Does Money Include Information for Output in the Euro Area?

HANS-EGGERT REIMERS*

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1. INTRODUCTION

Recently, the discussion on the specification of 'IS function' is intensified to analyse monetary policy in small macroeconomic models. Different approaches end up with an IS equation, which includes real interest rate variable (see e.g. RUDEBUSCH and SVENSSON 1999, 2000). This specification is in line with other small-scale macroeconomic models, which are used to investigate different monetary policy rules (see CLARIDA, GALI and GERTLER, 1999; and WOODFORD, 2001). These models have in common that the money stock and the demand for money remain in the background (see MCCALLUM, 2002). In contrast, MELTZER (1995, 2001) stress the importance of money in the monetary transmission process. He finds evidence for an IS function where changes in real money stocks, operating as a proxy for changes in relative prices and real wealth, have positive and significant effects on the change in consumption for the United States (see MELTZER, 2001, p. 127). More generally, NELSON (2001) examines the theoretical and empirical reasons for effects of base money on aggregate demand. Empirically, he provides evidence in favor of direct money effects for the United States and United Kingdom.

In this paper the importance of money for the output development is analysed over the period from 1980 to 2000 for the euro area. In extension to NELSON (2001), different historical monetary aggregates are investigated. On the one hand the simple sum aggregates $M1$ and $M3$ are considered, where fixed exchange rates are used to add up national data for the euro area data (ECB, 1999). On the other hand different Divisia aggregates are applied, where alternative assumptions for the exchange rates are conducted (see REIMERS, 2002) These settings result in one Divisia aggregate of national monetary components with fixed exchange rates, one Divisia aggregate of national monetary components with variable exchange rates and one aggregate of national Divi-

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sia aggregates, which are added up by accounting expenditure shares (expenditure weighted Divisia aggregate).

The information content of these aggregates as regards future output is investigated. For that purpose, IS-curves are estimated, which include, as additional regressors, money growth rates. Moreover, out-of-sample forecasts of output gaps are analysed for different horizons. Evidence is presented that the expenditure weighted Divisia aggregate has most information content from a forward-looking perspective.

The remainder is organised as follows. In the next section an economic framework for real money growth on aggregate demand is given. Section 3 contains the construction of multiplicative monetary aggregates, the data and examines the importance of liquidity for the IS-relation. Section 4 analyses the information content of monetary aggregates for future output movements. Finally, Section 5 concludes.

2. THE IMPORTANCE OF LIQUIDITY FOR THE OUTPUT

If the central bank is tightening its monetary policy by increasing its central bank interest rates it will effects many real interest rates relevant for economic activity. MELTZER (2001) argues that a measure of monetary conditions based on the real money stock might serve as a better summary of the various changes in yield than a measure based on a specific real interest rate. Money plays a role as an information variable for monetary policy. To ascertain whether money contains any marginal information about future realisations of variables, which monetary policy-makers care about, one approach is investigated: liquidity for the IS-curve. Theoretical questions concerning the direct money channel of the monetary transmission process are raised by NELSON (2001). He presents an IS equation for log output y_t resulting from log linearisation of first-order condition for consumption:

$$y_t = -c_1 r_t + E_t y_{t+1}, \tag{1}$$

where E_t is the expectation operator, $c_1 > 0$ and r_t is the real interest rate, which is approximated by a short-term real interest rate (r_t^s). In that case, iterations on the IS function produce:

$$\begin{aligned} y_t &= -c_1 r_t^s + E_t y_{t+1} \\ &= -c_1 r_t^s - c_1 E_t r_{t+1}^s + E_t y_{t+2} \\ &= \dots \\ &= -c_1 r_t^l \end{aligned} \tag{2}$$

where $r_t^l = E_t \sum_{j=0}^{\infty} r_{t+j}^s$ is a long-run real interest rate, according to the expectations theory of the term structure. The last relationship stresses that, for the forward looking IS equation, the long-run real interest rate matters (see ROTEMBERG and WOODFORD, 1997, 1999).

Noting that money demand depends not only on a short-term interest rate, but also on a range of interest rates (see FRIEDMAN, 1956) it may be specified as a semilogarithmic long-run money demand function and a partial-adjustment formulation of dynamic adjustment

$$m_t - p_t = c_2 y_t - c_3 R_t^l + c_4(m_{t-1} - p_{t-1}), \tag{3}$$

where lower cases denote logs $c_2 > 0, c_3 > 0, 0 \leq c_4 < 1$ and $R_t^l = E_t \sum_{j=0}^{\infty}(\Delta p_{t+j+1} + r_{t+j}^s)$ is the nominal long-run rate. Assuming $c_4 \approx 1$ and using $y_t = -c_1 r_t^l$, the money demand function reads as:

$$\Delta(m-p)_t \approx -c_1 c_2 r_t^l - c_3 R_t^l \tag{4}$$

The change in real money depends negatively on both the real and the nominal long-run interest rate. If inflation persistence makes r_t^l and R_t^l highly correlated, the $\Delta(m-p)_t$ will be a good indicator of the real long-term yield r_t^l, which is the crucial interest rate for aggregate demand. Moreover, NELSON (2001) presents a general equilibrium model to strengthen his position. Quoting the work of RUDEBUSCH and SVENSSON (1999, 2000) he suggests the simplified backward-looking IS-equation:

$$y_t = c_0 + c_1 y_{t-1} + c_2 r_t + c_3 \Delta(m-p)_{t-1} \tag{5}$$

The last term will be statistically significant, if the prior change in real balances contains information about the next period's output not yet present in lagged output and current short-term real interest rates. For the UK and US economies, he finds evidence in favour of a significant effect of real base money changes.

The analysis of the information content of money can be carried out using the IS-curve approach of RUDEBUSCH and SVENSSON (2000) and NELSON (2001). RUDEBUSCH and SVENSSON (2000) have recently argued that the broad simple sum aggregate $M2$ does not enter significantly into an estimated IS-curve for the US economy. The estimated model is as follows:

$$ygap_t = \delta_0 + \delta_1 ygap_{t-1} + \delta_2 r_{t-1}^{real} + \delta_3(L)\Delta(m-p)_{t-1} + u_t,$$

where $ygap$ is the output gap, r^{real} is a sum of lags of interest rates minus the inflation rate, e.g. $r_t^{real} = \sum_{j=0}^{3} R_{t-j}/400 - (p_t - p_{t-4})$, where R_{t-j} is either a money market interest rate or a bond yield rate. This issue will be examined for the euro area. In extension to RUDEBUSCH and SVENSSON (2000) not only one broad defined sum aggregate is investigated, but also the narrow defined aggregate $M1$ is analysed. The base money, which equals the cash in circulation and the reserve requirements of the central bank, is affected by changes of the reserve quotes. Since 1980 variations in the reserve quotes have taken place in the euro area. Moreover, Divisia aggregates are examined.

3. DATA AND IS-CURVE ESTIMATES

In this study different monetary aggregates are used for the euro area. On the one hand two simple sum aggregates $M1$ and $M3$ are considered. On the other hand alternative Divisia aggregates are used. The discrete (TORNQVIST-THEIL) approximation to the Divisa quantity of money index is calculated as follows

$$\Delta \ln DM_t = \sum_{i=1}^{L} \tilde{s}_{it} \Delta \ln m_{it} \tag{6}$$

where L is the number of monetary components, m_{it} is the i-th component and with weights $\tilde{s}_{it} = \frac{1}{2}(s_{it} + s_{i,t-1})$ and $s_{it} = \frac{(R_t - r_{it})m_{it}}{\sum_{i=1}^{L}(R_t - r_{it})m_{it}}$ (see BARNETT, OFFENBACHER and SPINDT, 1984, p. 1052). Assuming that there is a benchmark asset with yield R_t, which provides no monetary services and is held solely to transfer wealth intertemporally. Holding the liquid asset i with yield r_{it} costs $R_t - r_{it}$ per currency in period t.

Following REIMERS (2002) one aggregate is calculated on the assumption that the irrevocably fixed conversion rates of December 31, 1998 ($\bar{e}_j$) are applied to construct the expenditure shares and monetary components. As far as there are no exchange rate risks, the benchmark interest rate is the highest rate among all relevant national interest rates. In this sense, (6) is applied to all relevant component of the individual countries component of the euro area monetary aggregate:

$$\Delta \ln DM_t^1 = \sum_{i=1}^{L} \sum_{j=1}^{J} \tilde{s}_{ijt} \Delta \ln m_{ijt} \bar{e}_j, \tag{7}$$

where $\tilde{s}_{ij}$ ($m_{ij}\bar{e}_j$) is the i-th expenditure share (component) of the j-th euro area member and J the number of euro area members. The expenditure share are determined by using the $R_t = \max(R_{it})$.

Because not all members deliver data series for the components STRACCA (2001a) suggests using the euro area components and aggregate interest rate series to construct an aggregate:

$$\Delta \ln DM_t^2 = \sum_{i=1}^{L} \tilde{s}_{it}^{euro} \Delta \ln m_{it}^{euro} \tag{8}$$

where $m_{it}^{euro} = \sum_{j=1}^{J} m_{ijt}\bar{e}_j$, applying fixed exchange rates. The aggregate interest rate $\bar{r}_{it}$ ($\bar{R}_t$) are determined by $\bar{r}_{it} = \sum_{j=1}^{J} w_j^{GDP} r_{ijt}$ ($\bar{R}_t = \sum_{j=1}^{J} w_j^{GDP} R_{jt}$), where w_j^{GDP} is the GDP weight of country j in the euro area. It is worth noting that DM^1 equals DM^2 if $r_{i1t} = r_{i2t} = \ldots = r_{iJt}$ for $i = 1, \ldots, L$ and R_t is identical to $\bar{R}_t$.

However, both approaches have in common the fixed exchange rate assumption. This assumption contradicts the historical experience, where national currencies floated against the ECU. The stock of monetary assets is redefined to account for currencies of different denominations (see WESCHE, 1997), hence $m_{ijt}e_{jt}$, where m_{ijt} is the i-th monetary asset denominated in the j-th country's currency and e_{jt} is the j-th country's exchange rate, relative to a weighted currency basket like the ECU. In addition, a calculated own rate of return r_{it} of a component monetary asset has to take account for the expected depreciation or appreciation of the respective currency relative to the ECU. The user cost for the European Divisia index thus becomes

$$\pi^e_{ijt} = \frac{E_t(R_t - (r_{ijt} + \psi_{jt}))}{E_t(1 + R_t)} \tag{9}$$

with

$$E_t\psi_{jt} = \frac{e^e_{jt+1} - e_{jt}}{e_{jt}}$$

being the expected depreciation of the j-th country's currency and

$$E_tR_t = \max\bigl(E_t(R_{jt} + \psi_{jt})\bigr) \tag{10}$$

being the European benchmark yield, which is the highest yield on a portfolio of European bonds, corrected for the expected depreciation of the exchange rate. The Divisia aggregate becomes

$$\Delta \ln DM^3_t = \sum_{i=1}^{L}\sum_{j=1}^{J} \bar{\bar{s}}_{ijt} \Delta \ln m_{ijt}e_{jt}, \tag{11}$$

where $\bar{\bar{s}}_{ijt}$ involves π^e_{ijt}. Without variations in the exchange rates, DM^3 equals DM^1. It should be stressed that a common characteristic of the three proposals is that they do not account for differences in national behaviour and national financial systems.

In constrast, the next alternative implies no financial integration and accounts for differences in national financial systems. Since the weights of the Divisia aggregate are results from minimising total expenditures for a given transaction technology, it seems sensible to construct weights depending on expenditure shares, as proposed by REIMERS and TÖDTER (1994). The euro area total expenditures are $K^{euro}_t = \sum_{j=1}^{J} K_{jt}e_{jt}$. The national expenditure shares are $w^K_{jt} = \frac{K_{jt}e_{jt}}{K^{euro}_t}$. Hence the euro area Divisia aggregate is

$$\Delta \ln DM^4_t = \sum_{j=1}^{J} w^K_{jt-1} \ln \Delta DM_{jt}. \tag{12}$$

If the national benchmarks converge to one value and the national interest rates of the components converge to specific values, it is identical to an aggregate, where the components are summed up and afterwards a Divisia aggregate is calculated.

In this study, data from 1980 through 2000 are used. As a measure of $M3$, quarterly averages of the month-end stocks of $M3$ are used (Source: ECB, in billions of euro, using the definition of April 2000). The main components of $M3$ are currency in circulation, overnight deposits, deposits with an agreed maturity of up to two years, deposits redeemable at notice of up to three months, repurchase agreements, debt securities issued with a maturity of up to two years and money market fund shares/units and money market paper (see Table 1). The Bundesbank has monthly data on seven categories for five countries (Germany, France, Spain, Portugal and Finland) and for the whole euro area. Overnight deposits are constructed using $M1H$ from the Bundesbank converted into euro via the irrevocable fixed conversion rates of 31 December 1998. The attempt to do the same for time and saving deposits, using $M3H$, was not successful in the sense that the remainder money stock became negative. Therefore, a block is constructed, representing the stocks of Austria, Italy, Belgium, Netherlands, Luxembourg and Ireland.

Table 1: Monetary components of M3 and corresponding interest rates of the euro area

Monetary component	Own rate of return
Currency in circulation	Zero
Overnight deposits	Interest rate of overnight deposits
Deposits with an agreed maturity of up to two years (time deposits)	Time deposit rate up to 1 year
Deposits redeemable at notice up to three months (savings deposits)	Savings deposit rate up to 3 months
Repurchase agreements	3-month money market rate
Money market fund shares/units and money market papers	3-month money market rate
Debt securities issued with a maturity of up to two years	12-month money market rate

A key item of information necessary to derive Divisia monetary aggregates is the own rates of return on the monetary components. To this purpose, it is necessary to estimate series of rates of return over the sample period 1980Q1–2000Q4. The construction is split into two parts. From 1980 till 1997, country specific data are collected. Since 1998 euro area data have been used. They are published by ECB in its Monthly Bulletin (Table 2.6: Money market interest rates; Table 2.9: Retail bank interest rates, deposit interest rates).

Data collection before 1998 is more complicated. The ECB publishes retail interest rates of the member countries. Following DEDOLA, GAIOTTI and SILIPO (2001), in some cases the information is completed by data from national sources. They are taken from the database of the BIS or IMF. The central bank interest rates, money market rates and some public bond yields are from International Financial Statistics (IFS). Non-available data points are replaced by linear approximations of the neighbouring data points. To determine the corresponding interest rates of the block components, the country weights of the monetary component are calculated for the period 1998 to 2000. These weights are used to generate the composite interest rates of the block components.

When constructing a Divisia index, one has to select a benchmark asset. As mentioned above, it should be the rate of return on a capital certain financial asset providing no monetary services. However "pure" examples of such benchmark assets are hardly available in practice. The long-term government bond yield with a maturity of 10 years for the euro area is therefore used as a convenient proxy. In cases when the individual interest rate r_{ijt} is higher than the benchmark rate the difference $(R_t - r_{ijt})$ is set to zero. Hence, the growth rate of the corresponding component is set to zero. In this study the series DM^1, DM^3 and DM^4 are constructed and compared with $M3$ and $M1$. DM^2 is analysed by STRACCA (2001a). The calculation of DM^3 needs values for the expected exchange rate. In this study, the Hodrick-Prescott filter is used.

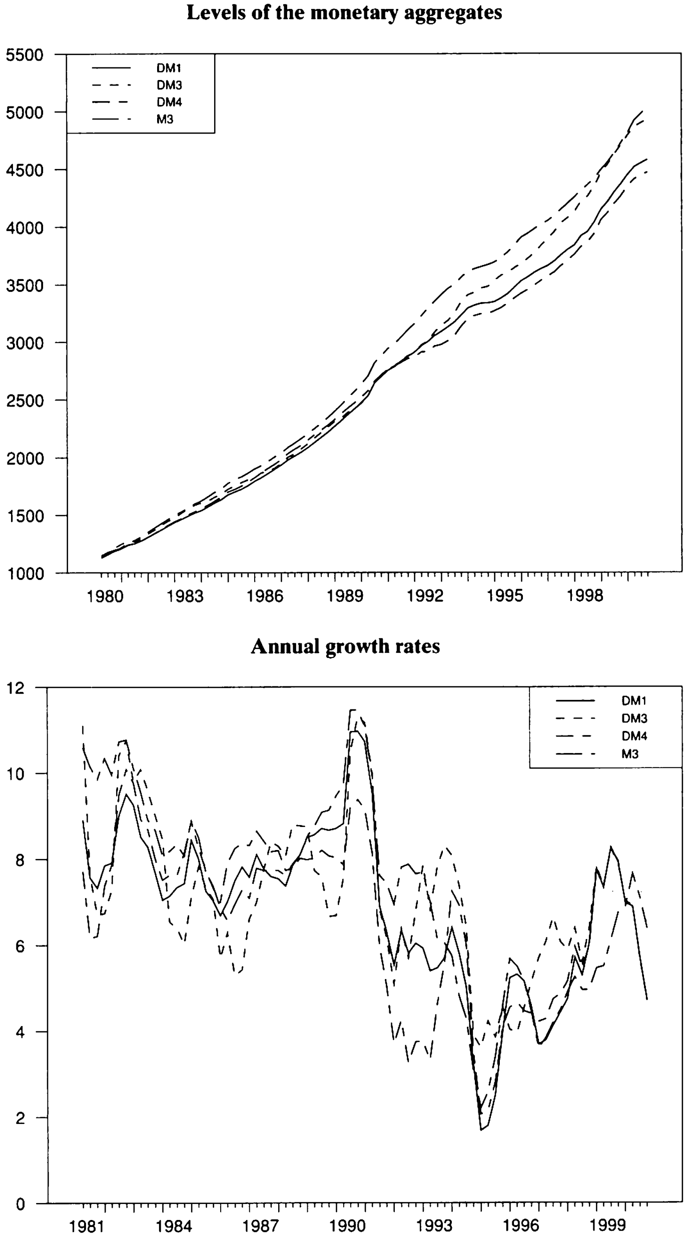
The multiplicative aggregates are individually constructed for the sample period 1980 to 1997. For the period 1998 to 2000, the existence of fixed exchange rates is assumed and a Divisia aggregate is calculated for the whole euro area. These values are used to complete the individually constructed series. The development of the monetary aggregates are given in Figure 1. To be in line with the real GDP the series are seasonally adjusted using X12-ARIMA routine of EViews4.0 (multiplicative). They are normalised in such a way that their values are identical in the second month of 1980. It is apparent that the level values of the multiplicative aggregates are smaller at the end of the sample period than official $M3$. All aggregates reflect German unification in the middle of 1990. Looking at the annual growth rates, the differences in the series are more pronounced (see Figure 1, lower panel). The descriptive test statistics are given in Table 2. The average annual growth rate of $M3$ and its volatility are higher than the growth rates of the other aggregates and their volatility. The correlation is strong among $\Delta_4 \ln M3$ and $\Delta_4 \ln DM^1$ as well as $\Delta_4 \ln DM^3$ and $\Delta_4 \ln DM^4$. These results indicate that the aggregates may cover the same long-run movement, however, may exhibit small but important difference in the short-term development.

Table 2: Descriptive statistics of annual growth rates of M1, M3 and Divisia M3 (DM^1, DM^3 and DM^4)

Statistic	$\Delta_4 \ln M3$	$\Delta_4 \ln DM^1$	$\Delta_4 \ln DM^3$	$\Delta_4 \ln DM^4$	$\Delta_4 \ln M1$
Mean	0.073	0.068	0.071	0.067	0.074
Maximum	0.115	0.110	0.114	0.101	0.125
Minimum	0.022	0.017	0.036	0.021	0.024
Std. Dev.	0.022	0.019	0.018	0.020	0.022
J.B.	1.534 (0.464)	2.471 (0.291)	1.555 (0.460)	5.836 (0.054)	1.207 (0.547)
Correlation with $\Delta_4 \ln M3$		0.898	0.731	0.718	0.259
Correlation with $\Delta_4 \ln DM^1$			0.800	0.900	0.565
Correlation with $\Delta_4 \ln DM^3$				0.728	0.535
Correlation with $\Delta_4 \ln DM^4$					0.714

Notes: J.B.: Jarque-Bera-test of normality, its p-value in parentheses. The information period is 1981Q2–2000Q4. Variables are seasonally adjusted.

Figure 1: Development of different monetary aggregates



Notes: Levels of the different monetary aggregates in euro billions, 1980–2000 (upper panel); Annual growth rates of the different monetary aggregates in per cent, 1981–2000 (lower panel).

Nominal and real GDP from 1991Q1 is calculated on the basis of the ESA95 System of Accounts (Deutsche Bundesbank). Using the data of STRACCA (2001b), the series are supplemented by linking their growth rates backwards until 1980Q1. The price index is the implicit GDP deflator (P). Potential output is estimated via a Hodrick-Prescott (HP) filter and expanded exponential smoothing[1] (see TÖDTER, 2000a, 2000b). Figure 2 exhibits the development of the series and the implied output gaps. The peaks and troughs of the gaps are more or less in the same quarter. However, the output gap of expanded exponential smoothing is more volatile than the series constructed by the HP filter. It worth noting that the hypothesis of a unit root in the output gap based on the HP filter (EES filter) is rejected at the 1 (5) per cent level using an ADF test and the Phillips-Perron test, making the assumption that the test regressions include no deterministic trend and intercept.

Determining the real interest rates needs the construction of euro area interest rate. $M3$ country weights are used to calculate the euro area money market rate (R^{mo}) and public bond yields (R^{bo}). The real rates are $r_t^{mo} = \sum_{j=0}^{3} R_{t-j}^{mo}/400 - (pb_t - pb_{t-4})$ and $r_t^{bo} = \sum_{j=0}^{3} R_{t-j}^{bo}/400 - (pb_t - pb_{t-4})$, where pb is the logarithm of the GDP deflator. Figure 3 gives their developments.

To start the empirical analysis, the IS-curve is estimated without any money variable (see Tables 3 and 4, left part). The description of the dynamics of the equation needs, in one case, the lagged output gap of order 5, elsewhere the lagged output gap of order 1 is sufficient. The estimated equations are free of autocorrelation. The stability forecast test of Chow does not indicate any instability for the last two years. The hypothesis of normal distributed residuals is often rejected at the 5 per cent significance level. The coefficients of the different real interest rate variables are all negative as expected. If the EES filter is used, they are significantly negative.

The results change if the annual growth rate of money is analysed. At first, the output gap determined by the Hodrick-Prescott filter is examined (see Table 3). Owing to delays, the lagged money changes are specified and their coefficients are significant regardless of which money concept is used. The signs of the coefficients are positive, as expected. However, the coefficients of the real capital market rate are positive and significant for the equations including DM^1, DM^3 and DM^4, which is in contrast to the theory presented. The residuals does not seem to be normally distributed, which complicate the assessment of the test results. This is found for all analysed monetary aggregates, except for DM^3. The problems posed by the assumption of normal distributed residuals decrease if the EES filter is applied. For this output gap the normality hypothesis is not rejected at the 5 per cent significance level (see Table 4). The positive coefficients of money changes are highly significant, whereas no cofficient of the real interest rates is significantly negative.

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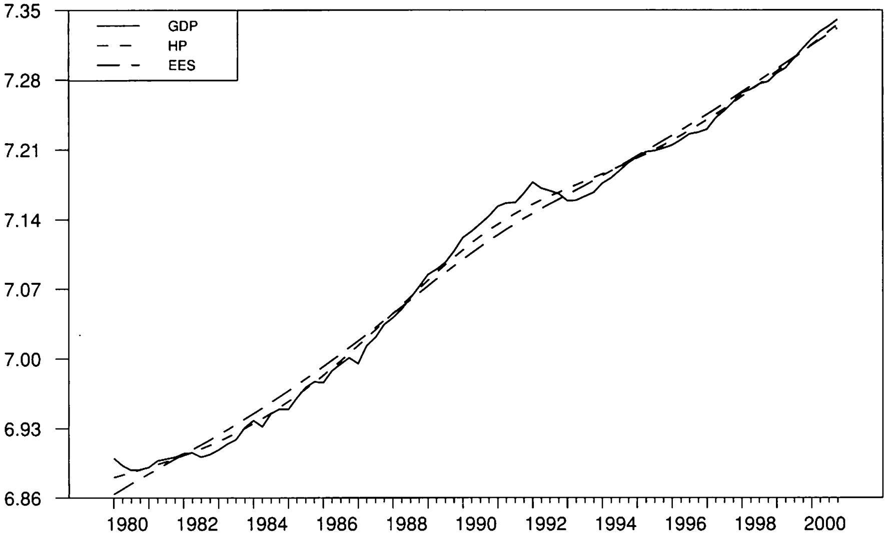
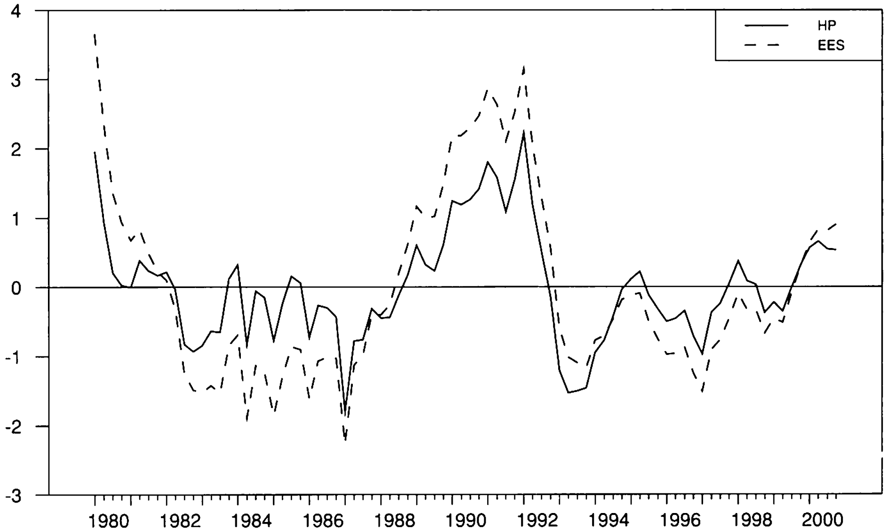
[1] A brief review of the methods is given in the Appendix.

Figure 2: Development of real GDP and its trend estimates

Level values

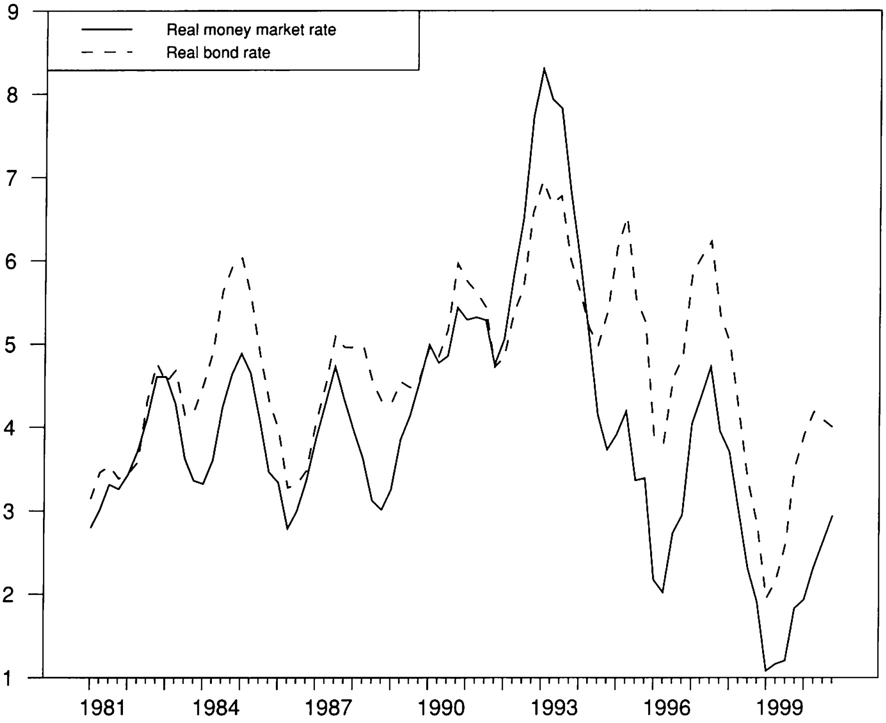


Output gap estimates



Notes: Levels of the log real GDP and its trend estimates HP (Hodrick-Prescott filter) and EES (extended exponential smoothing) (upper panel); Gap between real GDP and its trend estimates in per cent, 1980–2000 (lower panel).

Figure 3: Development of real interest rates



Notes: Development of the real money market rate and the real bond rate using the annual growth rate of the GDP deflator.

Table 3: Estimates of the IS-curve, using the output gap as endogenous variable constructed by the Hodrick-Prescott-filter

Variable			Simple sum M3		Divisia DM[1]		Divisia DM[3]		Divisia DM[4]		M1	
c	0.001	0.001	−0.003	−0.002	0.006	−0.004	−0.006	−0.004	−0.000	0.005	−0.007	−0.006
	(1.23)	(1.50)	(1.54)	(1.24)	(2.94)	(2.77)	(3.18)	(2.91)	(3.16)	(3.03)	(2.84)	(2.79)
$ygap_{t-1}$	0.842	0.842	0.785	0.792	0.758	0.773	0.799	0.808	0.795	0.800	0.812	0.818
	(12.3)	(12.2)	(10.6)	(10.8)	(13.3)	(12.9)	(11.5)	(11.5)	(16.8)	(17.0)	(15.0)	(15.3)
$\sum R^{bo} - \Delta_4 pb$	−0.010		0.010		0.025		0.024		0.027		0.037	
	(1.38)		(0.483)		(2.31)		(2.58)		(2.58)		(2.56)	
$\sum R^{mo} - \Delta_4 pb$		−0.011		−0.000		0.015		0.015		0.021		0.030
		(1.55)		(0.017)		(1.66)		(1.80)		(2.31)		(2.46)
$\Delta_4 mr_{t-2}$			0.076	0.069	0.107	0.092	0.088	0.077	0.109	0.103	0.081	0.075
			(2.29)	(2.10)	(4.51)	(4.40)	(4.59)	(4.17)	(4.48)	(4.32)	(3.62)	(3.50)
$\overline{R}^2$	0.693	0.695	0.710	0.709	0.734	0.728	0.729	0.724	0.745	0.741	0.729	0.725
DW	1.87	1.88	1.91	1.91	2.00	1.99	2.02	2.00	2.15	2.13	2.08	2.05
LMAR (1-2)	0.134	0.175	0.134	0.126	0.411	0.290	0.424	0.285	1.87	1.57	0.784	0.617
	(0.875)	(0.840)	(0.875)	(0.882)	(0.665)	(0.749)	(0.656)	(0.753)	(0.162)	(0.215)	(0.461)	(0.543)
J.-B.	6.74	6.17	6.78	6.38	11.2	10.6	3.40	3.55	20.6	18.6	23.4	21.6
	(0.034)	(0.046)	(0.034)	(0.041)	(0.004)	(0.005)	(0.182)	(0.169)	(0.000)	(0.000)	(0.000)	(0.000)
Chow (8)	0.534	0.141	0.240	0.203	0.105	0.097	0.159	0.139	0.112	0.106	0.091	0.085
	(0.996)	(0.997)	(0.982)	(0.989)	(0.999)	(0.999)	(0.995)	(0.997)	(0.997)	(0.999)	(0.999)	(0.999)

Notes: ygap: Difference between log GDP and trend of log GDP estimated by the Hodrick-Prescott- filter. $\sum R^{bo} - \Delta_4 pb$: Real interest rate variable that is $\sum_{j=1}^{4} R^{bo}_{t-j}/400 - \Delta_4 pb_{t-1}$ where R_{bo} is the euro area bond yields and R^{mo} the euro area money market rate. pb GDP deflator. $\Delta_4 mr$ annual change of real Divisia M3 or real simple-sum M3 (M1) using GDP deflator. Heteroskedasticity consistent covariance estimated t-values in parentheses. LMAR (1-2): Lagrange-multiplier test of autocorrelation of 1 and 2 lags. J.-B.: Jarque-Bera-test of normality. Chow(8): Chow stability forecast test for the period 1999Q1–2000Q4. Diagnostic statistics have p-value in parentheses. Estimation period: 1982Q1–2000Q4.

Table 4: Estimates of the IS-curve using the output gap as endogenous variable constructed by expanded exponential smoothing

Variable				Simple sum M3		Divisia DM[1]		Divisia DM[3]		Divisia DM[4]		M1	
c	0.002 (1.51)	0.003 (2.28)	0.002 (2.41)	−0.004 (1.86)	−0.003 (1.66)	−0.007 (3.18)	−0.004 (3.36)	−0.005 (2.41)	−0.004 (2.50)	−0.007 (3.43)	−0.006 (3.45)	−0.007 (2.44)	−0.006 (2.62)
$ygap_{t-1}$	1.01 (20.3)	0.932 (18.5)	0.935 (18.7)	0.857 (18.5)	0.861 (18.5)	0.842 (22.7)	0.848 (22.7)	0.887 (18.2)	0.890 (18.2)	0.900 (29.8)	0.898 (29.3)	0.929 (25.8)	0.925 (25.2)
$ygap_{t-5}$	−0.121 (2.18)												
$\sum R^{bo} - \Delta_4 pb$	−0.014 (1.71)	−0.020 (2.50)		0.000 (0.002)		0.025 (2.26)		0.016 (1.61)		0.024 (2.37)		0.031 (2.00)	
$\sum R^{mo} - \Delta_4 pb$			−0.020 (2.54)		−0.004 (0.459)		0.017 (1.93)		0.010 (1.26)		0.020 (2.28)		0.026 (2.14)
$\Delta_4 mr_{t-2}$				0.111 (3.27)	0.104 (3.10)	0.142 (5.07)	0.129 (5.40)	0.097 (4.19)	0.089 (4.24)	0.130 (5.52)	0.127 (5.42)	0.088 (3.59)	0.085 (3.74)
$\overline{R}^2$	0.928	0.869	0.870	0.881	0.881	0.894	0.892	0.885	0.884	0.898	0.897	0.886	0.885
DW	2.06	1.84	1.85	1.92	1.93	2.11	2.08	1.99	1.98	2.30	2.28	2.12	2.10
LMAR (1–2)	0.498 (0.610)	0.275 (0.760)	0.218 (0.805)	0.085 (0.918)	0.078 (0.925)	0.908 (0.408)	0.627 (0.537)	0.114 (0.892)	0.078 (0.925)	3.66 (0.031)	3.15 (0.049)	0.768 (0.468)	0.577 (0.564)
J.-B.	4.52 (0.104)	2.87 (0.238)	2.45 (0.294)	2.91 (0.233)	2.57 (0.277)	6.45 (0.040)	5.84 (0.054)	1.32 (0.518)	1.15 (0.564)	11.2 (0.004)	10.5 (0.005)	9.76 (0.008)	9.61 (0.008)
Chow (8)	0.147 (0.996)	0.141 (0.997)	0.131 (0.998)	0.274 (0.972)	0.240 (0.982)	0.102 (0.999)	0.093 (0.999)	0.149 (0.996)	0.134 (0.997)	0.128 (0.998)	0.117 (0.998)	0.110 (0.999)	0.097 (0.999)

Notes: ygap: Difference between log GDP and trend of log GDP estimated by expanded exponential smoothing. Furthermore see Table 3.

The results presented are in line with evidence presented by STRACCA (2001a) for DM^2, $M1$ and $M3$. It is worth noting that RUDEBUSCH and SVENSSON (2000) finds for the United States no significant influence of $M2$ in their IS equation, whereas NELSON (2001) gives evidence that the monetary base appears significantly in his IS equation for United Kingdom and the United States. It seems that the Divisia aggregate contains useful information for the policy-maker of the euro area, which is not found in the real interest rate, on output. Moreover, the paper of COENEN, LEVIN and WIELAND (2001) notes that real output data is often and substantially revised in the euro area over a period of up to five quarters after initial publication. They show that especially money demand shocks calculated with simple-sum $M3$ contain information about the true level of output.

4. OUT-OF-SAMPLE FORECASTS OF OUTPUT GAPS

The IS-curves estimated in the previous sections empirically establish a link between monetary aggregates and output. To investigate the out-of-sample forecasts, we calculate a series of stepwise forecasts using the IS-curve equations for the different monetary aggregates, together with interest rate equations:

$$ygap = f_2(ygap_{-1}, \Delta_4(m_{-1} - p_{-1}), r^{\text{real}}_{-1}) + \eta_1 \tag{13}$$

It should be noted that the results of this exercise are conditional on the exogenous variables real interest rates and money changes. Moreover, using historical values of the interest rates and money growth rates disregards the problem that the ECB would have set its rates differently if it had worked before 1999. On the other hand, there are many revisions of the GDP data, which take place over a period of more than one year after initial publication (see COENEN et AL., 2001). Moreover, especially the Hodrick-Prescott filter has a markedly end point problem (see MOHR, 2001).

The out-of-sample forecasts are computed with a so-called recursive regression method (see MCCRACKEN, 1999). A recursive estimation of the system yields a series of out-of-sample forecasts for different forecasting horizons $k = 1, \ldots, 8$. The coefficients are computed over the period 1982Q1 to 1993Q4. Using these coefficients, the forecasts are determined. The forecast errors $\hat{e}_{t+k}$ are the difference between the forecast of the output gap and the historical values. Then, the sample is extended by one period ahead and the equations are re-estimated to calculate the forecasts again. This procedure is continued until the end of the available data.

The benchmark approach is the IS-curve equation

$$ygap = f_2(ygap_{-1}, r^{\text{real}}_{-1}) + \eta_0. \tag{14}$$

The accuracy of forecasts can be judged by various statistics about the forecast errors. In this study the root mean square forecast errors are presented. The mean absolute forecast errors point in the same direction. To assess the relative predictive accuracy of two forecasting models, different test statistics are suggested and analysed by DIEBOLD and MARIANO (1995). Their preferred test statistic is

$$\hat{d}_F = F^{-1/2}\frac{\sum_{t=T+1}^{S-k}(\hat{e}^2_{0,t+k} - \hat{e}^2_{1,t+k})}{\hat{\sigma}_F}, \tag{15}$$

where T denotes the length of estimation period, F is the length of the prediction period, hence $S = T + F$, $k \geq 1$ is the forecast horizon, $\hat{e}^2_{0,t+k}$ and $\hat{e}^2_{1,t+k}$ are squared forecast errors of the benchmark model and the alternative model using consistent estimators, and

$$\begin{aligned}\hat{\sigma}_F =& \frac{1}{F}\sum_{t=T+1}^{S-k}\left(\hat{e}^2_{0,t+k} - \hat{e}^2_{1,t+k}\right)^2\\ &+ \frac{2}{F}\sum_{j=1}^{l_F} w_j \sum_{t=T+1+j}^{S-k}\left(\hat{e}^2_{0,t+k} - \hat{e}^2_{1,t+k}\right)\left(\hat{e}^2_{0,t+k-j} - \hat{e}^2_{1,t+k-j}\right),\end{aligned}$$

where $w_j = 1 - \frac{j}{l_F+1}$, $l_F = o(F^{1/4})$. The test statistic (15) is denoted the DIEBOLD-MARIANO (dm) test. The null of equal predictive ability is

$$H_0 : E\left(e^2_{0,t+k} - e^2_{1,t+k}\right) = 0,$$

while the alternative is

$$H_1 : E\left(e^2_{0,t+k} - e^2_{1,t+k}\right) \neq 0,$$

Under the null hypothesis, this statistic has an asymptotic standard normal distribution. HARVEY, LEYBOURNE and NEWBOLD (1997, 1998) analyse the test statistic using an extensive Monte Carlo design, and find that the test has good size and fairly good power properties.

The longest interval for all forecasts is from 1994Q1 to 2000Q4, hence the maximum length of the forecast period is $F = 28$. The truncation parameter is $l_f = 2$. Table 5 (6) gives the results of the out-of-sample forecasts of output gaps using the HP filter (EES filter). In general, the values RMSFE for model (14) increase for the output gap if the forecasting horizon grows, except for $h = 6, 7, 8$ for the output gap based on the HP filter without changes of one real money aggregate. The results of the other approaches are all given in relative values (RMSFE of the alternative approach divided by RMSFE of the benchmark model). Examining the output gap based on the HP filter in Table 5, the equations including real money market rate and money changes obtain higher forecast errors than the reference approach. The differences between the reference equation and the equation with a monetary aggregate are often statistically significant, especially for $h = 7, 8$. If the output gap is explained by the real bond yield variable, the changes of real Divisia aggregates decrease the forecast errors in the medium term (lower part of Table 5). The growth rate of real DM^4 dominates the other aggregates and reduces the RMSFE up to 20 per cent. Owing the small sample, the difference is also not statistically significant.

Table 5: Root mean squared forecast errors (RMSFE) for the output gap using the HP filter on the basis of IS-curve estimates

			Dynamic forecasts			
Horizon	RMSFE	M3	M1	DM^1	DM^3	DM^4
			Real money market rate			
1	0.0025	1.256	1.135	1.142	1.146	1.039
2	0.0040	1.231	1.114	1.103	1.095	0.947
3	0.0054	1.158	1.112	1.038	1.066	0.841
4	0.0059	1.143	1.204	1.060	1.132	0.835
5	0.0059	1.229	1.449^{*}	1.188	1.327	0.944
6	0.0056	1.332^{*}	1.775^{**}	1.350	1.575^{**}	1.077
7	0.0055	1.484^{**}	2.091^{**}	1.526^{**}	1.827^{**}	1.239
8	0.0052	1.749^{**}	2.548^{**}	1.829^{**}	2.181^{**}	1.522^{*}
			Real bond yields			
1	0.0025	1.221	1.122	1.103	1.112	1.046
2	0.0039	1.234	1.086	1.054	1.036	0.946
3	0.0052	1.178	1.066	0.965	0.980	0.817
4	0.0057	1.177	1.135	0.956	0.996	0.789
5	0.0057	1.226	1.384	1.037	1.148	0.879
6	0.0053	1.224	1.705^{*}	1.106	1.307	0.975
7	0.0051	1.198	2.066^{**}	1.212	1.534	1.132
8	0.0046	1.278	2.650^{**}	1.499^{*}	1.928^{**}	1.473^{*}

Notes: Ex ante root mean squared forecast errors for the period 1994Q1–2000Q4. Reference results of the IS-curve estimates without money The sign ** (*) indicates that the difference is significant at the 5 % (10 %) level between the benchmark model and the alternative model using the dm test.

Looking at the output gap based on the EES filter in Table 6, the equation with $M1$ obtains higher forecast errors than the reference approach (see Table 6). Using a broad monetary aggregate reduce the forecast errors in relation to the reference equation in the medium term. It is apparent that the equation with DM^4 outperforms the other approaches for the horizon $h = 2, \ldots, 6$.

**Table 6: Root mean squared forecast errors (RMSFE)
for the output gap using EESfilter on the basis of IS-curve estimates**

			Dynamic forecasts			
Horizon	RMSFE	M3	M1	DM^1	DM^3	DM^4
			Real money market rate			
1	0.0027	1.273	1.207	1.150	1.172	1.038
2	0.0046	1.209	1.198	1.080	1.104	0.920
3	0.0067	1.099	1.190	0.991	1.061	0.802
4	0.0079	1.050	1.282	0.993	1.108	0.783
5	0.0086	1.096	1.498*	1.086	1.255	0.858
6	0.0088	1.147	1.764**	1.197	1.429**	0.952
7	0.0090	1.260	2.048**	1.338	1.623**	1.078
8	0.0086	1.480*	2.511**	1.600**	1.931**	1.315
			Real bond yields			
1	0.0027	1.071	1.142	1.065	1.006	1.006
2	0.0047	0.974	1.107	0.973	0.866	0.874
3	0.0067	0.871	1.092	0.882	0.793	0.747
4	0.0080	0.784	1.163	0.858	0.777	0.704
5	0.0087	0.802	1.372	0.949	0.876	0.768
6	0.0090	0.813	1.621*	1.061	0.992	0.849
7	0.0092	0.881	1.904**	1.222	1.132	0.971
8	0.0087	0.994	2.377**	1.503**	1.354	1.208

Notes: Ex ante root mean squared forecast errors for the period 1994Q1–2000Q4. Reference results of the IS-curve estimates without money The sign ** (*) indicates that the difference is significant at the 5 % (10 %) level between the benchmark model and the alternative model using the dm test.

5. CONCLUSION

This study analyses information content of monetary aggregates for aggregate demand approximated by output gaps for the euro area. In addition to simple-sum aggregates M 1 and $M3$ Divisia monetary aggregates are considered. The IS-curve estimates show the information content of money for real output gap movements. Especially, DM^4 significantly explains the future development of output.

Turning to the out-of-sample exercise, the growth rate of $M1$ does not reduce the forecast errors of the output gap. In contrast, broadly defined monetary aggregates help to reduce the forecast errors of the output gap. The index DM^4 outperforms the other aggregates. In general, we find evidence that broadly defined money has information value for the output gap in the euro area and that the ECB should monitor, in addition to $M3$, Divisia aggregates in conducting monetary policy.

APPENDIX: ESTIMATION OF POTENTIAL OUTPUT

The estimation of potential output Y^* is conducted by statistical methods. A linear function $y_t = f(t)$ is characterised by the fact that its first differences Δy_t are constant and its second differences $\Delta^2 y_t$ are zero. The Hodrick-Prescott (HP) filter adopt the second form (see HODRICK and PRESCOTT, 1997). It is assumed that the series y may be divided into a trend component $\hat{y}$ and cyclical component y^c

$$y_t = \hat{y}_t + y_t^c.$$

The HP filter may be the solution of the following object function:

$$Z := \min_{(\hat{y}_t)} \left(\frac{\lambda}{2} \sum_{t=2}^{T} ((\hat{y}_{t+1} - \hat{y}_t) - (\hat{y}_t - \hat{y}_{t-1}))^2 + \frac{1-\lambda}{2} \sum_{t=1}^{T} (\hat{y}_t - y_t)^2 \right)$$

It results in the following:

$$Y^* = H^{-1} Y$$

where

$$H = \frac{1}{1-\lambda} \begin{pmatrix} 1 & -2\lambda & \lambda & 0 & \dots & 0 & 0 \\ -2\lambda & 1+4\lambda & -4\lambda & \lambda & \dots & 0 & 0 \\ \lambda & -4\lambda & 1+5\lambda & -4\lambda & \dots & 0 & 0 \\ \vdots & & & \ddots & \ddots & & \vdots \\ 0 & & & & & -4\lambda & \lambda \\ 0 & & & & & 1+4\lambda & -2\lambda \\ 0 & & & & & -2\lambda & 1 \end{pmatrix}$$

Except for the first and last two observations, the filter relation is:

$$\hat{y}_t = \frac{6\lambda}{1+r\lambda} \tilde{y}_t + \frac{1-\lambda}{1+r\lambda} y_t \quad t = 3, \dots, T-2,$$

where

$$\tilde{y}_t = \frac{y_{t-2} + 4\hat{y}_{t-1} + 4\hat{y}_{t+1} - \hat{y}_{t+2}}{6}.$$

MOHR (2001) discusses the structural breaks and the end-point problems posed by the HP filter as well as the choice of smoothing parameter λ. In the empirical literature the value of $\lambda = \frac{1600}{1+1600}$ is often used for quarterly data. TÖDTER (2002) presents calculations that this value implies a reference cycle of 8 to 9 years for a business cycle. He shows that a reference business cycle of 8 years implies a value of $\lambda = \frac{1410}{1+1410}$ which is close to the standard value. PEDERSEN (2001) argues that the HP filter with the standard value of $\lambda = \frac{1600}{1+1600}$ is in many cases less distorting than other filters.

In contrast to the Hodrick-Prescott filter, TÖDTER shows that extended exponential smoothing (EES) uses the assumption that the first difference of a series is constant. Following TÖDTER (2000a), the EES procedure is derived from the function:

$$Z := \min_{(\hat{y}_t, c_1)} \left(\frac{\lambda}{2} \sum_{t=2}^{T} (\hat{y}_t - \hat{y}_{t-1} - c_1)^2 + \frac{1-\lambda}{2} \sum_{t=1}^{T} (\hat{y}_t - y_t)^2 \right)$$

The first term reflects the smoothness of the filtered series and the second term gives the adjustment of the estimated series to the observed series. The first order conditions are determined by differencing the function to all $\hat{y}_t$ and c_1. The conditions imply that the intercept term c_1 may be determined by the following nonparametric estimate:

$$\hat{c}_1 = \frac{1}{T-1} \sum_{t=2}^{T} (\hat{y}_t - \hat{y}_{t-1}) = \frac{\hat{y}_T - \hat{y}_1}{T-1}.$$

The filtered series is:

$$Y^* = A^{-1} Y$$

where

$$A = \frac{1}{1-\lambda} \begin{pmatrix} 1-\frac{\lambda}{T-1} & -\lambda & 0 & 0 & & \cdots & \frac{\lambda}{T-1} \\ -\lambda & 1+\lambda & -\lambda & 0 & & \cdots & 0 \\ 0 & -\lambda & 1+\lambda & -\lambda & & \cdots & 0 \\ \vdots & & & \ddots & \ddots & & \vdots \\ 0 & & & & 1+\lambda & -\lambda & 0 \\ 0 & & & & -\lambda & 1+\lambda & -\lambda \\ \frac{\lambda}{T-1} & 0 & & \cdots & 0 & -\lambda & 1-\frac{\lambda}{T-1} \end{pmatrix}$$

The filter, which is denoted as extended exponential smoothing, is:

$$Y_t^* = \frac{2\lambda}{1+\lambda} \left(\frac{Y_{t-1}^* + Y_{t+1}^*}{2} \right) + \frac{1-\lambda}{1+\lambda} Y_t$$

for $t = 1, \ldots, T-1$ and λ smoothing parameter. Assuming that the EES is an approximation of an optimal filter for a reference business cycle of 8 years, $\lambda = 132/133$ (see TÖDTER, 2000b).

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SUMMARY

In this paper, the importance of money for the output development is analysed over the period from 1980 to 2000 for the euro area, where simple sum and Divisia monetary aggregates are used. Adapting an in-sample analysis, all real monetary aggregates help to explain the output gap of the euro area regardless of what real interest rate is used to explain the IS curve. The out-of-sample forecasting exercise presents evidence that broadly defined monetary aggregates reduce the forecast errors of the output gap in the medium term.

ZUSAMMENFASSUNG

In dieser Arbeit wird die Bedeutung von Geldmengen für die Outputentwicklung des Eurowährungsgebiets für den Zeitraum von 1980 bis 2000 untersucht, wobei einfache Summenaggregate und Divisia-Aggregate betrachtet werden. Bei der ex post-Analyse zeigt sich, dass innerhalb von IS-Kurven alle realen monetären Aggregate die Entwicklung der Outputlücke beeinflussen. Dieses Ergebnis ist unabhängig davon, welcher Realzins in den IS-Gleichungen berücksichtigt wird. Bei der Ermittlung von ex ante-Prognosefehlern wird deutlich, dass breit definierte monetäre Aggregate die Prognosefehler der Outputlücke für einen mittleren Prognosehorizont reduzieren.

RÉSUMÉ

Cette contribution analyse l'importance de la monnaie pour la croissance de la production sur la période 1980 à 2000 dans la zone euro, sur la base d'agrégats monétaires simples et "Divisia". Sur la base d'une analyse de l'historique des données, il apparaît que toutes les mesures réelles des agrégats monétaires ont un pouvoir explicatif de l'écart de production dans la zone euro, quelle que soit la mesure du taux d'intérêt réel employée pour l'explication de la courbe IS. L'exercice est ensuite conduit en vue d'une projection ex post. Les résultats montrent que les agrégats monétaires larges réduisent les erreurs de prévision de l'écart de production à moyen terme.