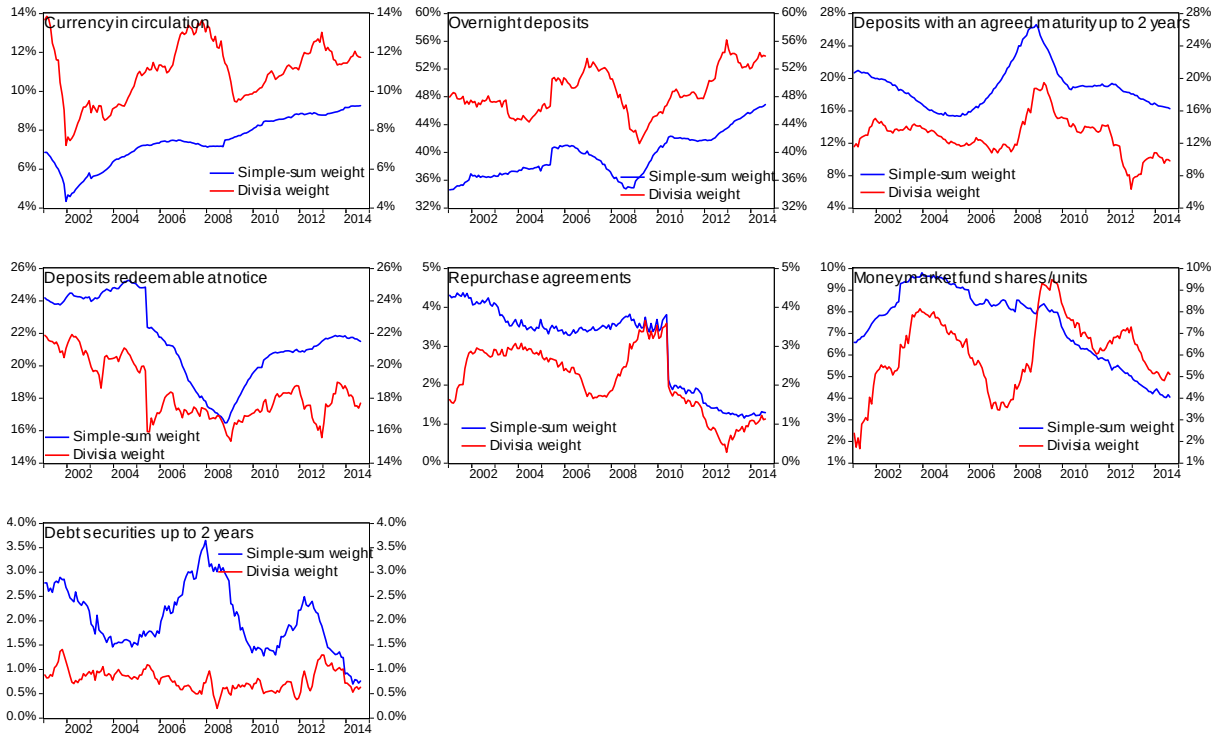


Note: the vertical lines with the country-codes above indicate the dates when these countries joined the euro area. SI: Slovenia, CY: Cyprus, MT: Malta, SK: Slovakia, EE: Estonia, LV: Latvia.

5. Some results

Figure 17 compared the simple-sum and Divisia weights for the seven components of M3. The Divisia weight for the zero-yielding currency and the low-yielding overnight deposits are much larger than their simple-sum weights. In contrast, Divisa weights of higher yielding components are smaller than their simple-sum weights.

Figure 17: Simple-sum and Divisia weights of the M3 components, constant-composition euro-area 12 aggregate



Note: values correspond to $v_{i,t}$ *defined in equation (2) and* $w_{i,t}$ *defined in equation (9).*

Figure 18 compared the levels and 12-month changes of simple-sum and Divisia M1, M2 and M3 aggregates based on our constant-composition calculations, while Figure 19 shows this comparison for the notional outstanding stocks as we calculated from transactions data. For M1 the difference between the two measures is hardly noticeable. The reason is that overnight deposits carry relatively low interest rates and therefore its user cost is not much smaller that the user cost of currency. Another reason is that the longer term trends are similar for currency and overnight deposits: from January 2001 to September 2014, currency in circulation increased by 166 percent, while overnight deposits increased by 167 percent.

There are some differences in M2 and M3, though not very large. However, our econometric analysis underlined that in a simple vector autoregressive (VAR) model the impulse responses to Divisia aggregates are more sensible and significant than impulse responses obtained when using the simple-sum aggregates.

Figure 18: Simple-sum and Divisia monetary aggregates, constant-composition euro-area 12, seasonally adjusted

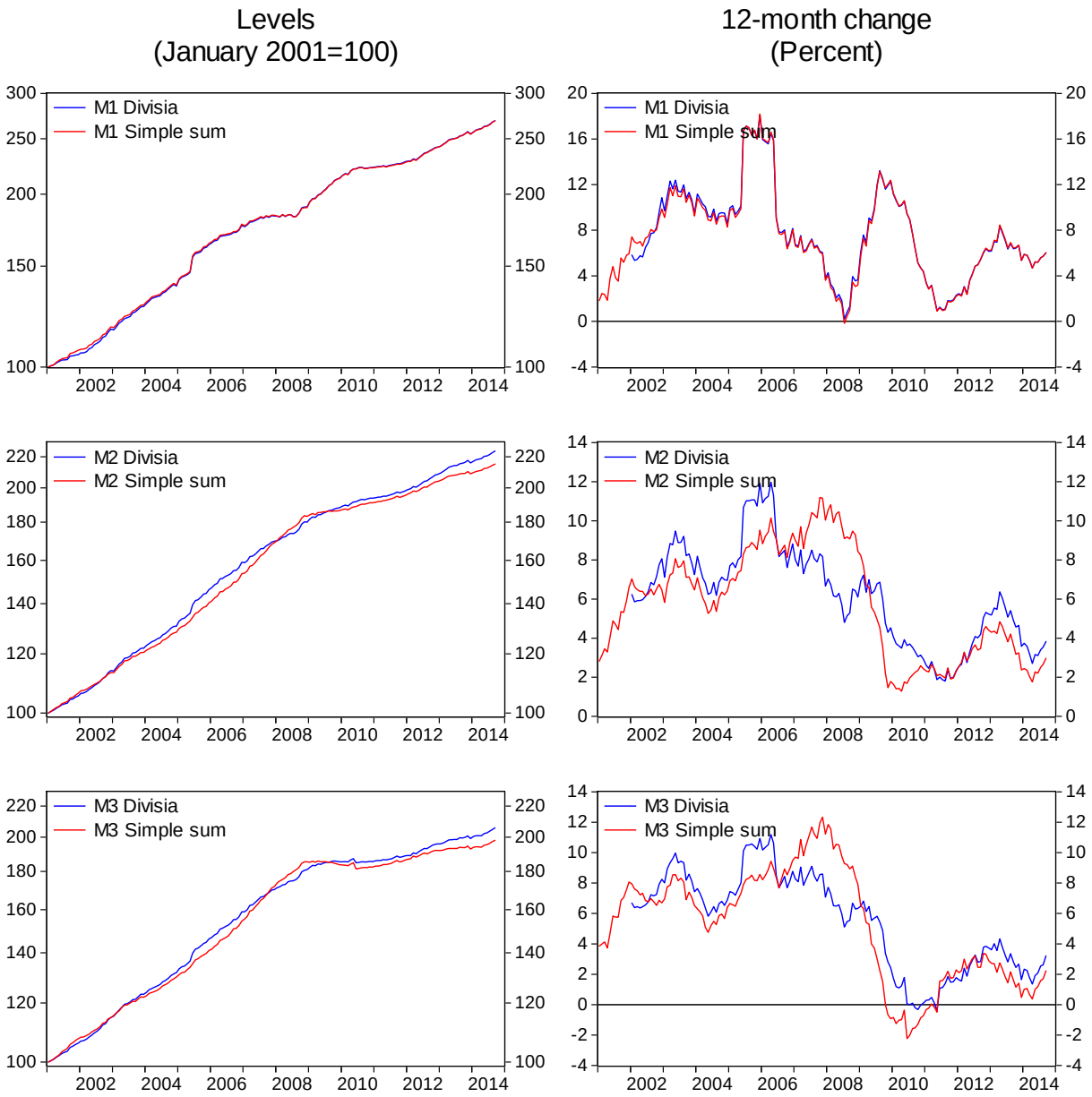
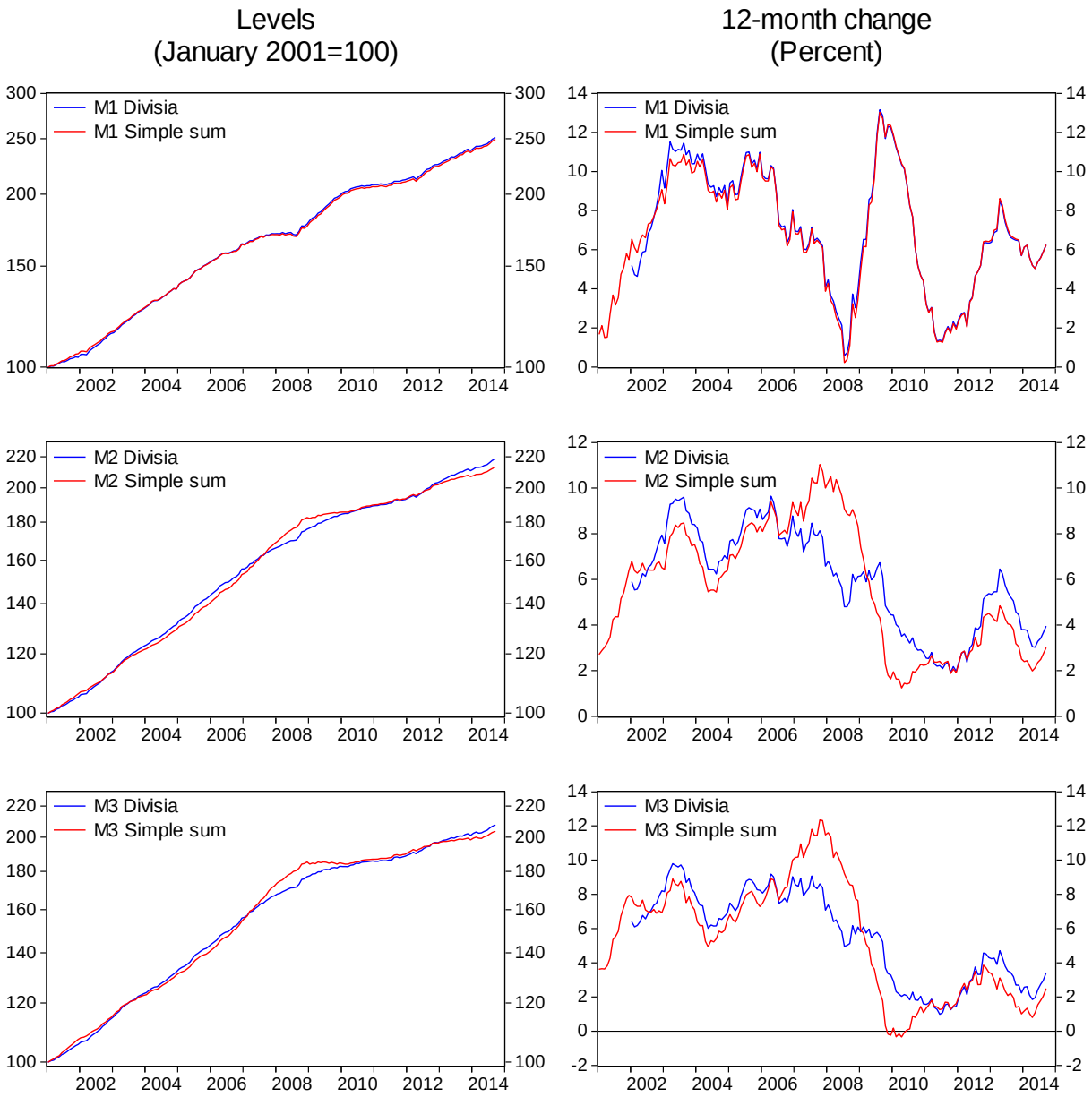


Figure 19: Simple-sum and Divisia monetary aggregates, using notional outstanding stocks derived from transactions data, seasonally adjusted



6. Summary

No official Divisia monetary aggregates are published for the euro area, in contrast to the UK and US. We derive and make available a dataset on euro-area Divisia money aggregates for January 2001 – September 2014 using monthly data and plan to update the dataset in the future.

Academic researchers used to calculate euro-area Divisia indices by using country-specific data and aggregating them to the euro-area level. Since the euro area existed throughout our sample period, we used euro-area-wide components. All necessary data are available from January 2003 onwards and we approximated the four missing interest rate series for January 2001-December 2002.

Our methodology differs from most of the literature in defining the benchmark rate (the return on a monetary asset that does not provide transaction services). Instead of relying on an *ad-hoc* spread assumption to approximate benchmark rate, we derived the benchmark rate by considering longer maturity bank debts. Our choice has the advantage of not relying on an *ad-hoc* assumption, but has the drawback that our benchmark asset may not be risk-free, which is an underlying assumption in the particular derivation of the Divisia formula. However, most components of the money stock are not risk-free either and available US and UK Divisia indices are not risk adjusted. We leave risk adjustment for future research.

When carefully analysing the data used by the ECB to calculate simple sum monetary aggregates, we spotted a data problem: from repurchase agreements central counterparties are excluded only from June 2010 onwards, leading to a visible break in this series and also in the M3 aggregate. However, this change and similar reclassification changes and other breaks in the data do not distort the transactions data that the ECB also publishes.

The euro-area data (monetary aggregates, their components, transactions and interest rates) published by the ECB are changing composition aggregates, ie new euro members are considered from the date of their entry to the euro area. While the member states that joined between 2007-2014 are small, such changing composition aggregates are not suitable for economic analysis. We therefore also derived two versions of euro-area Divisia aggregates which do not suffer from enlargement-related level shifts: one considers only the first twelve members of the euro area, while the other is based on transactions data. Unfortunately, none of the variants are perfect, yet in our assessment their drawbacks are minor. The drawback of the euro area twelve aggregate is that it is based on outstanding stocks of money components, which are subject to reclassification and valuation changes too. The drawback of the aggregate based on transaction data is that it is not a constant-country composition aggregate: when new countries joined the euro, it does not cause a level shift in the indicator, but the transactions in the new countries are also included from the date of their entry onwards. Since the six new countries that joined the euro between 2007 and 2014 are very small and accounted for only about 1.5 percent of the total euro-area M3 in September 2014, the distortion should be very small.

Finally, we invite the ECB to publish constant country composition monetary aggregates[10]. We also encourage the ECB to calculate and publish (constant country composition) Divisia indices.

[10] We note that the Eurostat currently publishes four different aggregates for the euro area in its national accounts database: changing composition, euro area 18, euro area 17 and euro area 12.

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