THE INFORMATION CONTENT OF THE DIVISIA MONEY IN FORECASTING INFLATION IN THE EURO AREA

Abstract

By means of a simulated out-of-sample forecasting exercise, it is examined whether the synthetic Divisia M3 monetary aggregate outperforms its simple sum M3 counterpart in forecasting the euro area inflation. In addition to the growth rate of the nominal money stock, also the performance of the real money gap and monetary overhang series calculated for both sort of monies are discussed. According to the results, the nominal growth rate of the Divisia M3 money contains more information about the future inflation than its simple sum M3 counterpart. In case of the real money gap and monetary overhang variables, the results become somewhat sensitive on the assumptions made about the time series properties of the indicators in specifying the forecasting equation.

KEY WORDS: Divisia monetary aggregate, P-Star, money demand, liquidity

JEL Classification: E31, E41, E47, E52

1. INTRODUCTION

In the long run, inflation is always and everywhere a monetary phenomenon. This traditional view is clearly reflected in the ECB's two pillars' strategy. While the first of the ECB's pillars refers to a broadly based assessment of the risks for price stability in the Euro area, the second pillar establishes a prominent role for the growth rate of nominal M3 money as an information variable about future inflation.

According to the quantity theory of money, there should exist a one-to-one relationship between money and inflation in the long-run. The empirical relevance of the information content of money for predicting inflation in horizons relevant for monetary policy making is debatable, however. De Grauwe & Polan (2001), for example, examine empirically the validity of the basic propositions of the quantity theory of money and concludes that even the long-run relation between inflation and the growth rate of money breaks down for low inflation countries. For the Euro-area data, a sort of compromise view can be found in some recent studies published by the ECB (see Altimari 2001, Gerlach and Svensson 1999 and Trecroci and Vega 2000). According to these papers, the change of the nominal M3 admittedly is not always a good leading indicator for the euro area inflation. From the so called P-star model however, the authors derived a set of measures for the abundance of real money in the economy (*real money gap, monetary overhang*) that seemed to provide valuable information about the future inflation in the euro area.

Even with this empirical support for the information value of money present, there still remains some theoretical problems related to the ECB's focus on only traditional monetary aggregates such that M1, M2 and M3. The traditional monetary aggregates are built simply by summing up their component assets, without explicitly paying attention to the different degree of liquidity of the components. This is equivalent to assume that the component assets are perfects substitutes to each other and thus, the simple sum aggregates become upward biased estimates of the degree of liquidity of the economy. A promising solution to this aggregation problem is provided by the Divisia monetary aggregates. These aggregates are monetary quantity index numbers based upon both the index number theory and the economic aggregation theory. The Divisia-aggregates are computed as weighted averages of their components so that the weights are derived from economic theory with optimizing agents. The weight of a given asset is associated with the opportunity costs of holding that asset, which measures the liquidity of the asset. Intuitively, the Divisia monetary aggregates then measure the flow of liquidity services in the economy.

The research problem of this study is to examine the information content of the Divisia M3 monetary aggregate in forecasting inflation in the euro area. The most important goal of the study is to find out, whether the Divisia M3 monetary aggregate outperforms its simple sum counterpart. The forecasting performance of both the nominal growth rates and a set of monetary indicators derived from the P-star model for inflation dynamics (*the real money gap and the monetary overhang)* for our two sort of monies are examined. The real money gap and the monetary overhang are monetary indicators that are derived from the long-run money demand equations. As an econometric method I use simulated out-of-sample forecasting that has recently been used to similar purposes by Stock and Watson (1999) and Altimari (2001).

The prominent role of the growth rate of M3 money given in the ECB's monetary policy is strongly criticized in Svensson (2000), mainly because of its lack of predictive power for inflation[1]. On the other hand, Altimari (2001), Gerlach and Svensson (2001) and Trecroci and Vega (2000) use P-star model to study whether the real money gap contains additional information in predicting the Euro area inflation. All of the studies confirm that measures derived from the P-star model really have predictive value for the CPI inflation, although Altimari's results do not support giving a strong role particularly to the real money gap. Also Svensson (2000) refers to the information content of the monetary indicators derived from the P-star model but highlights the distinction between the *level* of *real* money and the *growth rate* of *nominal* money. In addition, Svensson criticizes the P-star model for the lack of solid microfoundations and its dependence on the unreliable estimates of both real money and output gaps. King (2002), Nelson (2002) and Meltzer (2001), in turn discuss about the possibility that the real money balances may play a role in the transmission process of monetary policy that is independent of short term interest rates.

[1] Moreover, it may make the ECB's policy less transparent if the significance of the reference value of M3 growth for ECB's policy is highlighted in rhetoric, while at the same time the ECB in practice ignores even persistent deviations of M3 growth from the reference value (see e.g. Allsopp, 2001).

The information content of the Divisia money in predicting inflation in the euro area is discussed in Stracca (2001) and Reimers (2002). Both studies suggest that the Divisia money actually has additional predictive power for the euro area inflation. Stracca examines the predictive power of the growth rate of real Divisia money in forecasting future inflation and output with linear models. Stracca both estimates an equation for the demand of Divisia money in the Euro area and builds an unrestricted VAR model with changes in the real Divisia money as one of the variables. From the impulse responses of the VAR model, Stracca concludes that the changes in real Divisia money bears some information about the future inflation and output that is not contained in the stock of M3 money.

Reimers (2002) in turn, examines the properties of several alternative series for the euro area Divisia money, based on slightly differing methods used to aggregate the national monetary series to a single euro-area wide aggregate. Reimers examines the information content of both the growth rate of the Divisia money and a Divisia money based P-star measure for predicting inflation of the euro area. The results remained somewhat mixed, depending eg. on the exact aggregation method used and on whether the inflation was defined as a GDP deflator or HICP inflation. Reimers however concludes that it is possible to estimate a stable and reasonable looking money demand equation for the Divisia money in the Euro area. Further, both the in-sample and the out-of-sample forecasting exercises showed that both the Divisia money and the traditional M3 money have a connection with both inflation and output gap in the euro area.

Dorsey (2000) examined the relative information content of the Divisia and the simple sum aggregates in predicting inflation with the US and German data, using a simple artificial neural network (ANN) model. Also Dorsey concludes that the Divisia money consistently dominates its simple sum counterparts in explaining inflation. The ANN model was, in addition, found to be somewhat stable is a sense that the out-of-sample forecasts did not deteriorate rapidly when the forecast horizon was extended.

2. DIVISIA MONEY

2.1. About the theoretical background of the Divisia money

The definition of the Divisia monetary aggregate starts from the standard optimization problem of a representative consumer with money in the utility function[2] so that the utility function of a consumer can be written as

$$u = u(\mathbf{c}, \mathbf{x}),$$

where $\mathbf{c}$ is a vector of the consumption goods (possibly including leisure) and $\mathbf{x}$ is a vector of the quantities of the different monetary assets. Suppose that the utility of a consumer is separable in money so that the consumer's sub-utility from monetary services can be represented by economy's transaction technology over monetary assets denoted by function $Q(\mathbf{x})$, which is homogenous of degree one. Now the consumer's choice over the quantities of the monetary assets is reduced to maximizing $Q(\mathbf{x})$ w.r.t the components of $\mathbf{x}$ under a budget constraint $\mathbf{p}'\mathbf{x} = m$, where p_i :s stand for the user costs of the corresponding assets.[3]. Taking the first order conditions, after some manipulation, results in a formula for the growth rate of the Divisia money:

$$(2.1)\quad d\log Q(\mathbf{x}) = \sum_{i=1}^{n} w_i d\log x_i$$

Rewriting the equation as an explicit differential equation yields:

$$(2.2)\quad \frac{d\log Q(\mathbf{x}(t))}{dt} = \sum_{i=1}^{n} w_i(t)\frac{d\log x_i(t)}{dt}.$$

[2] The derivation of the Divisia money here follows Barnett (2000).
[3] Here we implicitly assume that the consumers either are risk neutral or that the consumers face no risk regarding the utility they derive from the monetary services. Naturally, it would be possible to introduce uncertainty into the model so that the consumers maximise expected utility over the monetary services, that is, $E_t(Q(\mathbf{x}_t))$.

The level of the Divisia money is obtained by solving the equation (2.2). w.r.t Q(t):

$$(2.3)\; Q(t) = \exp \int_{\tau=0}^{t} \left[\sum_{i=1}^{n} w_i(\tau) \frac{d \log x_i(\tau)}{d\tau} \right] d\tau$$

The $\mathbf{x}(t)$ in equations (2.2) and (2.3) is a vector that comprises all the components x_i(t) of the Divisia-aggregate. w_i:s stand for the weights, obtained from the formula:

$$w_i(t) = p_i(t)x_i(t) / \sum_{i=1}^{n} p_i(t)x_i(t)$$

where the user cost p_i is defined as the differences between the own yield of the asset i and the yield of a pure investment asset. The pure investment asset here means an asset that provides investment services, but no liquidity services at all.

It is seen in the equation (2.1) that the user cost p_i of holding an asset i is not the weight of the level of the asset i in the Divisia monetary aggregate. Instead, p_i should be interpreted as the contribution of the yield of the asset i as far as the changes of p_i induce changes in the components x_i of the Divisia-index.

2.2. Building the synthetic aggregates

When examining the properties of the Divisia money in the context of the whole euro area we face an additional problem of how to aggregate the national monetary data into a single European Divisia monetary index number[4]. One way to construct the time series for the Divisia money in the Euro area would be to assume one representative agent for the whole area, in which case the Divisia money for the Euro area would be computed as

$$(2.4)\; \Delta \ln Q_t = \sum_{i=1}^{k} \sum_{j=1}^{n} w_{ijt} \Delta \ln x_{ijt} \text{, where}$$

w_{ij} denotes the expenditure weights of the component assets x_{ij}, k is the number of the member countries and n is the number of the component monetary assets in the Divisia aggregate. Another possibility would be to first build the aggregates separately for each of the eleven member countries. The aggregate of the Divisia money in the Euro area would then be obtained as a weighted average of the stocks of the Divisia moneys in the member countries. Formally, writing the formula (2.1) for the growth rate of Divisia money in discrete form, the formula for the optimal aggregation method for the Euro area Divisia money (Q_t) reads as:

$$(2.5)\ \Delta \ln Q_t = \sum_{j=1}^{k} \rho^j \Delta \ln Q_t^j = \sum_{j=1}^{k} \rho^j \sum_{i=1}^{n} w_i^j \Delta \ln x_i^j \,,$$

where ρ^j denotes the weights put on the Divisia money stocks of the different member countries so that $\sum \rho^j = 1$.[5]

Because sufficiently long time series for the user costs for every component asset were not available for each Euro area country, it was impossible to calculate all the expenditure weights w_i^j. Thus calculating Divisia money series separately for each union country was not feasible. Stracca (2001) solved the problem of calculating a union wide Divisia money aggregate by approximating the true value of the area-wide Divisia money stock by the *synthetic* Divisia money. It becomes defined by the formula (2.6) below.

$$(2.6)\ \Delta \ln Q_t = \sum_{i=1}^{n} \left(\sum_{j=1}^{k} \rho^j w_i^j \right) \sum_{j=1}^{k} \rho^j \Delta \ln x_i^j \,,$$

where k is the number of such member countries, for which the user costs of a given monetary asset i was available. The expression in the brackets tells now the average expenditure weight of the monetary asset i, based on the user cost from only such countries for which the data was available. The expression $\sum_{j=1}^{k} \rho^j \Delta \ln x_i^j$ tells the average change of the holdings of the asset i in

[4] Our discussion about the aggregation problems in constructing an euro area wide Divisia money is based on Stracca (2001) and Reimers (2002).

[5] Note that both the formulas (2.4) and (2.5) assume fixed exchange rates between the EURO 11 countries for the whole sample period.

the euro area. A contribution of the asset *i* to Euro area wide Divisia money is then obtained by multiplying the average degree of liquidity by the average holdings of the asset. Obviously, the synthetic Divisia money is based on assumptions of one representative agent and fixed exchange rates. Finally, note that for calculating the *level* of the Divisia money, one has to chooce an arbitrary initial value for the period t=0. In this study the initial value was set at 100.

The price dual of the Divisia money ($DUAL_t$) is the opportunity cost variable for the whole aggregate. If the total transaction costs in period t are defined as $TC_t = \sum_{i=1}^{n}(R_t - r_{it})x_{it} = Q_t DUAL_t$, (where r_i is the user cost (level) for component i), then the level of the price dual is get from

(2.7) $DUAL_t = \left(\sum_{i=1}^{n}(R_t - r_{it})x_{it}\right) \Big/ Q_t$.[6]

3. METHODOLOGY

3.1. Monetary indicators

As already noted, in addition to the forecasting performance of the growth rate of the nominal Divisia money, we examine also the forecasting performance the real money gap and the monetary overhang. The definitions of these two measures for the deviations of the liquidity of the economy from its desired long-run level are based on the long-run demand for the real money stock. Thus, the monetary overhang corresponds simply to the residuals of the long-run money demand equation. Theoretical foundations of the real money gap in turn, are found from the so called P-star model. It is a model that explains the inflation dynamics of the economy to be driven by a kind of error correction mechanism that reacts to the deviations of

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[6] The log change of the price dual is calculated as $\Delta \ln(DUAL) = \sum w_i \Delta \ln u_i$, where w_i:s are the expenditure weights defined earlier in p. 4. $u_i = \dfrac{R - r_i}{1+R}$, where R is again the return of the pure investment asset and r_i is the own yield a given component asset.

price level p_t from its long-run equilibrium level p_t^* (a price gap).[7] P-star model suggests that in addition to the price gap, inflation is a function of the inflation of the previous period or the expected inflation of the next period. That is, the model can be defined either in backward looking or forward looking form. Sometimes also the change in the equilibrium price level Δp_t^* itself is used as one of the explanatory variables. More formally, the (forward looking) equation determining the time path of inflation reads as follows:

(3.1) $\pi_t = (1-\lambda)E_t\pi_{t+1} + \lambda\Delta p_t^* - \alpha_p(p_t - p_t^*) + \varepsilon_{t+1}$, where $\alpha_p > 0$.

It is seen that the P-star model resembles closely the Phillips-curve equation, with the exception that now the output gap is replaced with the "price gap". The equilibrium level for the price level (p_t^*) that is the key concept of the model, is based on the quantity theory of money. The equation (3.2) below defines p_t^* as the price level that prevails with a given stock of nominal money, when output is at its potential level y_t^* and velocity is at its long-run equilibrium v_t^*.

(3.2) $p_t^* = m_t - y_t^* + v_t^*$

At the same time, the equilibrium price level p_t^* defines the long-run equilibrium for the real money balances ($\hat{m}_t^*$).

$$\hat{m}_t^* = m_t - p_t^* = y_t^* - v_t^*$$

For practical applications like ours, an estimate for the long-run equilibrium real money balances can be constructed by using the parameters of the long-run money demand equation.

(3.3) $\hat{m}_{t_t}^* = m_t - p_t^* = k_y y_t^* - k_i i_t^*$,

[7] The P-star model has been sometimes erroneously referred as also providing the theoretical justification for the money growth pillar in the ECB's strategy also in its current form (for discussion, see e.g. Svensson 1999 and Seitz and Tödter 2001).

where k_y refers to the income elasticity and k_i to the interest rate elasticity of the money demand. i_t^* refers to the equilibrium level of the opportunity cost and y_t^* to the potential level of output. The *real money gap* measures now the deviation of the real money stock from its long-run equilibrium. It is defined as the negative of the price gap, as becomes evident from the equation 3.4) below.

(3.4) $\hat{m}_t - \hat{m}_t^* \equiv -(p_t - p_t^*) = \hat{m}_t - (\kappa_y y_t^* + \kappa_i i_t^*)$.

The equilibrium level for the opportunity cost of holding money (i_t^* in the Eq. 3.4), which is represented by the price dual in the case of the Divisia money and the interest rate variable in the case of the simple sum M3 - were measured as a sample average over the estimation period.

The *monetary overhang* m_t^{ov} at period t, in turn, tells the difference between the current real money stock and the long-run demand for real money, evaluated at the current level of output and opportunity cost for money holdings. From Eq. (3.5.) it becomes evident that the monetary overhang is defined simply as the residual term of the money demand equation.

(3.5) $m_t^{ov} = m_t - p_t - (k_y y_t - k_i i_t)$

Intuitively, the real money gap can be used as a summary statistic of the monetary developments in the economy. It incorporates the information that deviations of the economy from its potential output and equilibrium price level have on the demand for money. The monetary overhang in turn, tells more about the additional information in monetary developments, since it is unaffected by changes in the long-run levels of variables like the potential output or the equilibrium price level.[8] The conceptual difference between these two variables becomes clear if we do the following decomposition:

(3.6) $(\hat{m}_t - \hat{m}_t^*) - m_t^{ov} = \hat{m}_t^{ov} - k_y(y_t^* - y_t) - k_i(i_t^* - i_t)$

[8] Masuch and al. (2001), pp. 138 – 139.

Thus, the real money gap is a sum of the monetary overhang and the effect that the output gap and the deviation of the interest rate from its equilibrium level have on the money demand.

3.2. Econometric methodology

The assessment of the forecasting performance of our monetary indicators is based on simulated out-of-sample forecasting. Recent examples of applying this methodology for evaluating the properties of leading indicator candidates for inflation are eg. Stock and Watson (1999) and Altimari (2001). Stock and Watson examined the relative forecasting performance of the generalized Phillips curve, based on a number of different measures for real aggregate activity, while Altimari studied the leading indicator properties of some monetary variables for the euro area inflation. The econometric methodology of our study closely follows Altimari (2001). The key difference between the study of Altimari and that of ours is just that Altimari focuses only on traditional monetary aggregates, paying no attention to properties of the Divisia money.

Basically, the methodology of the simulated out-of-sample forecasting is based on the equation (3.7) below. It is a forecasting equation for euro-area inflation, in which the inflation is explained by the own history of the inflation itself, along with some given explanatory variable.

(3.7) $\pi_{t+h}^{h} = \phi + \gamma(L)\pi_t + \beta(L)x_t + \varepsilon_t$,

where π_t = inflation between periods t and t-1, π_{t+h}^{h} = the inflation h periods ahead, x_t refers to the variable whose forecasting performance is examined, ϕ = a constant and ε_t = an error term. $\gamma(L)$ and $\beta(L)$ are polynomials in lag operator. The forecasting horizon h will vary from 1 to 12 quarters.

The forecasting exercise proceeds recursively so that the parameters $\beta(L)$ and $\gamma(L)$ of the forecasting equation (3.7) are first estimated by using the first 44 observations of the data. After the model is estimated, a h-period ahead inflation forecast is made. Moving one period forward, the Eq. (3.7) is re-estimated using now k+1 observations, a new h-period forecast is made, and so on, until the end of the sample period is reached.

In each recursive step, the lag length for the estimated model was selected using the Rissanen-Schwarz information criterion (SBC) so that the lag length for both the inflation and the explanatory variable was allowed to vary from 1 to 4. The procedure for choosing the lag length implies that 16 models at each step of forecasting were estimated so that only one of these models, chosen according to the SBC information criterion, was used for computing the forecast.

The sample period allows for estimating totally 29 forecasts for each of the twelve forecast horizons. The h-period forecasting performance for the variable under discussion is then evaluated by calculating the MSE of the forecast errors. This way, the forecasting performance of the Divisia money based indicators can also be compared to the performance of their simple sum M3 based counterparts.

3.3. The Data

The data set for calculating the synthetic Divisia money was provided by Stracca, consisting of the same set of time series that was originally used in Stracca (2001)[9]. The sample period begins at 1980:1 and ends at 2000:4. The data are seasonally adjusted, quarterly, harmonized time series data from countries of the euro-12 area, excluding Greece. For calculating the Divisia monetary index, four components of the broad monetary aggregate M3 were considered, namely the currency in circulation (CC), overnight deposits (OD), short-term deposits other than overnight deposits (SD), and marketable instruments (MI)[10].

The calculation of the Divisia monetary index requires measures of the own rates of return of the component assets. For the overnight deposits (OD), the own rate of return can be obtained by applying the formula

$$r_{CC}\frac{CC}{M1} + r_{OD}\frac{OD}{M1} = r_{M1},$$

[9] Also the methods used for calculating the own rates of return to the component assets, and later, the price dual for the Divisia money are originally from Stracca (2001).
[10] For a more detailed description of the data set, see Stracca (2001).

where r_i:s refer to the own rate of return of *i*:th monetary asset. Given that the return to the cash in circulation (r_{CC}) is equal to zero, we get

$$r_{OD} = r_{M1} \frac{M1}{OD},$$

where r_{M1}, the own rate of return of the euro area M1, is originally from Stracca (2001b).

The own rate of return for the short-term deposits other than overnight deposits (r_{sd}) is obtained correspondingly, using the r_{M1} and the estimate for the own rate of return of M3, that was originally estimated in Calza and al. (2001). The own rate of return for the marketable instruments (r_{MI}), is approximated by the short-term market interest rate that is calculated as the weighted average over the 3-month money market interest rates of the member countries. The yield of a pure investment asset that is also needed for the calculation of the Divisia index, finally, is approximated by the long-term market rate, which is calculated as the weighted average of the 10-year government bond yields.

Figure A.1 in the Appendix A shows the annual growth rates of the M3 Divisia money and the simple sum M3 aggregate. The correlation between the two monies seems to have become stronger in the latter half of the nineties. Before the mid-nineties the growth rate of the traditional M3 money tended to be higher than that of the Divisia money, but towards the end of our sample period the stock of the Divisia money starts to grow faster.

Figure A.2, in turn, plots the annual inflation and the growth rate of the Divisia money in the same figure[11]. By visual inspection, the time-paths of the variables were more closely connected during the first half of the sample period than during the second. The relation between the variables seems to have been particularly loose during the last five years of the sample period. During this period the inflation has been at a record low level, while the growth rates of both the Divisia and simple sum M3 aggregates have increased sharply.

[11] Note that the estimations are based on quarterly series for the inflation, however.

The series for the Divisia M3 and its price dual in logarithmic levels are seen in Figures A.3 and A.4 The initial level of the Divisia money was standardized as 100 and also the calculation of the price dual using formula (2.7) is based on this standardization of the level of the Divisia money. Other time-series data used in the study consist of quarterly series for the real GDP (see Figure A.6) and the GDP deflator (see Figure A.5) aggregated for the euro area, as well as of the estimates for the potential output of the euro area that is needed for calculating the real money gap series [12].

The problems in calculating reliable estimates for the potential output are well-known. To control for the sensitivity of the results to the way the potential output is measured, three different potential output series were used in calculating the real money gap series. The first of the series was obtained simply by Hodrick-Prescott filtering the real GDP series. The other two potential output series were provided by the ECB and the OECD and they have been derived using more structural methods. The ECB estimates are based on the ECB's area-wide model, where the potential output is obtained from a constant-return-to scale Cobb-Douglas production function with calibrated factor share parameters. Also the OECD estimates are based on the Cobb-Douglas production function. All the three measures of the potential level of the real GDP along with the real GDP itself, are seen in the Figure A.7 in the Appendix A The figure A.8 in turn plots the corresponding output gaps for the three potential output series. It is seen in the figures that the output gap estimates based on potential output series based on HP-filtering and the ECB follow quite closely each other, although the HP-filter based estimate lies above while the output gap series based on the OECD data fluctuates more wildly.

3.4. The money demand equations

3.4.1. Estimation of the long-run money demand equations for the euro area

Each recursive step of calculating the real money gap and the monetary overhang series for both the Divisia and simple sum M3 monies, to be used in the forecasting equation (3.7) requires new, updated estimates of the parameters of the respective long-run money demand function. A necessary (but not sufficient) condition for the stationarity of the real money gap

[12] The euro area wide aggregates for the GDP and its deflator are the same than in Stracca (2001)

and the monetary overhang indicators is the existence of a stable cointegration relation between the real money, the real output and the variable describing the opportunity cost of the respective money.

There have been numerous attempts to estimate a stable money demand equation for the euro area in the previous literature. Stracca (2001) and Reimers (2002), for example, provide stable estimates for the long-run money demand equation for the Divisia M3 money. Coenen & Vega (1999), Brand & Cassola (2000), Calza & al. (2001) and Trecroci and Vega (2000), among others, provide evidence for the possibility to estimate a stable money demand equation for the euro area wide simple sum M3 money. Table X presents a short review of the recent estimates for the income elasticity and the interest rate semi-elasticity parameters for the long-run money demand equation estimated for the Euro area (for both the Divisia and the simple sum M3 money). Particularly the value of the income coefficient has been under discussion, since if its value exceeds unity, the observed declining trend in the Euro area money demand could be attributed to the trend in the GDP growth. As it appears in the table, most estimates, including those of Stracca (2001) and Reimers (2002), indeed exceed unity. On the other hand, all the studies did not include a formal statistical test, of whether the income coefficient differs significantly from unity.

In our simulated out-of-sample exercise, the estimation of money demand equation for each recursive step of creating new series for the real money gap and the monetary overhang is conducted simply by OLS. When the Divisia M3 money was considered, our money demand specification included a constant term, the real GDP the price dual of the Divisia money along with its square. The price dual measures the opportunity cost of holding the real Divisia money balances and its square is included into the specification to capture possible non-linearities in the money demand. With this specification we again follow the practice of Stracca (2001).[13]

[13] In fact, including the square of the price dual in the money demand specification has been put into question by Reimers (2002) both on ground of some methodological considerations (see Reimers (2002, p.19.) and on empirical grounds (see Reimers (2002, p. 34). Including the square term in our specification was partly motivated by an estimation exercise with the Johansen procedure, which suggested that the square term is included in the cointegration space.

Since the variables of the money demand equations for both the Divisia and simple sum M3 monies are all I(1)-variables[14], estimating the money demands simply by linear regressions actually corresponds to the Engle-Granger cointegration analysis. Using linear regressions instead of the more elaborate Johansen procedure is further justified by the fact that according to the economic theory, there should not be other cointegration relations between the variables than that defining the money demand equation.

When the full sample was considered, the money equation was estimated to be

$$(m-p)_t = k + 1.2 \cdot gdp_t - 0.43 \cdot DUAL_t + 0.01(DUAL_t)^2$$

Thus, also in the study at hand the income elasticity of the real Divisia money exceeds unity, which is in line with Stracca (2001) and Reimers (2002). The overall stability of the parameters of the money demand equation was examined by plotting the coefficient estimates against time (see the Figure A.9 in the Appendix A). The income elasticity and the squared price dual elasticity seem to be remarkable stable, while there seems to be a structural shift in the price dual elasticity and in the constant term at around 1991. Estimating correctly the value for the price dual elasticity matters only for calculating the monetary overhang series, however. Since the equilibrium value for the opportunity cost of dual money is measured as a sample average, the product of the price dual elasticity and the equilibrium rate of the price dual ($k_i i_t^*$ in Eq. (3.5)) becomes a part of the constant term of the equation defining the real money gap. Accordingly, the forecasts based on the real money gap series are unaffected by the value of $k_i i_t^*$, since it does not affect the variation of the real money gap series.

Calza & al. (2001) argue that the correct opportunity cost variable to be used in the money demand specification for the euro area simple sum M3 money is the spread between the short-term interest rate and the own rate of interest of the M3 money. This opportunity cost variable for the simple sum M3 money is adopted also here. The line graph representing the recursive estimates of the parameters of the money demand equation is presented in Graph A 10. The

[14] The order of integration of the variables in the money demand equations for both the Divisia M3 and the simple sum M3 was examined also formally, with ADF and PP tests (results reported in Tables A2 and A3 in the Appendix A). The tests confirmed that the variables in the money demand equation should be modelled as I(1) processes.

estimate for the income elasticity again seems to be remarkably stable and it exceeds unity, just as it was the case in the Calza and al. (2001) referred above, as well as in the studies eg by Coenen and Vega (1999) and Brand and Cassola (2000). The interest rate elasticity however, takes a value near zero, which does not sound plausible. However, the same argument applies here than in the case of the Divisia money, so that the interest rate elasticity term matters only for calculating the monetary overhang series.

3.4.2. The time series properties of the monetary indicator variables

Estimating the forecasting equation (3.7) makes sense only if the variables in both sides of the equation are stationary, or alternatively, if the series are non-stationary but cointegrated. Whether the inflation rate is a unit root process or not, has been under lively discussion. (See e.g. the studies by Juselius (1999) and Juselius and McDonald (2000).) Neither can the possibility of a unit root in the growth rate of money be excluded without a further examination. The results of the formal unit root tests for our all different monetary indicator series are reported in the Table A.3 in the Appendix A. According to the ADF and PP tests, both the inflation and the growth rate of the nominal Divisia money seem to be I(1) processes. The uncertainties due to the low power of the unit root tests are however further emphasized here because of the relatively short sample period and a possible structural break in the sample period, dividing the sample for periods of high and low inflation.

A priori, both the real money gap and the monetary overhang are expected to be I(0) variables. That the real money gap should be stationary follows from the fact that the gap reflects just deviations of the real money stock from its equilibrium level and this gap should get closed in the long-run. For the monetary overhang, the stationarity corresponds to the stability of the estimated underlying long-run money demand equation. When the stationarity of the monetary indicator series was tested formally, the unit root tests however, showed signs of nonstationarity for some of the real money gap and monetary overhang series calculated for the Divisia M3 and for most of these series for the simple sum M3 money.

The line graphs for the Divisia money based indicator series, based on the full sample, are plotted in Figures A.11-A.14 in the Appendix A. The figures show that as might be expected, the real money gap series seem to be somewhat sensitive to the underlying estimate of the potential output. According to the unit root tests then, the real Divisia money gap series based on the HP-filter estimates of the potential output seem to be I(1) process. Since a closer inspection of the Figure (A.11) suggests that the this result may follow from the structural break at the end of the real money gap series, the stationarity of the series was re-examined ignoring the last three years of the data. Accordingly, the tests now indicated stationarity.

For the real money gap series based on the ECB estimate of the potential output, the results of the ADF and PP tests contradict each other. The Figure (A.12) suggests however that the possible non-stationarity is more likely due to a deterministic than a stochastic trend in the data. Finally, the real money gap based on the OECD estimate of potential output contains a unit root according to both unit root tests. The possibility of non-stationarity is now supported also by inspection of the line-graph of the series (Figure (A.13)), according to which the series contains relatively large up- and downswings. Also the volatility of the series seems to be largest of all the three real money gap measures considered.[15]

The monetary overhang series for the Divisia money is shown in the Figure A.14. Testing the stationarity of the monetary overhang series in fact means just that our Engle-Granger type of cointegration analysis becomes completed. Since the monetary overhang series consist of the residuals of the money demand equation, the series should be stationary or otherwise there would not exist a stable cointegration relationship between the variables at all. Luckily, both the ADF- and PP-tests, along with the inspection of the graphs of the series suggest stationarity for both the Divisia and the simple-sum M3 money. The unit root tests were made also for the real money gap measures calculated for the simple sum M3 money (the results also reported in the Table A.4), for which the tests mostly reported non-stationarity.

In sum, the discussion above points out to some uncertainties regarding the order of integration of the variables of our forecasting exercise. While the forecasting equation (3.7) is based on an assumption of both inflation and the indicator variables being either I(0) variables or I(1) variables that are cointegrated, it is therefore still possible that

[15] Note that because of some measurement issues, the constant terms of the real money gap and the monetary overhang series are probably not correctly estimated. The "wrong" value for the constant term does not affect the results of our forecasting exercise, but there is now no sense in giving any interpretation for the absolute values of the real money gap and monetary overhang series.

- The inflation is I(1), while (some of) the indicator variables are I(0). Of course, in this case, our forecast exercise using eq. (3.7) would not make sense.
- Both the inflation and the indicator variables are in some of the cases I(1) but not cointegrated. In fact, when the cointegration between inflation and each of the indicators was examined with the Johansen test and the full sample, the test did not report cointegration in almost any of the cases.

Thus, we ended up with comparing the results obtained by the baseline forecasting equation (3.7) with two alternative model specifications (the equations (3.8) and (3.9) below). Eq. (3.8) is based on an assumption of the inflation as an I(1) process, but the indicator variables as I(0) series (see Altimari, p. 17). The eq. (3.9) in turn corresponds to an assumption of both the inflation and the monetary indicators as I(1) series that are not cointegrated with each other.

(3.8) $\pi^{h}_{t+h} - \pi_{t} = \phi + \mu(L)\Delta\pi_{t} + \beta(L)x_{t} + \varepsilon_{t+h}$

(3.9) $\pi^{h}_{t+h} - \pi_{t} = \phi + \mu(L)\Delta\pi_{t} + \beta(L)\Delta x_{t} + \varepsilon_{t+h}$

4. RESULTS

4.1. The performance of the out-of-sample forecasts

The (out-of-sample) forecasting performance of the monetary indicators is discussed by examining the ratios between the MSE of the forecasts based on the forecasting equations (3.7), (3.8) and (3.9) and the MSE of a univariate forecast based only on the own history of the euro area inflation. Clearly, if the MSE ratio gets a value below unity, the indicator under study contains some additional predicting power for inflation.

4.1.1. The baseline specification

Tables (4.1) and (4.2) below report the MSE ratios for the forecasts based on the baseline specification, Eq. (3.7). Table (4.1) reports the performance of the Divisia M3 indicators and Table (4.2) the performance of the simple sum M3 indicators. The forecasts are made for 1 – 12 quarters ahead and the evaluation of the performance of each indicator is based on the period 1991:1– 2001:4. The results can be inspected visually in the graphs of Appendix B, where the MSE ratios are plotted against the length of the forecast horizon.

Table 4.1. The MSE-ratios of the Divisia M3 based monetary indicators.

Period	1	2	3	4	5	6	7	8	9	10	11	12
RMSE univ %	0,4	0,4	0,43	0,45	0,43	0,42	0,42	0,42	0,43	0,45	0,46	0,47
RMSE univ pp	0,93	1,82	1,4	1,23	1,1	0,99	0,95	0,97	0,97	1	1	1,01
Real money gap HP	0,99	1,17	1,21	1,13	0,9	0,73	0,76	0,76	0,73	0,69	0,62	0,61
Real money gap ECB	1,33	1,33	1,49	1,59	2,02	2,19	1,83	1,75	1,75	1,74	1,74	1,66
Real money gap OECD	1,28	1,16	1,21	1,33	1,28	1,27	1,41	1,47	1,57	1,46	1,4	1,26
Monetary overhang	1,13	1,05	1,04	0,99	0,89	0,93	0,94	0,88	0,91	0,93	0,99	1,01
Diff nominal money	1,18	0,93	0,76	0,47	0,37	0,49	0,42	0,5	0,5	0,53	0,59	0,62

The first line tells the relative magnitude of the forecast error of the univariate forecast and the second row tells the absolute values of the univariate forecast error (in percentage points). The rest of the figures tell the ratios between the MSE of the respective bivariate inflation forecasts based on the forecasting equation (3.7) and the MSE of the univariate forecast, based only on the own history of inflation. Results for the three different series for the real money gap and the series for the monetary overhang are reported in the table. HP refers to the case when the potential output is calculated by HP-filtering, while ECB and OECD refer to the output estimates provided by ECB and OECD. The bottom line of the table reports the forecasting performance of the growth rate of nominal Divisia M3 money.

Table 4.2. The MSE-ratios of the simple sum M3 based indicators.

Period	1	2	3	4	5	6	7	8	9	10	11	12
Real money gap HP	0,99	0,94	0,84	0,86	0,83	0,86	0,73	0,59	0,46	0,39	0,38	0,36
Real money gap ECB	1,28	1,47	1,18	0,91	0,89	0,98	0,95	0,79	0,66	0,6	0,58	0,55
Real money gap OECD	1,14	1,31	1,29	1,07	0,78	0,83	0,87	0,87	0,77	0,7	0,64	0,59
Monetary overhang	1,23	1,24	1,42	1,18	1,36	1,23	1,13	0,92	0,82	0,76	0,75	0,76
Diff nominal money	0,89	0,88	0,85	1,1	1,12	1,13	0,87	0,81	0,75	0,74	0,74	0,73

The ratios between the MSE:s of the forecasts based on the forecasting equation (3.7) and monetary indicators calculated for the simple sum M3 money, and the MSE of an univariate inflation forecast. For an explanation for the names of the series used in the table, see the notes to the Table (4.1).

The first line of the Table (4.1) reports the mean square errors (MSE) of the univariate inflation forecasts, divided by the concurrent actual values of inflation, whereas the second line tells the MSE of the univariate forecasts in percentage points. The bottom lines of the tables in turn, report the forecast performance of the growth rate of the nominal money. It is a benchmark to which to compare the performance of the real money gap and monetary overhang series to find out, whether these indicators based on the level of the real money provide better inflation forecasts than the growth rate of the nominal money that the ECB has given the special role in its announced monetary policy strategy.

When the Divisia M3 based indicators are compared with each other, it is seen in the Table (4.1) that the real money gap series perform surprisingly poorly, being beaten by the univariate forecasts in most of the cases. The only exception is the real money gap measure based on the potential output estimate obtained by HP-filtering. When the forecast horizon is extended beyond five quarters, the forecast MSE of this indicator levels at around 60 – 75 % of the MSE of the univariate forecast. The other two real money gap measures however, are clearly outperformed both by the univariate forecasts and also by the monetary overhang series that seems to predict future inflation for periods beyond three quarters.

It would be expected that the relative performance of the monetary indicators is increasing in the length of the forecast horizon, both because the relation between money and inflation should be seen only with lag and because in general, the univariate forecasts perform best in the short run. Except the real money gap series based on the potential output estimate obtained by HP-filtering, the line graphs in the Appendix B are flat or even upward sloping, thus revealing that extending the forecast horizon does not improve the relative forecasting performance of the Divisia money indicators.

Interestingly, the most accurate inflation forecasts are provided by the growth rate of the nominal Divisia money. Beyond a horizon of three quarters, the forecast MSE:s of the growth rate of the nominal Divisia money level at around 50 % of the MSE of the univariate forecast. The finding contradicts the results in Altimari (2001), for the simple sum M3 aggregate, in which the real money gap yielded better inflation forecasts than the growth rate of the nominal money. On the other hand, in Reimers (2002) the growth rates of both the Divisia money and the simple sum M3 seemed to perform equally well as the P-star indicator, when the inflation was defined as GDP inflation.

When the forecasting performance of the Divisia M3 based indicators are compared to the performance of their simple-sum M3 counterparts, reported in the Table (4.2), it is seen first that the real money gap series for the simple-sum M3 clearly outperform their Divisia M3 counterparts, irrespective on the way the potential output is defined when calculating the gaps. Whereas the forecasts based on the Divisia M3 real money gap indicators are mostly beaten even by the univariate forecasts, the corresponding simple sum M3 series perform relatively well, particularly in the long end of the forecast horizons. Beyond the horizon of one year, the simple sum M3 based real money gap series actually outperform the univariate forecasts in almost all cases. The downward sloping line graphs in the figures of the Appendix B also show that in contrast to the Divisia M3 based indicators, the forecasts with the simple sum M3 tend to be improved when the forecast horizon is extended.

According to the Table (4.2), it does not matter very much for the forecasting performance of the real money gap series for the simple sum M3 money, on which estimate of the potential output they are based, although the series based on the potential output estimate from HP-filtering performs best. This is seen particularly well in the long end of the forecast horizons. In contrast to the case of the Divisia M3 indicators, neither the monetary overhang nor the nominal growth rate of the simple sum M3 aggregate outperforms the real money gap series.

In the case of the monetary overhang series, the Divisia money based series perform better in the short end of the forecast horizons, while in the long end of the horizons it is the other way round. When it comes to the growth rates of the two nominal monies, Divisia money performs better. The MSE-ratios for the growth of the nominal Divisia M3 stays near the level of 50 % in most forecast horizons, while the MSE-ratios of the simple sum M3 based forecasts ranges between the levels of 70 % - 80 %. The finding contradicts Reimers' (2002), in which the simple sum M3 outperformed two of the three alternative Divisia M3 measures in forecasting the GDP inflation.

4.1.2. The alternative specifications for the forecasting equation

The two alternative specifications (3.8) and (3.9) for the forecasting equation are based on forecasting the change of inflation, instead of the inflation itself. The results for the first alternative specification, namely the forecasting equation (3.8), are reported in the Table (4.3) for the Divisia money and Table (4.4) for the simple sum money. Since the specification is based on an assumption of the euro area inflation as a non-stationary I(1) process, but the indicator variables as following I(0) process , the lagged inflation terms in the right hand side of the equation are in differences but the lagged indicator variable in levels. Comparing the top lines (reporting the errors of the univariate forecasts) of the tables (4.3) – (4.6) with those of the tables (4.1) and (4.2), shows that the growth rate of inflation appears to be much more difficult to predict than the inflation itself, as can be expected. In the specification of Eq. (3.7), the univariate forecast errors remained at around 40 % of the actual values of inflation, whereas in the specifications (3.8.) and (3.9.) the forecast errors in all periods exceeds 100 % of the actual inflation.

In most cases, neither the monetary indicator series for the Divisia nor the simple sum M3 monies do seem to contain additional information for predicting the change of the euro area inflation. In the cases of the real money gap series and forecast horizons beyond three quarters the MSE ratios tend to exceed unity. The forecasts based on the growth rate of the nominal moneies however still beat the univariate forecasts in the cases of both sort of monies.

Table 4.3. The MSE:s of the forecasts based on the I(1) specification and the Divisia M3 indicators.

Period	1	2	3	4	5	6	7	8	9	10	11
RMSE univ %	1,29	7,86	66,5	5,52	2,55	3,24	2,71	1,45	14,5	1,96	2,62
RMSE univ pp	4,95	1,5	0,89	0,73	0,62	0,55	0,57	0,56	0,54	0,52	0,54
Real money gap HP	0,78	0,79	0,98	0,63	0,73	0,94	1,11	1,14	1,42	1,54	1,93
Real money gap ECB	0,63	0,99	1,41	1,59	1,57	1,78	2,12	2,18	2,43	2,67	2,7
Real money gap OECD	0,99	0,79	1,19	1,45	1,41	1,48	1,78	1,53	1,58	1,55	1,49
Monetary overhang	1,06	1,07	1,04	0,89	0,89	0,88	0,9	0,85	0,99	0,9	0,97
Diff nominal money	0,43	0,48	0,45	0,46	0,58	0,63	0,68	0,76	0,82	0,85	0,89

The ratios between the MSE:s of the forecasts based on the forecasting equation 3.8) and monetary indicators calculated for the Divisia M3 money, and the MSE of an univariate inflation forecast. For an explanation for the names of the series used in the table, see the notes to the Table 4.1.

Table 4.4. The MSE:s of the forecasts based on the I(1) specification and the simple sum M3 indicators.

Real money gap HP	0,84	0,71	0,82	0,9	1,26	1,33	1,25	1,15	1,15	1,18	1,22
Real money gap ECB	0,87	1,02	1,1	1,03	1,19	1,23	1,19	1,11	1,09	1,13	1,02
Real money gap OECD	1,06	0,8	1,11	1,09	1,15	1,04	1,03	1,19	1,29	1,23	1,21
Monetary overhang	1,16	1,35	1,16	1,09	1,33	1,52	1,39	1,34	1,38	1,38	1,39
Diff nominal money	0,58	0,74	0,67	0,7	0,84	0,98	0,82	0,86	0,89	0,91	0,95

The ratios between the MSE:s of the forecasts based on the forecasting equation 3.8) and monetary indicators calculated for the simple sum M3 money, and the MSE of an univariate inflation forecast. For an explanation for the names of the series used in the table, see the notes to the Table (4.1).

When it comes to the relative forecasting performance of the two monies, the results of the specification (3.8) seem to remain qualitatively close to the results of the specification (3.7). When the real money gap series are considered, in two cases out of three, (based on ECB's and OECD's estimates for the potential output), the simple sum M3 based indicators perform better, whereas in one case (the HP-filter based potential output) the Divisia M3 indicator tends to yield lower MSE ratios. The simple sum M3 real money gap series perform better particularly in the long end of the forecast horizons. When the monetary overhang series are considered, on the other hand, the series based on the Divisia money beats its simple sum M3 counterpart.

The best forecasts are again attained with the growth rates of the nominal monies, the Divisia M3 performing better than the simple sum M3. It is also notable that when the level of inflation was considered (the specification 3.7), the monetary indicators seemed to predict inflation best in the long end of the forecast horizons, while in case of forecasting the change of inflation (the specification 3.8), the monetary indicators contain most information for short end of the forecast horizon.

Tables (4.5) and (4.6) below report the results for the second of the alternative specifications (Eq. 3.9.). In addition to the inflation, now also the real money gap and the monetary overhang series are assumed to be I(1) variables. It is further assumed that the indicator variables are not cointegrated with inflation and accordingly, they appear as differences in the right hand side of the forecasting equation. Since the MSE ratios in the tables mostly get values below unity, the results now suggest that both the Divisia and the simple sum M3 based indicators seem to contain information for forecasting the Euro area inflation. Interestingly however, now the Divisia M3 based indicators seem to slightly outperform their simple sum M3 counterparts, although the difference in favor of the Divisia money indicators does not seem to be large, however. In case of the real money gap series based on the Divisia money, the MSE ratios mostly stay in a range between 0.75 and 1, while the corresponding figures for the simple sum money get slightly higher values. Also the monetary overhang for the Divisia money outperforms its counterpart for the simple sum money. In contrast to the results of the previous specifications, the real money gap variables for the Divisia money seem to perform better than the overhang series, however.

Table 4.5. The MSE:s of the forecasts based on the I(1) specification and the Divisia M3 indicators.

Period	1	2	3	4	5	6	7	8	9	10	11
RMSE univ %	1,29	7,9	66,5	5,52	2,55	3,2	2,7	1,4	14,5	1,96	2,62
RMSE univ pp	4,95	1,5	0,89	0,73	0,62	0,55	0,57	0,56	0,54	0,52	0,54
Real money gap HP	0,98	0,96	0,92	0,75	0,72	0,75	0,71	0,7	0,69	0,7	0,71
Real money gap ECB	1,02	1,01	0,97	0,75	0,77	0,77	0,75	0,75	0,74	0,74	0,75
Real money gap OECD	1,38	1,07	0,98	0,73	0,71	0,71	0,7	0,74	0,71	0,76	0,76
Monetary overhang	1	1	1,02	1	1,01	1,02	0,92	0,89	0,88	0,86	0,86
Diff nominal money	0,95	0,85	0,84	0,85	1,01	1,11	1,05	1,06	1,07	1,1	1,1

The ratios between the MSE:s of the forecasts based on the forecasting equation 3.9) and monetary indicators calculated for the Divisia M3 money, and the MSE of an univariate inflation forecast. For an explanation for the names of the series used in the table, see the notes to the Table (4.1).

Table 4.6. **The MSE:s of the forecasts based on the I(1) specification and the simple sum M3 indicators.**

Period	1	2	3	4	5	6	7	8	9	10	11
Real money gap HP	0,96	1,06	1,04	0,77	0,86	0,78	0,69	0,68	0,67	0,66	0,68
Real money gap ECB	1,02	0,95	1,01	0,96	1,11	1,15	0,93	0,87	0,84	0,84	0,86
Real money gap OECD	1,47	1,03	0,9	0,68	0,89	1	0,99	0,98	0,97	0,93	0,96
Monetary overhang	1,24	1,33	1,39	1,36	1,32	1,19	1,05	1	0,97	0,95	0,95
Diff nominal money	0,98	0,81	1,12	1,32	1,78	1,13	1,31	0,94	0,92	0,87	0,86

The ratios between the MSE:s of the forecasts based on the forecasting equation (3.9) and monetary indicators calculated for the simple sum M3 money, and the MSE of an univariate inflation forecast. For an explanation for the names of the series used in the table, see the notes to the Table (4.1).

The bottom lines of the tables report now the forecast MSE ratios for the second differences of the two nominal M3 money series. It is seen that the "growth of growth rate" of the Divisia M3 performs yields better forecasts in short horizons, while that of the simple sum M3 performs better in the long end of the forecasts. Looking at the line graphs in the Appendix C also reveals that the forecasting performance of the indicators is improved in many cases when the forecast horizon is extended.

Looking at the alternative specifications of the forecasting equation thus provides a possible explanation for the relatively poor forecasting performance of the Divisia monetary indicator series in specifications (3.7) and (3.8). That is, the real money gap and monetary overhang series might be I(1) series that are not cointegrated. This conclusion was also supported by our formal testing of the time series properties of the indicators.

5. CONCLUSIONS

The ECB has given the M3 monetary aggregate an important role as an indicator variable for the future inflation in the euro area. This study has discussed, whether synthetic Divisia M3 monetary aggregate could provide more accurate inflation forecasts than the ordinary M3 aggregate that does not take into account the differing degrees of liquidity of the component assets of the aggregate. Although in the long-run the effect , in the short run, As an econometric method I have used simulated out-of-sample forecasting. In addition to comparing the forecasting performance of the growth rates of the two nominal M3 monies, the study has focused on the performance of the real money gap and the monetary overhang variables calculated for the monies.

Perhaps the most interesting finding of the study was the good performance of the growth rate of the nominal Divisia money, regardless of the specification of the forecasting equation. The growth rate of the nominal Divisia money seemed to significantly improve the forecasts for both inflation and the change of inflation, compared to the forecasts based only on the own history of inflation. The growth rate of the Divisia money yielded the best forecasts not only within the Divisia money based indicators but it outperformed also the simple sum M3 based indicators. The finding contradicts the previous findings based on the simple sum M3 money, according to which real money gap and money overhang – variables that measure the gap between the desired and actual *level of real* money holdings, suit best for the forecasting purposes. From a theoretical perspective, the performance of the growth rate of the Divisia money is even more interesting, when taking into account the recent arguments according to which the estimations based on simple linear regressions in fact understate the relations between money and inflation, since this relation probably is too subtle to be revealed by a simple linear one-equation model[16].

When it comes to comparing the forecasting performance of the real money gap and monetary overhang measures for the two sort of monies, the simple sum money based indicators performed better in forecasting both inflation and the change of inflation, as long as the indicator variables were considered in levels. The relatively short sample period and some obvious structural breaks in the period resulted in some uncertainties concerning the time series properties of the monetary indicator series. Because of these uncertainties, also the information content of the real money gap and monetary overhang series in differences was examined. Now the Divisia money based real money gap and monetary overhang series surprisingly outperformed their simple sum money based counterparts.

Although the results remain somewhat conditional on the assumptions made on the time-series properties of the data, they still support the role of the Divisia money as a valuable indicator on the future price developments in the euro area, at least along with the ordinary, simple sum monetary aggregates. A longer inflation history will be needed, however to ascertain, whether it is the growth rate of the nominal Divisia money or some Divisia money based measure for the excess liquidity in the economy, that the ECB should be looking at.

[16] See eg King (2002)

Some caution is needed in interpreting the results, however. Firstly, because the study is based on aggregated euro-area wide data, all the relations between money and prices that the study suggests represent averages of these relations over the EMU member countries. Most of the time in the sample period, the transmission process between money and prices has been based on independent monetary policies in the member countries, however. The average of these transmission processes may differ from the transmission process under the regime of common monetary policy, which may have caused a structural shift also in the relation between money and prices. Secondly, in the end of the sample period there might have occurred pure portfolio shift in the money demand, due to changes in the opportunity costs of holding money and this kind of shifts in the holdings of money do not have much to do with the future inflation pressures.

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APPENDIX A

Figure A1. The annual growth rates of the Divisia (GRDIV) and simple sum (GRM3) M3 monetary aggregates.

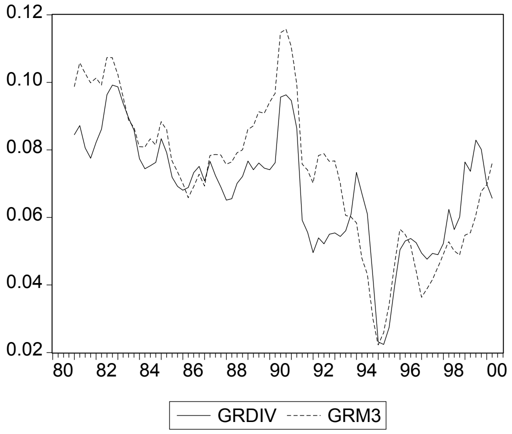


Figure A2. The annual GDP inflation (ANNINF) and the annual growth rate of the Divisia M3 (GRDIV).

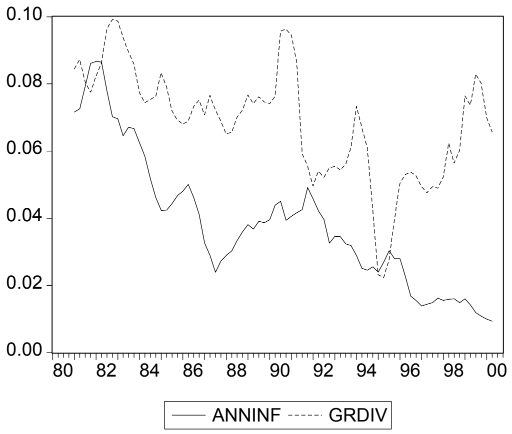


Figure A3. The log of the Divisia M3 money

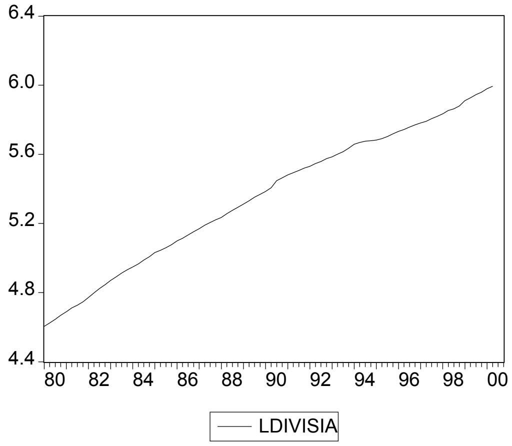


Figure A4. The log of the price dual for Divisia M3 money .

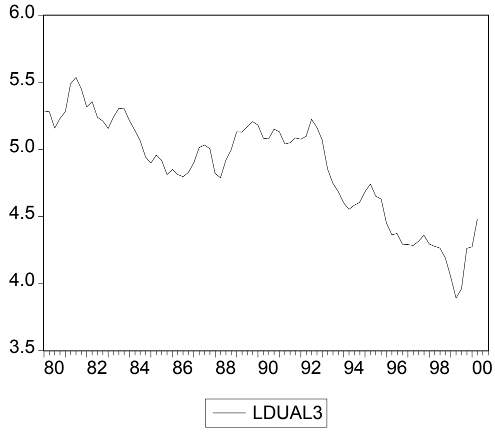


Figure A5. The quarterly GDP inflation in the Euro 11 area

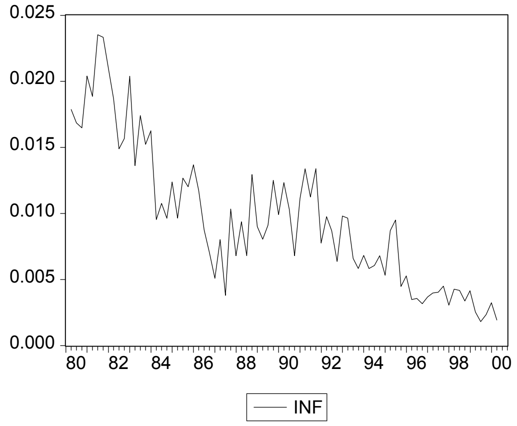
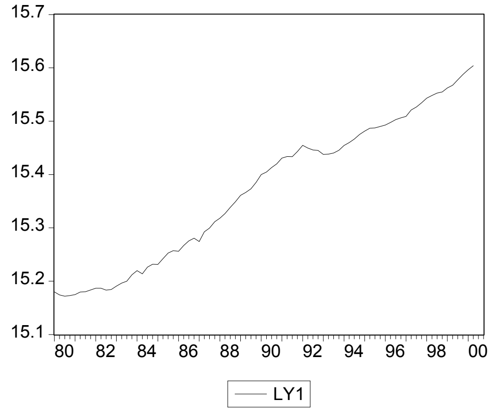
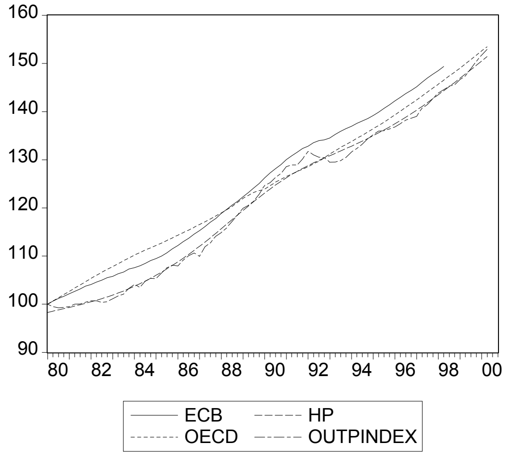


Figure A6. The real GDP in the Euro 11 area



Figures A7 and A8. Three measures for the euro 11 potential output, along with the Euro 11 real GDP (**A7**.) and the corresponding output gaps (**A8**.). OUTPINDEX denotes to the real GDP of the euro area, ECB and OECD correspond to the estimates for the potential output provided by the ECB and OECD, respectively, while HP denotes to the potential output estimate obtained by Hodrick-Prescott-filtering. GAPOECD, GAPECB and GAPHP denote to the output gap estimates based on the respective series for the potential output. All the series have also been adjusted for the German reunification. Note also that all the series for the potential output are reported as index numbers with the first observation (1980:1) as standardised to 100. Thus, the figures tell only on the variability of the potential output and the output gap during the sample period, but it is not possible to make conclusions on the actual sign of the output gap.



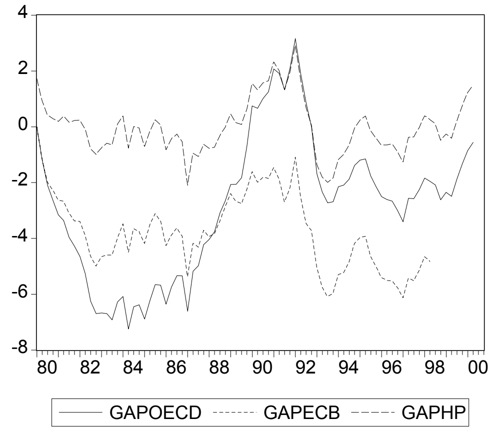


Table A1. Parameter values of some previous estimated money demand equations for both the simple sum and the Divisia M3 aggregates of the Euro area. "income" refers to the income elasticity, while "long interest" and "short interest" refer to the elasticity of the money demand on the short-term and long-term interest rate. "short own" inturn denotes to the elasticity on the spread between the short-term interest rate and the own return of M3. Fagan and Hendry (1998) and Reimers (2002) provided a number of estimates, each corresponding to a different specification of the model. Thus, in these cases the table reports the range where the estimates were located.

The model				
The simple sum M3/	income	long interest	short interest	short own
Calza and al. (2001)	1,34			-0,86
Brand and Cassola (2000)	1,33	-1,61		
Trecroci and Vega (2000)	1,158			
Fagan and Henry (1998)	1,55 - 1,61	-0,20 - (-0,58)*	0,32	
Coenen and Vega (1999)	1,17	-1,26		
Gerlach and Svensson (2000)	1,51			
Kontolemis (2000)	1	-1,89		
Kontolemis (2002)	1	-1,45		
The Divisia money/	income	price dual		
Stracca (2001)	1,19	-1,72		
Reimers (2002)	1,00-1,36	-0,06 - (-0,11)		

Table A2. The unit root tests for the variables in the Divisia M3 money demand equation. The figures in the column "specif" denote to the lag length used in the unit root test, while c and t refer to a constant and a linear trend if they were included into the specification.

Variable	specif.	ADF	PP
GDP	1-4,c,t	-2.404955	-2.310080
Dual	1,c	-1.621749	-1.309498
Sqdual	1,c,t	-2.798961	-2.399084
d(sqdual)	1-2	-5.082891	-6.052015

Table A3. The unit root tests for the variable in the simple sum M3 money demand specification. For explanation for the column "specif.", see the Table A1.

variable	specif.	ADF	PP
m3	1,c,t	-1.452038	-0.969632
GDP	1-4,c,t	-2.404955	-2.310080
userm3	1,c,t	-3.184589	-2.640535
userm3lt	1,c,t	-4.180678 xx	-2.828700

Figure A9. The recursive estimates for the coefficients of the money demand equation estimated for the Divisia money. B1VEC = constant term, B2VEC = coefficient for the log of output, B3VEC = the coefficient of the price dual and B4VEC = the coefficient of the squared price dual.

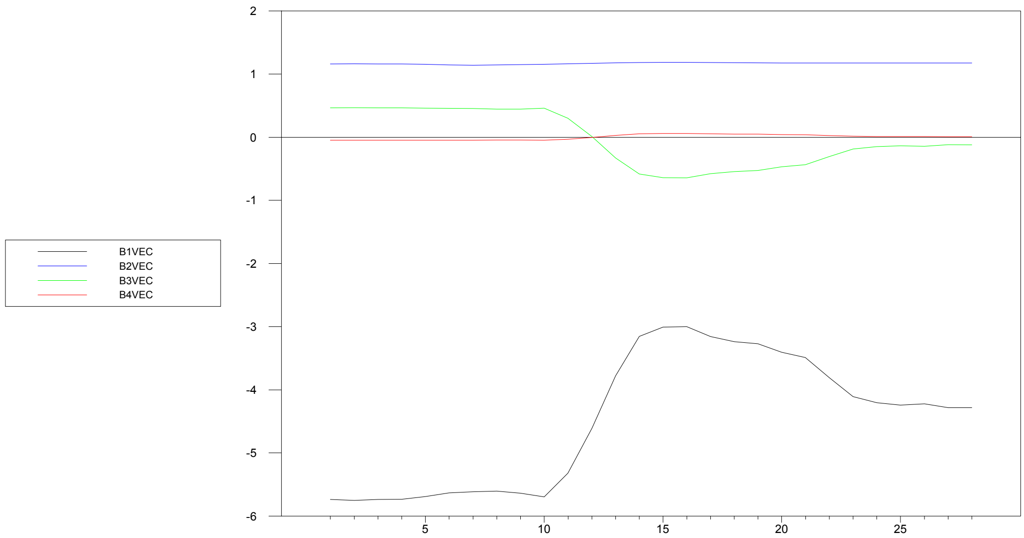
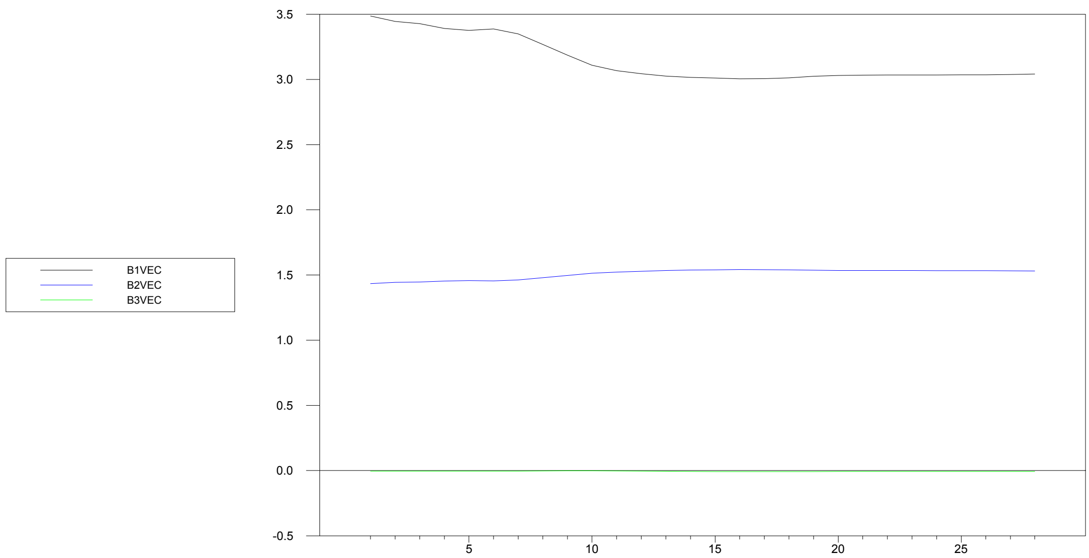


Figure A10. The recursive estimates for the coefficients of the money demand equation estimated for the simple sum M3 money. B1VEC = constant term, B2VEC = coefficient for the log of output and B3VEC = the coefficient of the interest rate variable. Note that the coefficient estimate for the interest rate elasticity is so close to zero, that it is almost indistinguishable from the zero-line in the figure.



Figures of the real money gap and monetary overhang measures calculated with the full sample and the Divisia M3 money.

Figures A10 – A15 plot the series for the real money gap series and figures A16 and A17 represent the monetary overhang series. HP refers to the potential output estimate obtained by Hodrick-Prescott filtering, while ECB and refers to the potential output estimates provided by the ECB and the OECD, respectively. Number 1 and 2 in the end of the name of the series denotes to the money demand equation based on linear regression and Johansen procedure, respectively.

Figure A. 11.

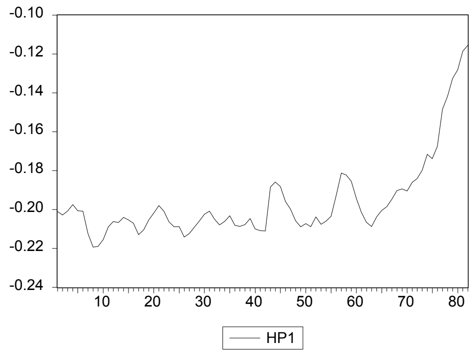


Figure A12.

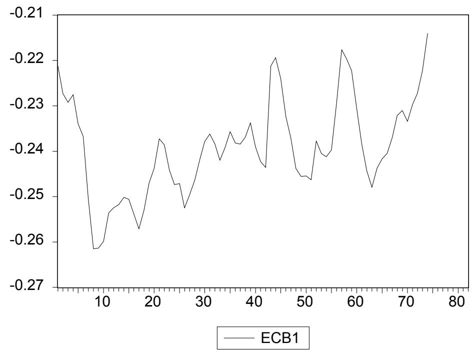


Figure A. 13.

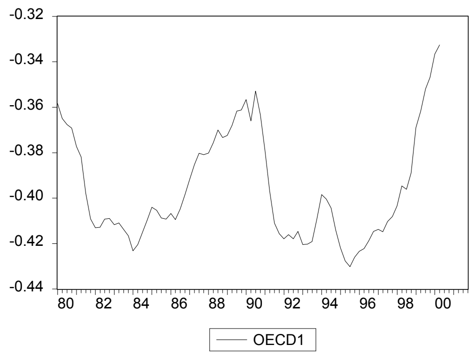


Figure A.14

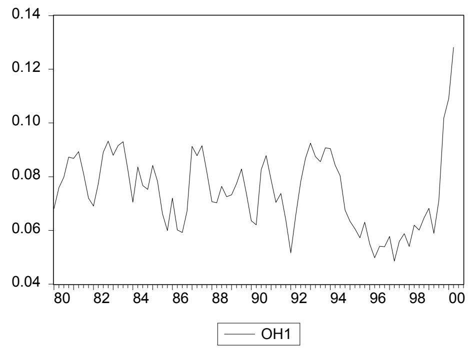


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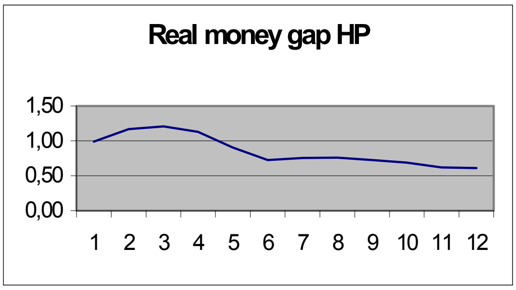
Table A.4

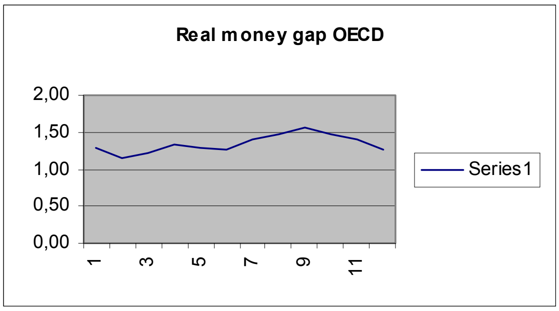
The results of the unit root tests for the different monetary indicators for both the Divisia M3 money (div money in the table) and the simple sum M3 money (money in the table). Money gap refers to the real money gap series and money oh to the monetary overhang series. Hp, ecb and oecd again denote to the source of the series for the potential output.

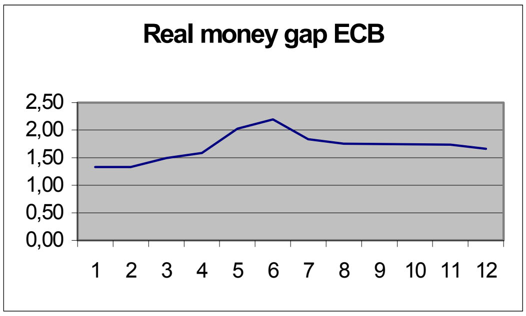
Variable	ADF	PP	specific.
inf	-2.964352	-4.925672 xx	c,t,1
dM3	-2.604535	-3.414204 x	c,t,1
lddiv	-6.214867 xx	-6.244935 xx	c,t,0
div money gap hp	-1.166549	-0.834533	1
div money gap ecb	-1.578305	-0.916825	c,1
div money gap oecd	-2.177563	-1.477843	c,1
money gap hp	-2.380200	-1.957308	c,1
money gap ecb	-1.552156	-1.165160	1
money gap oecd	-1.888206	-1.815010	c,t,1
div money oh	-2.501796	-2.189717	c,1
money oh	-3.057139 x	-2.990816 x	c,1

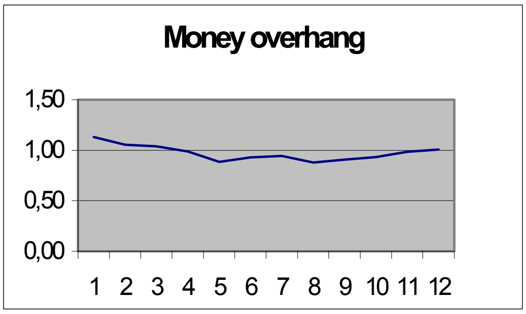
APPENDIX B. THE LINE GRAPHS OF THE MSE RATIOS.

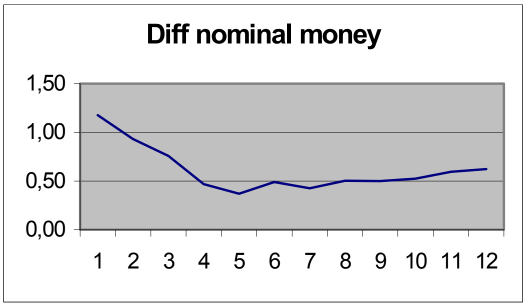
The relative MSE:s of the indicators based on the forecasting equation 3.7) and the Divisia money. The names of the series are the same as in Figures A10 – A14.



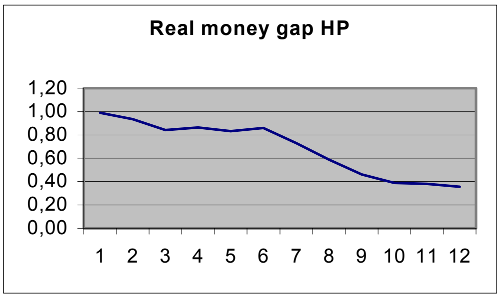


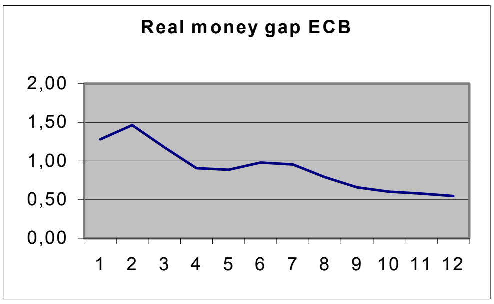


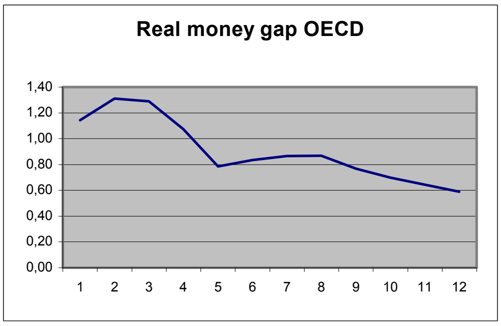


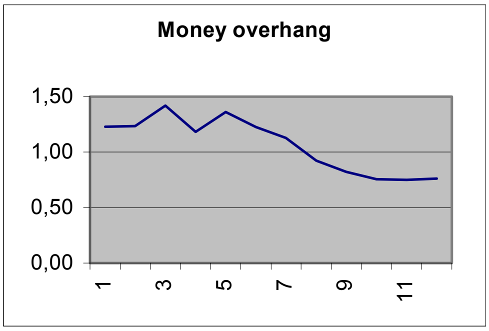


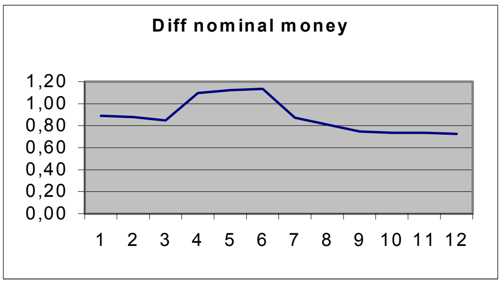
The relative MSE:s of the indicators based on the forecasting equation 3.7) and the simple sum M3 money.



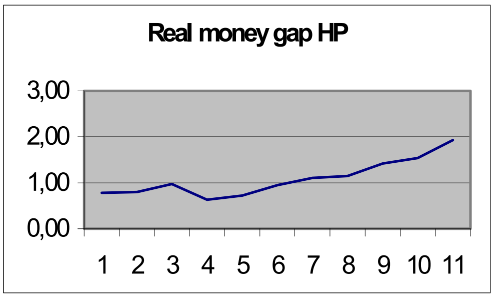


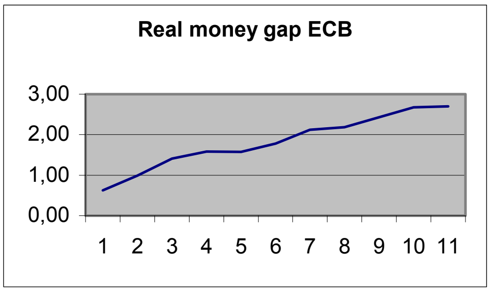


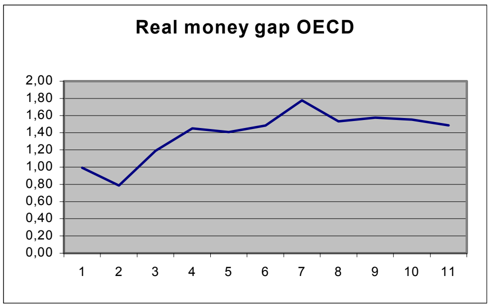


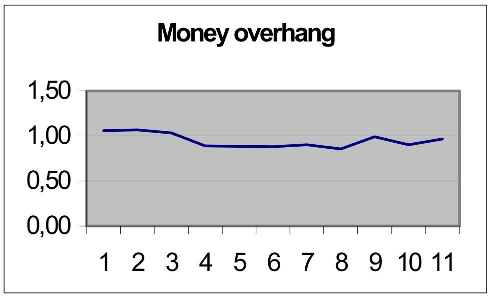


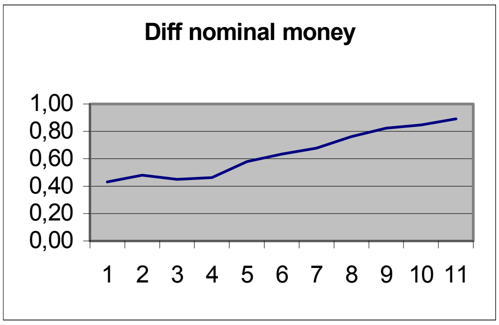
The relative MSE:s of the indicators based on the forecasting equation 3.8) and the Divisia M3 money.



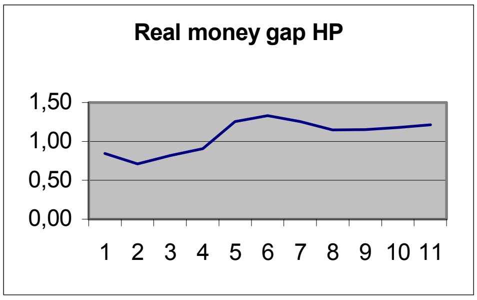


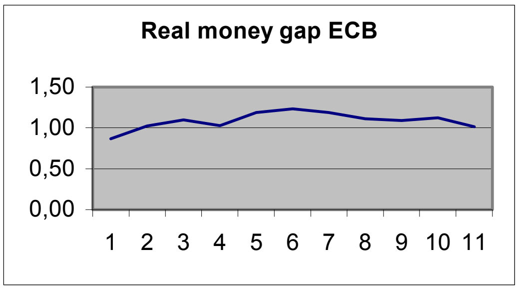


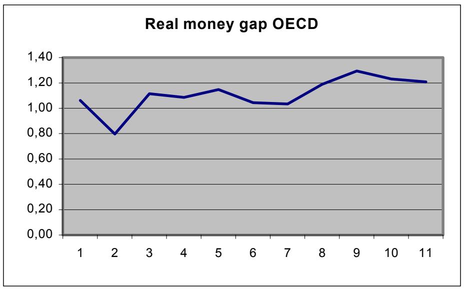


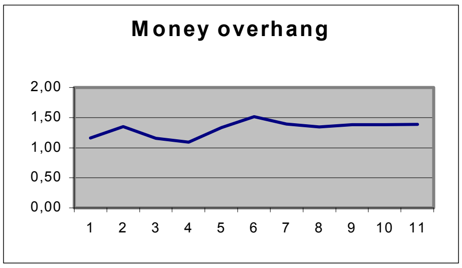


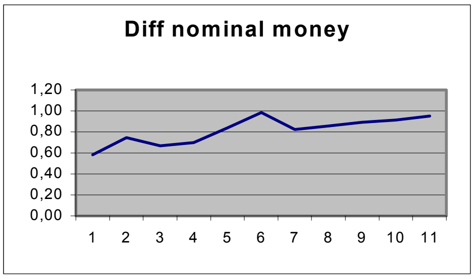
The relative MSE:s of the indicators based on the forecasting equation 3.8) and the simple sum M3 money.



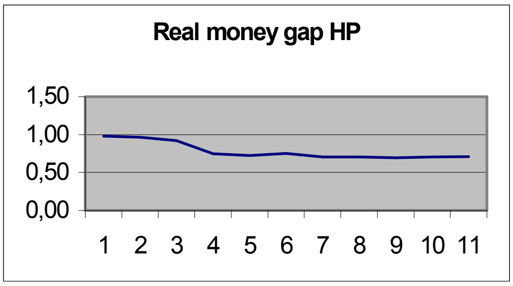


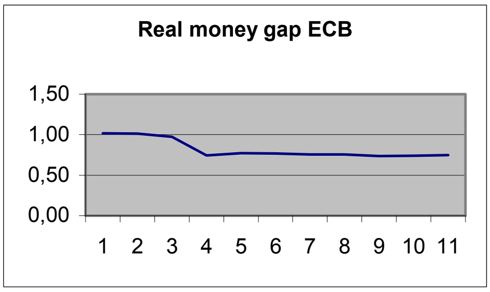


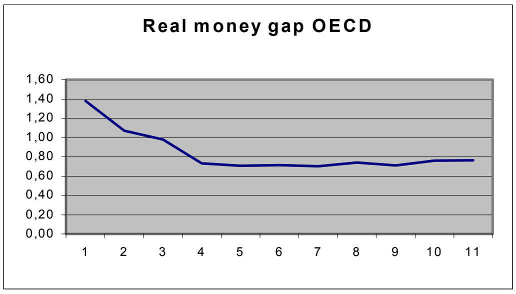


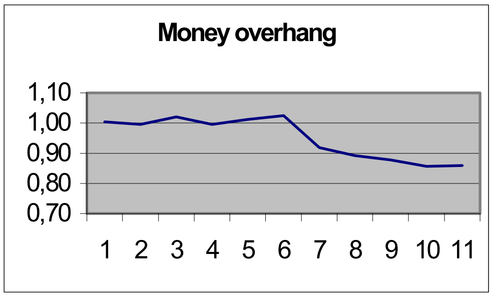


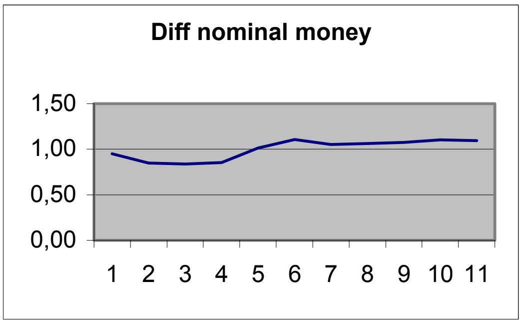
The relative MSE:s of the indicators based on the forecasting equation 3.9) and the Divisia M3 money.











The relative MSE:s of the indicators based on the forecasting equation 3.9) and the simple sum M3 money.