Monetary aggregates with special reference to structural changes in the financial markets

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I. Introduction

During the eighties, a large number of central banks had to abandon the strategy of monetary targeting. In the majority of cases, the reasons for this were increasingly unstable basic relations between money stock, interest rates, income and prices due to structural changes on financial markets, such as financial innovations.

The development of the German financial market was rather smooth, primarily due to early measures of deregulation and liberalization as well as a high degree of adaptability of the universal bank system to new needs. Nevertheless also Germany experienced innovations concerning financial assets with potential influence on monetary policy. This applies particularly to euro deposits, commercial papers, commercial deposits, money market funds, and special savings facilities. On the one hand, these innovations carry market-related interest rates, on the other hand they enjoy a high degree of liquidity. This moved the border between money and monetary capital,[1] it has become harder to differentiate between them. The Bundesbank captures euro deposits and money market fund certificates of domestic non-banks in the aggregate M3 extended. This reflects the lack of experience necessary for an immediate differentiation (money market funds) or the lacking definiteness of their degree of "moneyness" (euro deposits). Special savings facilities with three month's notice on the other hand are included in M3, consequently "distorting" this aggregat.

Besides these structural changes on financial markets, there have occasionally been further explanations for an unstable money demand. Goodhart's Law or the Lucas Critique for instance postulate a correlation between the choice of a particular aggregate as an official intermediate monetary target and the unstable demand for this aggregate (Goodhart (1975)). Additional instabilities may occur owing to German unification or to the foundation of the European Monetary System and the associated intervention duties.

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1 In terms of banking statistics, neither of these investment instruments counts as monetary capital, but well in terms of the capital finance account.

Indeed the temporal development of the monetary aggregate M3 was very erratic sometimes. Volatility increased particularly in recent years. This raises the question for monetary policy, as to whether M3 is still the appropriate target variable or if the innovations mentioned should be taken into account by a modified definition of the money stock. This paper treats this question both, theoretically and empirically.

Generally money can be defined according to theoretical criteria or empirical findings. As a theoretical definition of money will not be unambiguous, the literature in general and this paper as well focus on empirical approaches: The admissibility of a monetary aggregate in the sense of weak separability, stability of money demand, stability of the link with the ultimate goal (predictability), and controllability.[2] In this sense we will at first examine the tendencies on German financial markets and analyze, how far particular monetary aggregates are still appropriate for an anti-inflationary monetary policy in the view of financial innovations. Then recent econometric approaches will be applied for empirical analyses in order to define an appropriate monetary aggregate. As differing approaches may result in differing definitions of the "optimal" aggregate, the conclusion will have to take aspects of applied monetary policy into account.

II. Definitions and characteristics of monetary aggregates

1 The definition of money

Money can be defined theoretically as well as empirically. The former approach starts with theoretical explanations for holding money. Based on this we define - a priori - functions, "money" should have. Assets with such properties would be included in our definition of money, others would be excluded. Another possibility is to define money empirically according to particular objective functions. For example, a central bank committed to anti-inflationary monetary policy will decide for the definition of money that allows best to influence future price trends. Another potential starting point for the empirical definition of money are the revealed preferences of individuals (admissibility of a monetary aggregate). These approaches will not necessarily yield the same result (Fisher (1989)). Thus further considerations concerning the relevance of the criteria for monetary policy, i.e. their weight, are necessary for a definite statement. In terms of practical monetary policy, particularly the stability of money demand, a stable link with the ultimate target variable and controllability are important. If one of these criteria is not met, then the respective aggregate cannot be used.

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2 As Laidler ((1985), pp. 83 f.) puts it, "... the correct definition of money becomes an empirical matter, at least within rather broad boundaries laid down by one's "rough idea" of what money is".

In the following, we will exclusively consider simple-sum aggregates, although they have been heavily criticized in the theoretical literature on money for reasons of aggregation and index number theory (cf. Barnett (1978), Barnett, Fisher and Serletis (1992)). In Germany the definitions derived by summation result from the consolidated balance sheet of the banking system. Thus they are fastly and easily available and can be interpreted within the balance sheet identities. M3 for instance can be computed as the sum of bank lending to domestic non-banks and net external assets of credit institutions and the Bundesbank minus monetary capital formation[3] at credit institutions from domestic sources, federal deposits in the banking system, and other factors (Deutsche Bundesbank (1995a), S. 71).

Some theoretical macroeconomic approaches emphasize the crucial role of the banking system in the transmission mechanism of monetary policy (Bernanke and Blinder (1988)). If the reaction of domestic credit is seen to be crucial in the monetary transmisson process and thus for the effects of monetary policy ("credit channel", Bernanke (1993), Friedman and Kuttner (1993), Romer and Romer (1990)), then simple sum aggregates can be used as indicators for the banking system's consolidated balance sheet (Pill and Pradhan (1994a)). In this case a broad aggregate such as M3 will be a good measure for total lendings. This will not be achieved by variably weighted aggregates, focusing on liquidity services instead of liquidity stocks. They will rather distort the systematic links between credit and output by changing weights.

1.1 Theoretical approaches

Money serves as a medium of exchange, as a store of value, and as a unit of account. Goods or assets performing these functions are referred to as money. As unit of account money is the good that defines the rate of exchange of all other goods. Thus it serves everybody as the general measure. As medium of exchange money grants universal exchange opportunity, being accepted by everybody any time. Money will perform its payment function only if it does not lose its value over the period of intermediation. Thus money gains asset characteristics.

For the definition of money both, the reduction of transaction costs and of information costs is of relevance. Already for the classical economists was the reduction of transaction costs in the exchange of goods resp. the function as unit of account a central criterion concerning the definition of money. ("The principal inconveniences which we should

[3] Monetary capital in terms of the banking statistics.

experience if we had not such a medium."). For instance it is called "... common measure for values of different sorts" (Mill (1848), S. 483).

The information approach by Brunner and Meltzer (1971) took up these reflections again. Concerning a variety of goods, economic agents are subject to uncertainty regarding the goods' properties or the market conditions. Thus they have to use resources to obtain information. The amount necessary depends on the conditional framework for the exchange of goods. That is why society strives for a framework keeping the necessary investment on a low level. In principle any good or asset could serve as an exchange medium. But every exchange medium requires a certain quantity of resources. Due to comparison of the respective costs, one or more goods or financial assets will eventually dominate transactions, as they minimize the resources needed. "The production of information is optimized when the loss in welfare due to the use of endowed resources in the production of information is matched by the gain in welfare associated with more information" (Brunner (1971), p. 9). But a good may well lose its "moneyness" over time and be replaced by another good. And it is by no means necessarily the case that individuals exclusively use legal tender as money. Assuming general acceptance it is possible that financial securities issued by private individuals perform money functions. But in this case the information costs might be higher, as credit risks may well occur. These costs have to be compared with the costs of depreciation.

If the payment function is in the focus, monetary aggregates should be defined rather narrowly. Currency and sight deposits are very liquid. They show no market risk and take little time to be transformed into goods and services. If, in addition, the store of value function of money is considered, rather broad definitions such as M2 and M3 are preferable. Besides, there are some other financial assets that can relatively easily be employed for transaction purposes.

However, the theoretical approach is not really promising, "because money is basically valued for what it does and not for what it is" (Fisher (1989), p. 1). There is no generally valid definition of money. In practice several aggregates can perform the functions of money mentioned. The existing financial assets are in some cases very narrow substitutes. Besides, ever new financial commodities are being developed. Thus for monetary policy empirical approaches are necessary in order to come to an optimal definition. The definition of the appropriate monetary aggregate depends on the purpose of monetary policy. Therefore the decision on the appropriate monetary aggregate should more be made empirically (ex post) and to a lesser extent theoretically (ex ante). In the following the empirical approaches employed in this paper will be explained closer.

1.2 Empirical approaches

1.2.1 Weak separability of a monetary aggregate

Usually the components of a monetary aggregate are chosen on grounds of theoretical considerations or for reasons of a close link with the ultimate target variable. It remains unconsidered, whether this selection corresponds with individuals' revealed preferences. Some recent papers, however, start with individuals' preferences and apply the criterion of weak separability in order to examine the admissibility of financial assets for aggregation. Weak separability is insofar relevant for monetary aggregation, as weakly separable groups of financial assets behave like elementary goods, so that the analysis of money demand can be confined to the respective aggregate.

If an individual's utility function is as follows

$$u = u(c_1, c_2, l, m_1, m_2, m_3), \tag{1}$$

where c_1 and c_2 are consumption goods, l is leisure time, and m_1, m_2 and m_3 are financial assets with a potential for "moneyness", then weak separability means that some arguments of the utility function can be grouped together. This is possible if the marginal rate of substitution between any two goods of the same group is independent of the quantity of goods of another group (Green (1964)). If weak separability is given for the two consumption goods and for the three financial assets, then the utility function can be written as

$$u = u(C(c_1, c_2), l, M(m_1, m_2, m_3)) \tag{2}$$

with

$$\partial \frac{(\partial m_1 / \partial m_2)}{\partial c_1} = 0, \qquad \partial \frac{(\partial m_1 / \partial m_3)}{\partial l} = 0 . \tag{3}$$

The marginal rate of substitution between the financial assets m_1 and m_2 is not affected by changing quantities of the consumption good c_1. The same holds for m_1 and m_3 concerning leisure time l as well as other elements of C, l and M. Possibly only m_1 and m_2, or m_1 and m_3 can be grouped together in one aggregate. In the latter case the marginal rate of substitution between m_1 and m_2 would change with variations of, for instance, c_1.

Weak separability implies the structure of a utility-tree. It is both, a necessary and sufficient condition for utility maximization in two or more stages. In the first stage expenditures are allocated among broad categories of goods (consumption goods, leisure time, financial assets), and in the second stage expenditures are allocated within each category. The total utility function is a function of the subutility functions $u_C(C)$, $u_L(L)$ and $u_M(M)$

$$u = f(u_C(C), u_L(L), u_M(M)). \tag{4}$$

With given utility levels u_C and u_L, utility maximization will be reduced to the maximization of u_M under the constraint

$$\sum_{i=1}^{3} p_i m_i = y_M , \tag{5}$$

where p_i is the price and m_i the quantity of the financial asset i. y_M are the expenditures on M. The demand for the particular components of M depends only on the relative prices of the particular financial assets and on the amount of expenditures spent on financial assets

$$m_i = \theta_i(p_M, y_M) \qquad i = 1,2,3. \tag{6}$$

The total income $y = y_C + y_L + y_M$ and the prices p_L and p_C affect the demand for group M goods only via their influence on y_M (general substitution effect). When y_M is given, p_C and p_L can be disregarded. All prices p_C exert a proportionate influence on m_i $(i \in M)$.

Weak separability requires that the empirical data can be described by a "well-behaved" utility function, i. e. individuals reveal no preferences inconsistent with GARP (Generalized Axiom of Revealed Preference). An aggregate satisfies GARP if

$$p^j m^j \geq p^j m^i \tag{7'}$$

applies and at the same time

$$p^i m^i > p^i m^j \tag{7''}$$

does not apply (Varian (1982, 1983)). m^i and m^j are vectors of financial assets, p^i and p^j are the respective prices. If i and j are interpreted as time indices, then p^i, p^j, m^i and m^j can be interpreted as combinations of prices and quantities in two different periods. If condition (7') holds, m^j is chosen although combination m^i would be cheaper, i.e. individuals reveal a preference for m^j. With (7'') valid, individuals reveal a preference for m^i, i.e. combination m^j would be cheaper. Both conditions represent a contradiction that cannot be represented by a "well-behaved" utility function. If GARP is not met, there is no stable money demand function.

Besides the question of weak separability of financial assets as a whole, it is also of interest whether there are weakly separable subsets within the category of financial assets. As for practical monetary policy there are further criteria to be considered besides the question of admissibility of a particular definition of money.

1.2.2 Stability of money demand

A policy that is based on the control of money supply requires a stable demand for money. In order to define the future course of monetary policy, an estimation of the future demand for money is needed. Due to this the money demand should be explainable by a small set of macroeconomic variables that can easily be estimated, in order to keep the prediction error small (Judd and Scadding (1982)).

In classical quantity theory, the velocity of money is primarily determined by the institutional framework, which is stable in the short-term. Therefore the nominal money demand is proportionate to nominal income. In the long run velocity is subject to slow changes due to institutional development (Fisher (1911)). Pigou emphasized already 1917 the relevance of opportunity costs of holding money, but he did not integrate them into the formal representation of the money demand function. The development of this idea was left to Keynes.

Keynes (1936) distinguishes three motives for money holding. Money is being held for the transactions motive, in order to synchronize receipts and expenditures diverging over time. Thus the demand for money reacts on variations in income. The decision on holding speculative balances depends on an individual's ideas concerning what the normal interest rate is. Precautionary balances can also be seen as proportionate to the level of income.

Baumol (1952) and Tobin (1956) derive the same macroeconomic explanatory variables from an inventory-theoretic approach. In the Baumol-Tobin model, money is being held as cash inflows do not correspond with cash outflows (transactions motive). However, money holding as such causes costs in the form of foregone interest. The substitution of bonds for money, on the other hand, causes transaction costs. Economic agents will demand the quantity of money that minimizes total costs. On the macroeconomic level, money holdings are therefore positively correlated with the transactions volume and negatively with interest rates being opportunity costs.

In Tobin's (1958) portfolio model, where Keynes' speculative motive is being developed further, money is a specific financial asset without any risks in return (besides the risk of depreciation). It competes with various interest-bearing assets that show a potential for serving money functions, but are subject to a higher risk in return. Following return and risk considerations, economic agents will try to realize a portfolio maximizing their expected utility. Accordingly the demand for money depends on the own rate of return of the component in question, the rate of return of alternative financial assets and on actual wealth.

According to Friedman (1956), cash holdings are also determined by total wealth (including human capital). If one views total wealth as the discounted total future income, the interest rate r will under certain conditions indirectly capture wealth. Therefore in this paper wealth will not be included in the money demand function.

All theories result in a (real) demand for money (M / P) that in the long term depends on a transaction cost variable (Y / P) and an opportunity cost variable (r), to be specified closer in the empirical analysis.

$$\frac{M}{P} = f\left(\frac{Y}{P}, r\right) \tag{8}$$

1.2.3 Stability of the link with the ultimate target variable

It is the general problem of monetary policy that the ultimate target variable cannot be controlled directly. On one hand, there is only imperfect knowledge of the interconnection of effects, on the other hand there is uncertainty concerning future trends of these variables. Therefore it is advantageous to choose a variable from the transmission process that is situated between the instruments and the ultimate target of monetary policy and can be managed directly. Currently the Deutsche Bundesbank uses M3 as its indicator and intermediate target (until 1987 the central bank money stock). In order to be a suitable intermediate target, the monetary aggregate in question must exhibit close and stable links with price level trends. If these are given and the aggregate chosen is easily controllable, then the inflation rate can be reduced in both, level and variance.

In this paper the prediction of future price level trends is based on the P-Star approach developed by Hallman, Porter and Small (1991). The P-Star concept starts with the classical quantity equation

$$PY \equiv MV, \tag{9}$$

according to which the nominal transaction volume PY corresponds to the product of money stock M and velocity of circulation V. P^* is defined as the price level that would occur at a given money stock if velocity of circulation V^* and output Y^* were in equilibrium. Therefore P^* is the equilibrium price level that the actual price level P moves towards.

$$P^* = \frac{M}{Y^*} V^* \tag{10}$$

The comparison of the equilibrium price level P^* with the actual price level P reveals the future trend in inflation. If the actual price level is below the equilibrium price level, then the increase in prices will accelerate in the future. P^* represents the relation between total monetary demand and the macroeconomic supply conditions. Formulated in logarithmic form, (9) and (10) yield

$$p^* - p = (y - y^*) + (v^* - v) \tag{11}$$

Inflation may either be the result of an over-utilization of production capacities (output gap: $y - y^*$), or of a velocity of circulation below its long-term average (liquidity gap: $v^* - v$). Therefore the long-run price trend is determined by the money stock development, whereas in the short term the impact of other variables such as wage trends, import prices or changes in indirect taxes must be taken into account.

The liquidity gap can be specified in connection with a long-run money demand function. If one puts the long-run money demand function (8) in log-linear form[4]

$$m - p = \beta_0 + \beta_1 y - \beta_2 r + u\ , \tag{12}$$

where u denotes deviations of money demand from its long-run level, the combination with (9) yields

[4] Except for interest rates, lower case letters denote natural logarithms.

$$\begin{aligned} v &= y - (m - p) \\ &= (1 - \beta_1)y - \beta_0 + \beta_2 r - u \end{aligned} \tag{13'}$$

With all variables replaced by their long-run equilibrium levels ($y = y^*$, $r = r^*$, $u = 0$), the equilibrium velocity of circulation is

$$v^* = (1 - \beta_1)y^* - \beta_0 + \beta_2 r^* \; . \tag{13''}$$

Thus the liquidity gap is expressed by

$$v^* - v = -(1 - \beta_1)(y - y^*) - \beta_2 (r - r^*) + u \; . \tag{14}$$

Here the degree of liquidity is determined by deviations of actual production from potential output $(y - y^*)$, of the interest rate from its long-run level $(r - r^*)$, and of money demand from its long-run level (u). If the income elasticity β_1 is greater than unity, an increase in capacity utilization will result in an increased liquidity gap. The more the interest rate level exceeds its long-run level, the weaker are inflationary tendencies. Real cash holdings exceeding the long-run equilibrium $(u > 0)$ will result in accelerated inflation.

1.2.4 Controllability

Controllability of the money stock by means of monetary policy instruments is a necessary condition for the suitability of a monetary aggregate as an intermediate target of monetary policy. How easily a particular monetary aggregate can be controlled by the central bank, depends on the interest rate elasticity of the respective aggregate. The higher its interest rate elasticity, the lower the central bank impulses necessary in order to generate the desired effect on the money stock. If the demand for an aggregate is rather inelastic with respect to the interest rate, it is not suitable as an intermediate target, no matter how close it is linked to the price level.

For the analysis of controllability, the model developed by Herrmann, Reimers and Tödter (1994) will be employed:

$$\Delta(m - p) = f_1(y, rl - re, \ldots) + \varepsilon_1 \tag{15}$$

The demand for money is modelled as an error-correction-equation, where the real long-run money demand depends on real GDP and on the difference between the long-term interest rate and the own rate of return of the aggregate in question. This rate is the weighted sum of rates of returns of the money stock components, with each weight indicating the proportionate share of the respective component in the aggregate. The long-run correlation between money stock and prices is described using the P-Star concept. In the short-run further influencing factors are taken into account.

$$\Delta p = f_2 \left(p^* - p\right) + \varepsilon_2 \tag{16}$$

The current long-term interest rate (rl) and the aggregate's own rate of return (re) both depend on the development of the repo rate (rw) that serves as the central bank's control variable.[5]

$$rl = f_3 \left(rl_{-i}, rw\right) + \varepsilon_3 \tag{17}$$

$$re = f_4 \left(re_{-i}, rw\right) + \varepsilon_4 \tag{18}$$

This approach takes account of two categories of imperfections practical monetary policy is subject to: control error and projection error (Belongia and Batten (1992), Andersen and Karnosky (1977)). The control error results from the fact that the central bank cannot directly and unambiguously control the interest rate relevant for money demand (ε_3 bzw. ε_4). Narrow aggregates can be controlled better, as the central bank exerts direct influence on money market conditions and thus has a much higher influence on short-term than long-term interest rates. Besides the demand for money is affected by further factors that cannot be influenced by the central bank (ε_1). The projection error results from the ambiguous relation between money stock trend and inflation rate (ε_2).

2 Developments of monetary aggregates and their components in Germany

Financial innovations have partly been stimulated by regulatory measures on financial markets. In the USA for instance governmental interest rate ceilings led to the introduction and expansion of time deposits and savings deposits carrying market-related interest rates. Germany experienced such developments on a much smaller scale. This might primarily be caused by the fact that bank interest rates have not been controlled since April 1967.

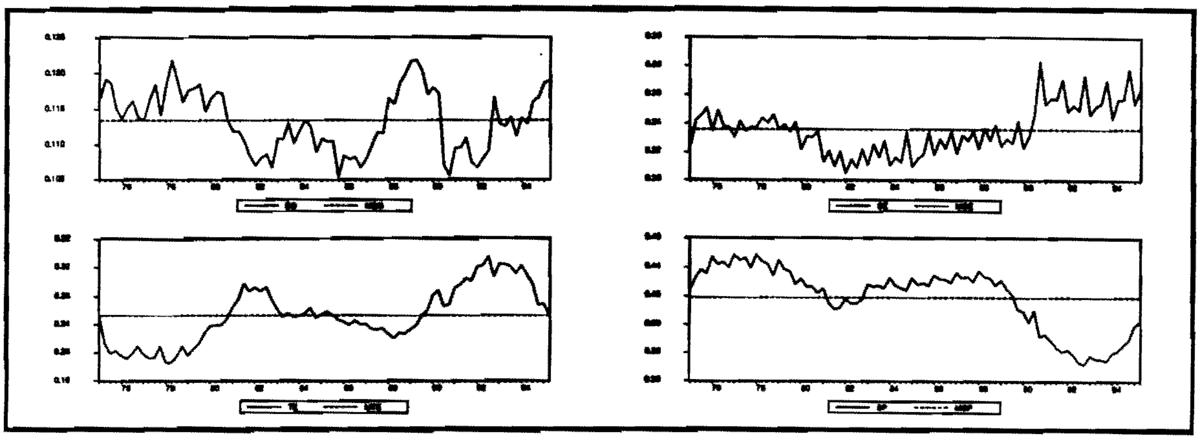
[5] It is taken into account that the capital market interest rate is only marginally affected by the money market rate. The long-term interest rate is determined particularly by international interest rate relations and by inflation expectations.

M3 has been the Deutsche Bundesbank's official intermediate target since 1988. It consists of currency and sight deposits held by domestic non-banks with domestic credit institutions, plus time deposits for less than four years held by domestic non-banks with domestic credit institutions, and savings deposits at three months' notice held by domestic non-banks with domestic credit institutions. In the following the development of the components of M3 from 1975 onwards will be described. Afterwards potential substitutes for M3 will be depicted.

Cash (BG) bears no interest. In the past, its development exhibited high volatility. Due to this the central bank money stock, heavily depending on cash holdings, was abandoned as a target variable in 1987. For the future, competition with prepaid cards has to be expected. Just like cash, sight deposits (SE) are regarded to be liquid at any time. Their rate of return is rather modest with only little variation over time.[6] A higher average interest rate for sight deposits can, however, be expected for the future (money market accounts).

Time deposits (TE) carry market-related interest rates. Those running for up to one year are of greatest relevance. Savings deposits with three months' notice (SP) are covered by M3.[7] Beside savings deposits in the traditional sense they include a number of special savings facilities, that are formally subject to a three months' withdrawal notice. By prolonged non-terminability, however, they carry market-related interest rates. Interest payments on traditional savings deposits are considerably lower than the market level. With the exception of special savings facilities, they are more liquid than corresponding time deposits. Figure 1 shows the share of each component in M3. M.. indicates the average share for the period 1975 through 1995. The correlation coefficients are given in Table 1.

Figure 1: Current and average shares of components in M3



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6 Interest-bearing sight deposits can be found particularly in the USA (NOW and Super NOW accounts).

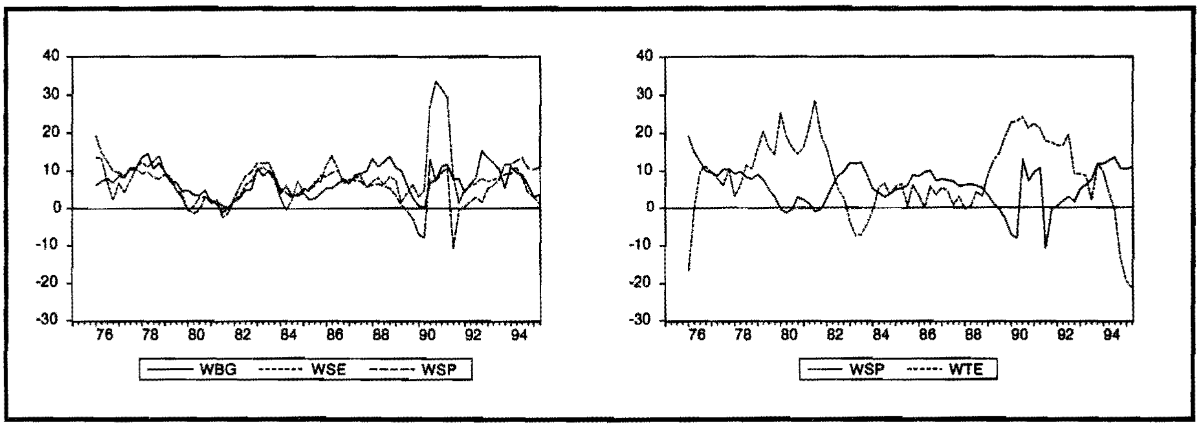
7 Up to July 1st 1993, savings deposits subject to the statutory withdrawal notice.

Table 1: Correlation of shares and growth rates of M3 components[8]

	Cash	Sight deposits	Time deposits	Savings deposits
Cash	1	0.51	-0.14	0.42
Sight deposits	0.55	1	-0.08	0.70
Time deposits	-0.25	-0.36	1	-0.50
Savings deposits	0.01	0.07	-0.95	1

In periods with a high weight of time deposits in M3, the share of savings deposits is considerably below its long-term average. The correlation coefficient is -0.95. The correlation of the other components' shares is much lower. This might indicate a cost conscious cash management or a reaction to changing relations between interest rates on savings and time deposits. With an increasing interest differential in favour of time deposits, savings deposits are replaced by time deposits.

Figure 2: Growth rates of currency in circulation, sight, time, and savings deposits



The growth rates of time deposits do not correlate with those of cash or sight deposits. Those of time and savings deposits, however, are negatively correlated. In certain periods, M2 runs different from M1 and M3. This is caused by time deposits, varying heavily over time with a slightly increasing tendency.[9] Savings deposits show strong variations, as well, but within M3 these developments offset each other.

Therefore the relevant question for monetary policy is, to what extent time deposits have liquidity character, i. e. to what extent the stock of time deposits will be reduced and

[8] The correlation of shares is given below the main diagonal, the correlation of growth rates is given above the main diagonal.

[9] Hence considerations have come up to eliminate time deposits from M3. For Switzerland an aggregate M1B has been established, even if it is not an official intermediate target (Fischer and Peytrignet (1994)).

converted to media of exchange in the future. Only in this case can they be explained by a transaction variable. If, however, time deposits have a monetary capital character, then they serve the storage of value and the accumulation of wealth. In case of term structure changes in favour of longer-term financial assets, these time deposits will be converted to fixed-interest-bearing bonds. In that case the transaction variable is not a relevant explanatory variable.[10] If one creates an aggregate M1B consisting exclusively of cash, sight deposits and savings deposits, this behaves quite similar to M1 (Figure 3).

Figure 3: Developments of M1, M1B and M3 over time

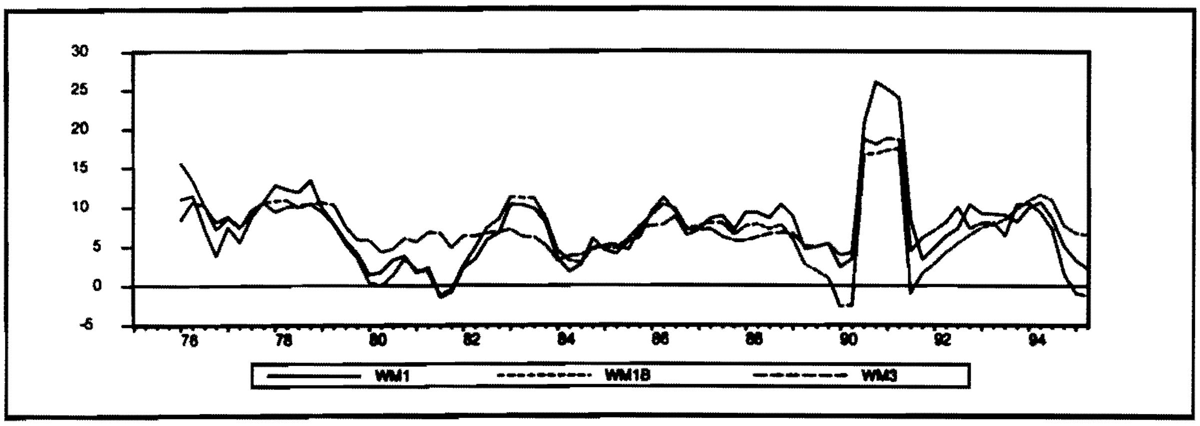
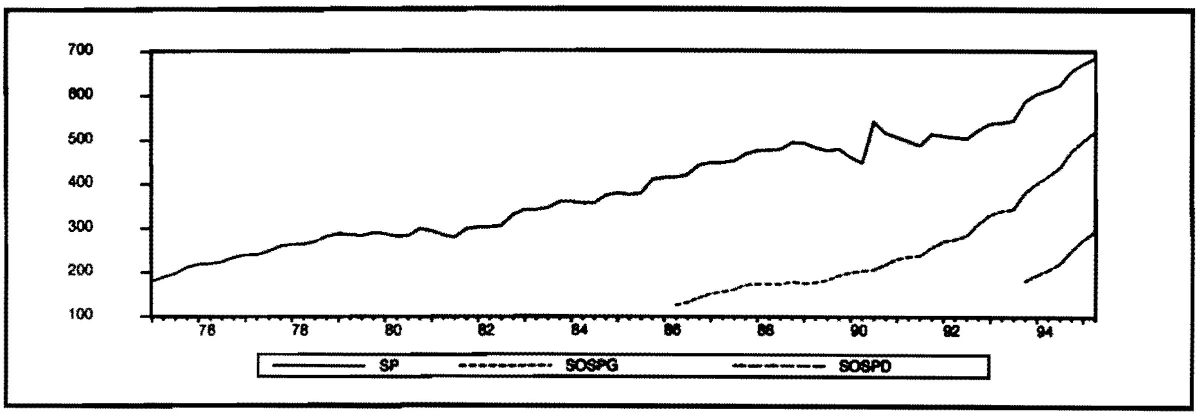


Figure 4 depicts the developments of savings deposits (SP) and special savings facilities (SOSPG). It shows a strong increase in these special forms. Concerning the latter, however, it should be taken into consideration that during the period shown here there has not been a differentiation according to periods of withdrawal notice. These financial assets have been collected separately since 1986, but only from 1993 onwards have they been differentiated according to their periods of notice.

Figure 4: Development of special savings facilities relative to total savings deposits



10 In the USA for instance, small time deposits are included in M2, whereas large time deposits are an M3 component.

Investment in special savings facilities with three months' notice (SOSPD) expanded especially in 1992/93 and due to the revision of saving transactions regulations mid 1993. The expansion continues undiminished. Despite their formal short-term notice, these savings facilities have a rather long-term character, as only longer-term non-terminability grants attractive yields, whereas savings deposits with a "factual" three months' period of notice have liquidity character.

The effects on current definitions of monetary aggregates depend on various factors. As long as special savings facilities expand to the detriment of time deposits, M3 does not change. In view of their market-related returns, however, switchings of monetary capital are very possible. If traditional savings facilities are reduced in favour of special forms, M3 remains unchanged, but effects on interest rate elasticity, and thus controllability, would inevitably occur. Due to this one might propose to adjust M3 for these specific assets. Whether such an adjusted aggregate is a better intermediate target, will only be analyzed in years to come, as time series available are too short for respective research.

Money market funds are investment funds investing the acquired resources entirely in bank deposits, interest-bearing securities with maximum 12 months maturity, and floating-rate securities (bonds with short maturities, floating rate notes, discounted treasury notes). The returns are oriented at the money market rate. These financial assets are highly liquid, as balances can be drawn on at one day's notice. Fees are charged in proportion to the period of holding.

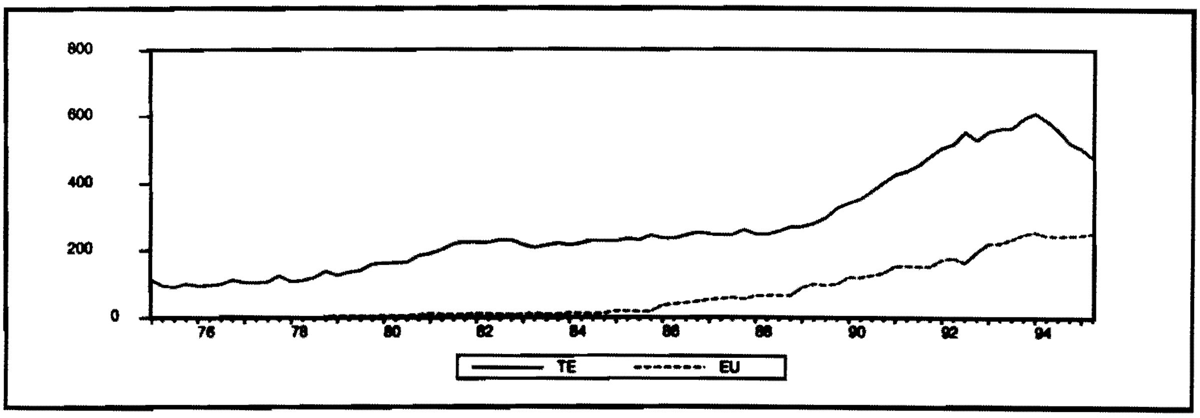
Money market funds have been admitted in Germany since August 1994. At first, a strong demand for these assets could be observed, reaching its peak for tax law reasons in December 1994. Since April 1995, however, the demand has been levelling-off, most probably due to low interest rates.

The actual money stock trend will be understated to the extent that investors substitute deposits belonging to M3 for money market funds, and if investment companies choose investments not included in M3. If money market funds invest their resources in domestic short- or medium-term money, M3 is not affected.[11] Money market funds are as well potential substitutes for savings deposits. Savings deposits bearing rather low rates of return are particularly being held for reasons of liquidity (immediate availability within certain limits). Money market funds are very liquid and yield market-related rates. The interest differential between money market fund certificates and special savings facilities, however, is significantly smaller. Their inclusion in an official aggregate would result in a

[11] In some other countries, such as the USA, the introduction of money market funds had a much stronger impact.

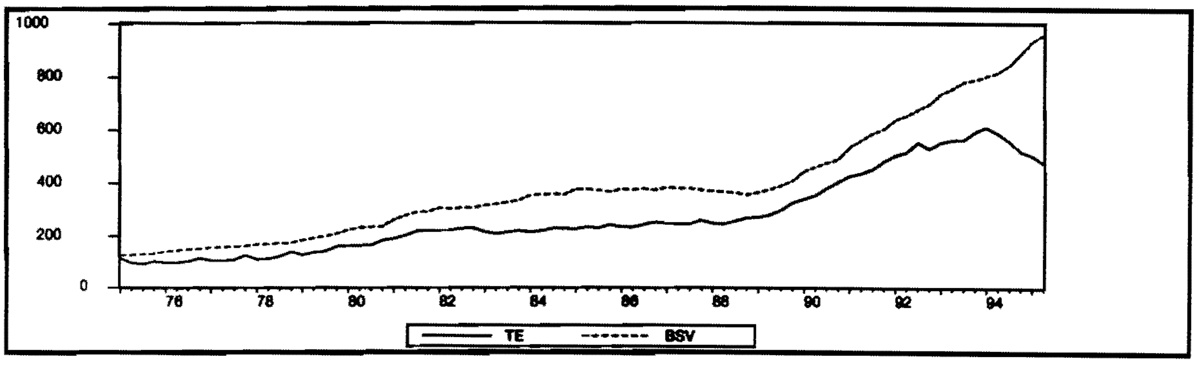
reduced interest rate elasticity and corresponding effects on controllability. Resources invested in money market funds are covered by the monetary definition M3 extended (M3E).

Figure 5: Time deposits and euro deposits



Euro deposits (EU) realized high growth rates during the eighties. Apart from growth impulses induced by tax law amendments (withholding tax), they developed largely parallel to domestic time deposits. As for liquidity management, euro deposits, money market fund certificates and short-term time deposits are probably considered to be substitutes. Private investors as well are increasingly thinking in terms of rates of return. As with time deposits, it is rather difficult to differentiate between transactions motive and investment motive.

Figure 6: Short-term time deposits and bank debt securities in circulation



Until 1993 time deposits and bank debt securities (BSV) developed parallel over time. Since then they have been negatively correlated (Figure 6). This can be taken as an indication of the increasingly blurred dividing line between money and monetary capital. Short-term bank debt securities held by domestic non-banks as well as Euro-deposits are covered by M3 extended.

Primarily caused by their strong increase in 1991 and 1992, investment in commercial papers gained a certain importance. Since then their development has settled down. This investment instrument, however, does not affect the banking system's consolidated balance sheet on which the statistical calculation of monetary aggregates is based upon.

III. Econometric methodology

Procedures for the estimation of long-run equilibrium relationships can be distinguished as to whether or not the variables considered are differentiated into endogenous and exogenous variables. Single equation approaches assume either weak exogeneity (Stock approach) or strict exogeneity (Fully Modified OLS) of the regressors. Against this, the Johansen procedure assumes all variables to be endogenous at first. Then partial models can be derived by testing for exogeneity.

Weak exogeneity is a necessary condition for efficient estimation and testing in single equation models. In this case the analysis can be limited to a conditional model, taking the weakly exogenous variables as given. If one considers a simple first-order bivariate vector autoregressive model (Ericsson (1994))

$$\begin{aligned} \Delta y_t &= \gamma_{11} y_{t-1} + \gamma_{12} x_{t-1} + \varepsilon_{1,t} \\ \Delta x_t &= \gamma_{21} y_{t-1} + \gamma_{22} x_{t-1} + \varepsilon_{2,t} \end{aligned} \tag{19}$$

where $\varepsilon_t \sim IN(0,\Omega)$, and assumes the existence of a long-run equilibrium relationship $(\beta' = (1, -\delta))$, model (19) can be reformulated as

$$\begin{aligned} \Delta y_t &= \alpha_1 (y_{t-1} - \delta x_{t-1}) + \varepsilon_{1,t} \\ \Delta x_t &= \alpha_2 (y_{t-1} - \delta x_{t-1}) + \varepsilon_{2,t} \end{aligned} \tag{20}$$

where $\alpha_1 = \gamma_{11}$, $\alpha_2 = \gamma_{21}$ and $\delta = -\gamma_{12} / \gamma_{11} = -\gamma_{22} / \gamma_{21}$. If weak exogeneity is given, then the equation for Δy_t is sufficient for an efficient inference about the cointegration parameter δ. Hence the test for significance of the error correction term for Δx_t $(H_0{:}\,\alpha_2 = 0)$ is a test for weak exogeneity. The LM-Test by Boswijk (1991) is an alternative approach.

1 Estimation of long-run relationships

It is assumed that the level variable y_t can be represented by the dynamic model

$$y_t = by_{t-1} + a_0 x_t + a_1 x_{t-1} + u_t \tag{21}$$

The resulting long-run coefficient is

$$\beta = \frac{a_0 + a_1}{1 - b}$$

The estimation of the long-run relationship by means of a static regression

$$y_t = x_t \beta + u_t \tag{22}$$

(first step of the Engle-Granger-procedure) can be shown to be problematic, as despite super-consistency the estimators are biased in their distribution and the asymptotic distribution is non-normal (Banerjee et al. (1986)). Simulations run by Kim (1994) show that in small samples of the size typical in economic analyses (50 observations) severe biases can be observed. The reason for this is that neither the short-run dynamics, nor the correlation between the regressors and the error term, or the serial correlation of the error term are not accounted for.

Therefore, following Stock (1987), the error correction equation (23) consisting of the long-run equilibrium relationship and the short-run dynamics is estimated

$$\Delta y_t = (b-1) y_{t-1} + (a_0 + a_1) x_{t-1} + a_0 \Delta x_t + u_t \ . \tag{23}$$

By using this additional information, the bias can be considerably reduced, even in small samples (Kim (1994)). Assuming that the explanatory variables are weakly exogenous, the respective equation can be estimated by OLS. Because of the non-stationarity of the regressors, however, the standard tests for significance are not applicable. Based on the t-value of the error correction term $(b-1)$, cointegration can be tested for (Kremers, Ericsson and Dolado (1992)). As the distribution of the adjustment coefficient is non-standard, the critical values generated by MacKinnon (1991) have to be used. This procedure yields more reliable testing results than the application of the (Augmented) Dickey-Fuller test on non-stationarity of the residuals in the static regression equation. The t-statistics of the long-run coefficients are calculated by means of the Bewley-transformed equations.

$$y_t = -\frac{b}{1-b}(y_t - y_{t-1}) + \frac{a_0 + a_1}{1-b}x_{t-1} + \frac{a_0}{1-b}\Delta x_t + \frac{1}{1-b}u_t \tag{24}$$

In equation (24) the cointegration parameters are estimated directly. Due to the contemporaneous correlation between Δy_t and u_t, though, an instrumental variables estimation has to be conducted. Instead of Δy_t, y_{t-1} is employed as the instrument. Under the condition of weak exogeneity of the regressors, the t-values are normally distributed, so that significance can be tested for.

Starting point of the Fully Modified OLS- (FMOLS-) estimation (Phillips and Hansen (1990)) is a triangular model structure for $z_t = (y_t \quad x_t)$. The variables are divided up into r endogenous variables y_t, and k strictly exogenous variables x_t. Additionally, deterministic terms (constant terms, seasonal dummies) can be included.[12]

$$\begin{aligned} y_t &= \beta x_t + u_{1,t} \\ x_t &= x_{t-1} + u_{2,t} \end{aligned} \tag{25}$$

$u_{1,t}$ and $u_{2,t}$ are stationary processes. Hence y_t and x_t are cointegrated with the cointegration vector $[1 \quad -\beta]$. The residuals of long-run equation $u_{1,t}$ are usually serially correlated and correlated with $u_{2,t}$.[13] Orthogonality between regressors and error terms is achieved by non-parametric modification.

The long-run variance Ω can be factorized into the contemporary covariance Σ and the sum of the covariances Λ and Λ'

$$\begin{aligned} \Omega &= E(u_t u_t') + \sum_{i=1}^{\infty} E(u_t u_{t-i}') + \sum_{i=1}^{\infty} E(u_{t-i} u_t') \\ &= \Sigma + \Lambda + \Lambda' \end{aligned} \tag{26}$$

and $\quad \Delta = \Sigma + \Lambda$.

The long-run variance of $u_{1,t}$ with $u_{2,t}$ given (conditional variance) is

$$\Omega_{11.2} = \Omega_{11} - \Omega_{12}\Omega_{22}^{-1}\Omega_{21} \ . \tag{27}$$

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[12] In the following, $r = 1$ is assumed.

[13] The correlation of $u_{1,t}$ and $u_{2,t}$ is not taken into account in the estimation of a single equation ECM. This has negative effects on the efficiency of the estimators (Phillips and Loretan (1991)).

The endogeneity of the regressors results in the following bias

$$\Delta_{21}^{+} = \Delta_{21} - \Delta_{22}\Omega_{22}^{-1}\Omega_{21} \,. \tag{28}$$

The long-run variance is estimated on the basis of the residuals of an OLS estimation of the long-run relationship in (25). All autocovariances are weighted and combined by using a kernel. The specific form of the weighting scheme (e.g. Bartlett, Parzen, QS) is of rather little relevance (Hansen (1992)). The lag truncation parameter has to be chosen so that the bias Δ_{21}^{+} caused by endogeneity is eliminated. The estimates react sensitively on the value of the bandwidth parameter. Andrews (1991) proposes an estimator for the lag truncation parameter that is based on minimization of the asymptotic truncated mean squared error.

The FMOLS estimator for the long-run parameter in (25) is

$$\hat{\beta}_{FM} = \left(\sum_{t=1}^{T}\left(y_t^{+}x_t' - \left(0 \;\; \hat{\Delta}_{21}^{+}\right)\right)\right)\left(\sum_{t=1}^{T}x_t x_t'\right)^{-1} . \tag{29}$$

It corresponds to the OLS estimator of the modified model

$$\begin{aligned} y_t^{+} &= \beta x_t + u_{1,t}^{+} \\ \Delta x_t &= u_{2,t} \\ \begin{pmatrix} u_{1,t}^{+} \\ u_{2,t} \end{pmatrix} &= \begin{pmatrix} I & -\Omega_{12}\Omega_{22}^{-1} \\ 0 & I \end{pmatrix}\begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} \end{aligned} \tag{30}$$

with the respective long-run covariance matrix

$$\Omega^{+} = \begin{bmatrix} \Omega_{11.2} & 0 \\ 0 & \Omega_{22} \end{bmatrix} .$$

The test statistics are asymptotically t-distributed. Hence statements on the significance of parameters can be made.

The data generating process of the full information maximum likelihood estimation following Johansen (1988, 1991) is a VAR(p) model for y_t. There is no a priori differentiation between endogenous and exogenous variables

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + \mu + \varepsilon_t \ . \tag{31}$$

y_t is a vector of k variables. $A_1,\ldots,A_p$ are $(k \times k)$-dimensional coefficient matrices, ε_t is a k-dimensional vector of Gaussian errors ($\varepsilon_t \sim$ iid $N(0,\Omega)$). p is the lag order of the system. Vector μ contains k constant terms. Under certain conditions this system can be reformulated in error correction form

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{p-1} \Delta y_{t-p+1} + \Pi y_{t-p} + \mu + \varepsilon_t \ , \tag{32}$$

where $\Gamma_i = \sum_{j=1}^{i} A_j - I$, $i = 1,\ldots,p-1$.

The vector error correction model is a VAR model in first differences (Δy_t), explicitly taking into account the long-run equilibrium relationships between the variables' levels. The coefficient matrix Π can be decomposed into the loading matrix α and the matrix β containing the cointegrating vectors

$$\Pi = \alpha\beta' \ .$$

If Π has not full rank, this is a reduced rank regression or a multivariate canonical correlation analysis. $\hat{\lambda}_i$ are the eigenvalues of the characteristic equation

$$\left|\hat{\lambda}_i S_{kk} - S_{k0} S_{00}^{-1} S_{0k}\right| = 0 \ . \tag{33}$$

The eigenvalues are the squared canonical correlations between the "level" residuals and the "difference" residuals. Ordered from the largest down to the smallest, these are

$$\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots > \hat{\lambda}_k$$

with eigenvectors ordered correspondingly

$$\hat{V} = (\hat{v}_1, \hat{v}_2, \ldots, \hat{v}_k).$$

These vectors $\hat{v}_i$ are normalized, so that

$$\hat{V}' S_{kk} \hat{V} = I \ .$$

The cointegration relationships $\hat{\beta}$ are the first r normalized eigenvectors. The eigenvectors determine the linear combinations $\hat{v}_i' y_t$ which are, conditional on Δy_{t-i}, most strongly correlated with Δy_t. The value of $\hat{\lambda}_i$ is a measure for the size of the correlation of the cointegration relationships $\hat{v}_i' y_t$ with the stationary part of the process. The remaining k-r linear combinations are non-stationary. Theoretically they are not correlated with the stationary part of the process, i.e. $\lambda_i = 0$, $i = r+1,\ldots,k$.

$$\hat{\beta} = (\hat{v}_1,\ldots,\hat{v}_r) \tag{34}$$

For any eigenvector $\hat{v}_i$, i=1,...,r there is a respective $k \times 1$-dimensional vector α_i with at least one non-zero element. The elements of α_i measure the speed of adjustment towards the long-run equilibrium. The space spanned by α and β is defined unambiguously by the column space and the row space of Π. The parameters α_{ij} and β_{ij}, however, are not defined unambiguously. For any non-singular matrix ξ, $\alpha\xi$ and $\beta(\xi')^{-1}$ result in the same matrix Π and thus in the same probability distribution of the variables. Hence the unrestricted cointegration vectors β_i are not identified, i.e. they cannot be interpreted in terms of economic theory.

The statistical problem in this maximum likelihood procedure is the distinction between significant eigenvalues and non-significant eigenvalues. For this problem Johansen proposes likelihood ratio tests. The trace test tests the hypothesis of r cointegration vectors against the alternative of k long-run equilibrium relationships

$$-2\ln Q\big(H_1(r)\big|H_0(k)\big) = -T\sum_{i=r+1}^{k}\ln\big(1-\hat{\lambda}_i\big). \tag{35}$$

The test statistic follows a Brownian motion. Critical values were given i. a. by Johansen (1988). Within the Johansen procedure the assumption of weak exogeneity can be tested for by restrictions on the loading matrix. The test statistic for the hypothesis $H_0: \alpha_i = 0$ is distributed as χ^2.

2 Tests for stability

2.1 Tests based on the FMOLS estimation

As the variables of the long-run equilibrium relationship are non-stationary, tests for structural constancy, which are usually applied for stationary variables (CUSUM test, Chow test etc), cannot be employed using standard critical values. Hansen (1992) developed test procedures based on the residuals of the Fully Modified OLS estimation.

The SupF-test and the MeanF-test assume structural constancy under the null hypothesis. The alternative hypothesis is non-constancy of the long-run parameters. The timing of the structural break is unknown. The test statistic of the SupF tests is the supremum of the F-statistics

$$\mathrm{SupF} = \sup_{t/T \in \tau} F_{\tau} \tag{36}$$

where the test region τ is a subset of the set $(0,1)$.

$$F_{Tt} = \mathrm{vec}(S_{Tt}) \left(\hat{\Omega}_{11.2} \otimes V_{Tt}\right)^{-1} \mathrm{vec}(S_{Tt}) \tag{37}$$

$$S_{Tt} = \sum_{j=1}^{t} \hat{s}_j \qquad \hat{s}_t = \left(x_t \hat{u}_{1,t}^{+}{}' - \begin{pmatrix} 0 \\ \hat{\Delta}_{21}^{+} \end{pmatrix} \right)$$

$$V_{Tt} = M_{Tt} - M_{Tt} M_{TT}^{-1} M_{Tt} \qquad M_{Tt} = \sum_{j=1}^{t} x_j x_j'$$

For a particular breakpoint F_{Tt} corresponds with the traditional Chow test. The estimates covering two subperiods are compared with each other using the variance for the entire sample. The MeanF-test is based on the average of the F_{Tt} test statistic over all values of τ, disregarding the first and last observations.

The choice of the test region is difficult. If the extremes 0 and 1 were included in the test, the test statistic would with high probability converge to infinity, and thus parameter constancy would be rejected. Therefore Hansen suggested selecting $\tau = [0.15, 0.85]$.

In contrast to the SupF-test and MeanF-test, the Lc-test takes all observations into account, no stabilization (trimming) is necessary

$$Lc = \mathrm{tr}\left\{ M_{TT}^{-1} \left(\sum_{t=1}^{T} S_t \hat{\Omega}_{11.2}^{-1} S_t' \right) \right\} \ . \tag{38}$$

Under the null hypothesis parameter constancy, and thus cointegration, is assumed, whereas under the alternative hypothesis parameter instability, and thus no cointegration, is assumed. In this case the model parameters change gradually, i.e. they follow martingale processes.

2.2 Tests within the Johansen procedure

The recursive analysis of a conditional model facilitates tests for parameter constancy. The variability of the cointegration relationships $\hat{\beta}_i$ and that of the loading coefficients $\hat{\alpha}_i$ is reflected in the time path of the eigenvalues $\hat{\lambda}_i$ (Hansen and Johansen (1993)). If the eigenvalues show signs of variation over time, this indicates instabilities in the model under perspective.

In another test variant, the cointegration vectors estimated for the various subsamples are compared with those for the entire sample and/or a particular subsample. The first subsample should contain significantly more observations than regressors. The latter procedure is appropriate if a structural break is to be expected at a some point. The former procedure facilitates tests as to whether the cointegration vectors of the entire sample are in the space spanned by the cointegrating vectors in each subsample. The test can be conducted with or without parameter restrictions for all subsamples. The null hypothesis is

$$H_{\beta_\tau} : \tilde{\beta} \in sp(\beta_\tau) \qquad \tau = T_0, \ldots, T .$$

The test statistic is

$$-2\ln\left(Q\left(H_{\beta_\tau} \middle| \hat{\beta}(\tau)\right)\right) = \tau \sum_{i=1}^{r} \left(\ln\left(1 - \hat{\rho}_i(\tau)\right) - \ln\left(1 - \hat{\lambda}_i(\tau)\right)\right), \tag{39}$$

where $\hat{\rho}_i(\tau)$ are the solutions of the restricted eigenvalue problem

$$\left|\rho \tilde{\beta} S_{kk}(\tau)\tilde{\beta} - \tilde{\beta} S_{k0}(\tau) S_{00}^{-1}(\tau) S_{0k}(\tau)\tilde{\beta}\right| = 0 \tag{40}$$

and $\hat{\lambda}_i(\tau)$ are the r largest eigenvalues of the unrestricted eigenvalue problem. The test statistic is asymptotically distributed as χ^2 with $(d_k - r)r$ degrees of freedom ($d_k = k+1$, if the constant term is restricted to the long run relationship). If the time paths of the structural coefficients are to be evaluated, these coefficients have to be identified.

The stability of the short run parameters can be tested for by means of the CUSUM test.

IV. Empirical Analysis

The analysis covers the period from first quarter 1975 through second quarter 1995.[14] In spring 1973 the Bretton Woods system of fixed exchange rates was abandoned, and in December 1974 the Deutsche Bundesbank announced a monetary target for the first time. These events may have led to structural breaks in the time series, therefore observations from earlier than 1975 were not taken into account. The time series for monetary aggregates and components as well as for interest rates and capital market yields were taken from the Monthly Reports of the Deutsche Bundesbank. The data on gross domestic product come from the Federal Statistical Office (Statistisches Bundesamt). Up to the second quarter 1990, the data refer to West Germany, from third quarter 1990 onwards to all Germany. This way the necessity to model the varying jumps in monetary aggregates and the transaction variable could be avoided. The data are unadjusted. Simulation analyses show that the use of seasonally adjusted time series has unfavourable effects on the adjustment coefficients of error correction terms (Ericsson, Hendry and Tran (1994)).

1 Test for weak separability

Based on utility theory, tests for weak separability make an interesting contribution to monetary definition approaches. The definition chosen by a central bank should comply with the conditions for aggregation. If these requirements are not met, it is not sufficient to analyze the aggregate's development as a whole, but it is rather necessary to include structural changes within the aggregate.

The test for weak separability employed here is non-parametric.[15] No particular functional form of the utility function is assumed. Thus problems of parametric approaches, reacting sensitively on the functional form, can be avoided. Besides, it is always the joint hypothesis of weak separability <u>and</u> of the specific functional form of the utility function chosen that is tested for validity.

The admissibility of particular monetary definitions for Germany has been tested in the literature by Belongia (1993a) and Spencer (1995).[16] For monthly data Spencer could identify M3 as an admissible aggregate for an observation period from February 1991 to

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14 With the exception of the tests for weak separability. Here computational constraints limited the maximum number of observations to 75: first quarter 1977 through second quarter 1995.

15 The analysis was undertaken using the programme NONPAR (nonparametric revealed preference procedure), developed by Varian.

16 For the USA und Great Britain, there has been a multitude of analyses of this kind (for instance Fisher (1989), Belongia (1993a), Swofford (1995)).

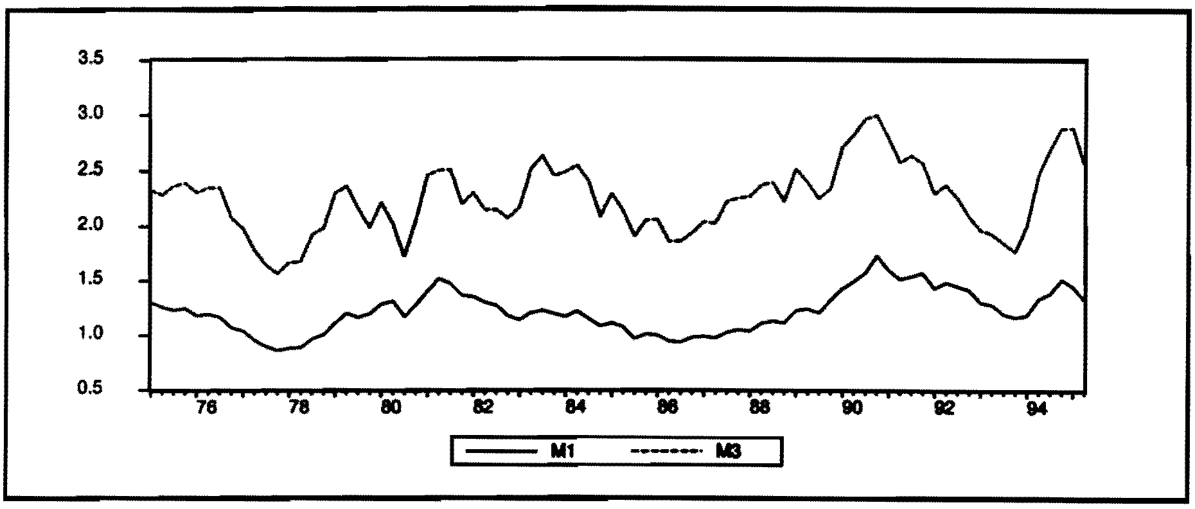
January 1995. The results of Belongia (1993a), however, suggest not to include time deposits in an aggregate. He analyzed monthly data from January 1975 to May 1990.

Holding money implies costs in the form of foregone interest. These opportunity costs are positively correlated with the interest rate level of alternative assets. Depending on whether the particular money components yield positive interests, they imply different opportunity costs. Based on an intertemporal utility maximization approach, Barnett (1978) derived an expression for the real user cost $\pi_{i,t}$ of financial asset i, which will be used as the opportunity cost measure in the following:

$$\pi_{i,t} = \frac{R_t - r_{i,t}}{1 + R_t}.$$

R_t is the yield on a benchmark asset represented by the current yield on government bonds. $r_{i,t}$ is the own rate of return of asset i. If there is an inverted term structure of interest rates, the user costs are set to zero (Swofford (1995), S. 159). $(1 + R_t)$ is the discount factor. As Figure 7 shows, transaction costs of M1 and M3 in relation to real gross domestic product fluctuated heavily and did not show a trend over time.

Figure 7: User costs of M1 and M3 in relation to real GDP (in percent)



The assets considered include cash (BG), sight deposits (SE), time deposits running for up to four years (TE), savings deposits with three months' notice (SP), euro deposits (EU), and short-term bank debt securities (BS). Thus the broadest monetary aggregate analyzed is M3 extended (excluding money market funds). It is assumed that according to the criterion of weak separability goods can be grouped into categories of consumption goods, leisure time and financial assets, so that the analysis can be limited to the category of financial assets. Based on this, the admissibility of particular monetary aggregates narrower than M3 extended can be tested. The real holding of the components is looked at. Interest rates on cash and sight deposits are assumed to be zero. Concerning time deposits, the rate on deposits amounting to DEM 100.000 up to DEM 1 million with maturity between one and three months has been applied, concerning savings deposits, the rate on deposits with three months' notice has been chosen, for euro deposits it is the rate on three months money at the euro money market, and the interest rate on bank debt securities has been measured by their current yield.

Concerning the entire sample (77.1-95.2), M3 extended (M3E), being the broadest category of financial assets, does not meet GARP (7 violations of the conditions of consistency). But if the sample is reduced to 83.1-95.2, no violations of GARP can be observed. When particular components within this group are summed up, weak separability can be shown for M1, M3 and M3+euro deposits (M3EU). It has to be noticed, however, that cash and sight deposits have identical user costs. For M2 and M1B (M1 plus savings deposits), this property must be rejected, as in these cases GARP is not met.

Table 2: Results of tests on GARP and on weak separability (83.1-95.2)

Elements of the utility function	Elements of the subutility function	GARP-violations	weak separability
BG, SE, TE, SP, EU, BS		0	
"	BG, SE, TE, SP, EU	0	+
"	BG, SE, TE, SP	0	+
"	BG, SE, TE	1	-
"	BG, SE, SP	1	-
"	BG, SE	0	+

One should, however, notice the low statistical power of these tests. If only one observation does not meet the conditions of consistency, then testing for weak separability is impossible. But such a violation could be caused by random effects (Barnett, Fisher and Serletis (1992)). Due to these limitations, this approach should not be overinterpreted as an appropriate criterion for optimal monetary aggregation.

2 Analysis of money demand functions

The stability of money demand is of crucial relevance for monetary targeting (Friedman and Schwartz (1963)). "In sum, a stable demand function for money means that the quantity of money is predictably related to a small set of key variables linking money to the real sector of the economy" (Judd and Scadding (1982), S. 993). Thus it has to be clarified, whether stable demand functions can be specified for the alternative monetary aggregates.

The stability of German money demand has been analyzed in a number of papers (see tables 3a and 3b). Recent papers focused on the question as to whether German unification caused structural changes. German unification led to an increase in output of about 9 % and in money stock of about 15 %. In order to avoid effects of these breaks in time series on the estimated coefficients, some authors propose an adjustment for breaks in the respective time series, i.e. they try to differentiate between jump effects and structural changes. Lütkepohl, Teräsvirta and Wolters (1995), for instance, examine per capita demand functions for M1 and M3. In doing this they assume the per capita money demand in East Germany to correspond with the respective West German figures and that no adjustment processes were necessary. The authors ascertain instabilities for M1, due to changing seasonal patterns in time series concerning the money stock and the transaction variable.[17] For M3 they could not find an appropriate specification. Herrmann, Reimers and Tödter (1994) made an adjustment for the jump by reducing the post-unification figures for 9 %. This equals the jump in gross domestic product in the third quarter 1990. This, however, might rather be an ad hoc approach, as it implies, for instance, an income elasticity of unity. The majority of authors does not adjust for jumps. The estimation methods prefered in recent analyses are the maximum likelihood estimation by Johansen and the Stock method as a single equation approach.

The analyses yield differing results concerning the existence of a long run equilibrium relationship. In the majority of cases the estimations indicate a cointegration relationship between the variables examined. Stability analyses are usually restricted to the numerical comparison of results that cover different subperiods. Only recently have tests been applied that explicitly take the non-stationarity of the regressors into account.

[17] This indicates the relevance of the decision to use either seasonally adjusted figures or unadjusted figures.

Table 3a: Survey of selected analyses of German money demand (incl. unification)

Author	Aggregate	Period	Method [18]	Result
Hansen, Kim (1995)	M1, M3 M1, M3	60.1-89.4 60.1-92.4	SEECM, FMOLS SupF-, MeanF-tests	M1 stable, M3 stable, M1 stable, M3 ?
Lütkepohl, Teräsvirta, Wolters (1995)	M1	60.1-93.4	non-linear	M1 unstable
Kole, Meade (1995)	M3	70.1-94.4	SEECM	M3 stable
Issing, Tödter (1995)	M3	75.1-93.2	EG	M3 stable
Sachverständigen-rat (1995)	CBMS[19]	74.1-94.2	SEECM	CBMS stable
Deutsche Bundes-bank (1995b)	M3	75.1-94.4	EG	cointegration M3 stable
Falk and Funke (1995)	M1	77.4-92.4	SEECM Chow	M1 stable
Kim (1994)	M1, M3	60.1-92.4	SEECM, FMOLS SupF-, MeanF-tests	M1 stable M3 stable
Gerlach (1994)	M3	71.1-89.4	SEECM prediction (90.1-92.1)	M3 stable
Herrmann, Reimers, Tödter (1994)	M1B, M3	76.3-93.4	EG	M1B stable M3 stable
OECD (1993)	M3	70.1-92.4	SEECM	M3 unstable
Scheide (1993)	M3 (velocity)	72.1-92.6	ARIMA	M3 stable
Von Hagen (1993)	M1, M3 (velocity)	65.1-91.4	SEECM	M1 stable M3 unstable

[18] EG denotes the Engle Granger procedure, SEECM the single-equation error correction model (Stock (1987)) and DOLS the dynamic OLS approach (Stock and Watson (1993)).

[19] Central Bank Money Stock in the definition of the Board of Experts for Assessment of Overall Economic Trends (Sachverständigenrat).

Table 3b: **Survey of selected analyses of German money demand (excl. unification)**

Authors	Aggregate	Period	Method	Result
Lütkepohl, Moryson, Wolters (1995)	M1	60.1-90.4	time varying coefficients	M1 unstable
Hoffman, Rasche, Tieslau (1995)	M1	60.1-88.4	Johansen, DOLS recursive estimations	M1 stable
Buscher, Frowen (1993)	M1, M3	73.1-87.4	SEECM	M1 stable M3 stable
Gaab, Liedtke (1992)	M1, M2, M3	61.2-88.4	Johansen	unstable
Funke and Hall (1992)	M3	69.1-90.4	Johansen	M3 stable
Boughton (1991)	M1, M3	72.1-88.4	EG, SEECM, Johansen	break in 74.2
Rüdel (1989)	M1	61.1-87.4	EG, Johansen	M1 stable
Trehan (1988)	CBMS, M1, M2, M3	75.1-86.4	SEECM	CBMS stable M3 stable

In the following empirical analysis, the long-run money demand $(m-p)$ will be specified for several monetary aggregates in real form

$$m-p=\beta_0+\beta_1 yr+\beta_2 rl+u_t\,. \tag{41}$$

This implies that price homogeneity is given.[20] The nominal money stock is discounted by the deflator of domestic expenditure (p). Real gross domestic product (yr) is the scale variable or transaction variable. Opportunity costs are represented by the long-term interest rate (rl) in the case of broad money stock definitions and by the money market rate on three months' money (rk) in the case of narrow definitions. Alternatively, concerning broad aggregates one could use the difference between the long-term rate and the own rate of return of the aggregate in question, as these aggregates contain interest-bearing components. Hence, the demand for money reacts positive on changes of the aggregate's own rate of return and negative on changes of the long-term rate. An aggregate's own rate

20 "The quantity theory of money takes it for granted, first, that the real quantity rather than the nominal quantity of money is what ultimately matters to holders of money and, second, that in any given circumstances people wish to hold a fairly definite real quantity of money" (Friedman (1987), p. 4).

of return is the weighted mean of its components yields, with varying weights being used.[21] The inflation rate (Δp) is integrated in equations for the short-run development as a regressor. This allows for temporary deviations from price homogeneity.

$$\Delta(m-p)=\alpha_0+\alpha_1\Delta yr+\alpha_2\Delta p+\alpha_3\Delta rl+\alpha_4(m-p)_{-1}+\alpha_5 yr_{-1}+\alpha_6 rl_{-1}+\varepsilon_t \quad (42)$$

At first, the variables are tested for unit root.[22] Afterwards it is tested by means of the Johansen approach, whether long-run equilibrium relationships exist in a multi-dimensional system, and if, how many. If relations of that kind are given, the question of weak exogeneity of the real gross domestic product and of the interest rate variable is analysed. If these variables are weakly exogenous, then the model under perspective can be reduced to a conditional model for the real money demand without neglecting the information content of the marginal model for the estimation. The Johansen test indicates only one long-run relationship each. These equilibrium relationships are then estimated and tested for structural breaks using various procedures.

2.1 Unit root tests

As estimation and test procedures depend on the statistical properties of the time series under perspective, firstly the variables are examined for their order of integration with unit root tests. The analysis is done by means of the augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP). In the ADF test, the lag length is fixed so that the error terms of the ADF regression are not autocorrelated. In the PP test, the lag truncation parameter is four in general. However, the power of these tests is rather poor. Normally the variables are integrated of order one. According to the ADF test, the price level is I(2), but according to the PP test it is I(1). The current yield is integrated, the interest rate differential possibly stationary. In the following, the price level is assumed to be I(1).

2.2 Tests for rank of the cointegration matrix

Starting point is a VAR model for the real money stock, real gross domestic product and the respective interest rate. Starting with a low lag order, the lag order is chosen so that the

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21 In some analyses, average weights are calculated for the entire sample (Herrmann, Reimers and Tödter (1994)). This, however, does not allow for structural changes of the components.

22 This approach is employed although the Johansen-procedure implicitly tests for stationarity of the variables.

residuals are white noise. The values of the trace statistic for the three null hypotheses possible are given in table 4.

Table 4: Tests for cointegration (trace statistic)[23]

	M1	M1B	M2	M3	M3EU	M3E
H_0	c, 4, rk	c, 4, rk	c, 4, rl	c, 4, rl	c, 4, rl	c, 4, rl
$r=0$	29.53	57.54**	38.11*	52.56**	58.23**	66.70**
$r\leq 1$	7.51	16.60	13.31	19.91	18.88	21.80*
$r\leq 2$	0.86	2.11	1.11	1.69	1.67	2.33
LM (1)	21.75 (0.01)	27.18 (0.00)	10.85 (0.29)	6.23 (0.72)	5.11 (0.82)	4.87 (0.85)
LM (4)	11.27 (0.26)	13.12 (0.16)	9.12 (0.43)	6.81 (0.66)	11.27 (0.26)	10.13 (0.34)
NV	18.24 (0.01)	8.49 (0.20)	8.34 (0.21)	5.72 (0.45)	2.31 (0.89)	1.14 (0.98)

c represents a constant term that is restricted to the long-run relationship. The short-run dynamics contain the inflation rate and a dummy variable (D90.3), set to unity in the third quarter 1990 and to zero elsewhere. This dummy variable is to cover the 15 % increase in money stock induced by German monetary union. LM(1) and LM(4) are Lagrange multiplier tests on autocorrelation of the first and fourth order (Godfrey (1988)). NV is a test on normal distribution (Shenton and Bowman (1977), Doornik and Hansen (1994)). All these tests refer to the multivariate case. The marginal significance levels are given in parentheses below the test statistics.

For the each of the monetary aggregates under perspective, there is one cointegrating relationship. In some cases the trace statistic indicates the existence of a second cointegration vector on the 10 % significance level. For M1, however, the assumptions of the linear model do not hold.

2.3 Analysis of exogeneity

As for each aggregate one long-run relationship can be found in the VAR models, these relationships have to be tested on whether they can be interpreted in terms of a money

[23] For the critical values in the trace statistic cf. Hansen und Juselius (1995), p. 80, Tab. B.2. ** and * denote significance levels of 1% and 5%.

demand relationship. Hence we will test whether the transaction variable and the opportunity cost variable can be assumed to be weakly exogenous for the cointegration vector. If this assumption holds, it is sufficient for inference purposes to estimate a conditional model for the real money stock. In this case, no equations must be specified and considered concerning the exogenous variables. The test is conducted via zero restrictions on the loading matrix. If α_2 denotes the loading coefficient of the cointegration vector in the equation for Δyr and α_3 denotes the loading coefficient in the equation for Δrl, then yr and rl are weakly exogenous, if the null hypothesis

$$H_0: \alpha_2 = \alpha_3 = 0$$

cannot be rejected. The results are given in table 5.

Table 5: Results of the exogeneity analysis (Johansen)

	M1	M1B	M2	M3	M3EU	M3E
$\alpha_2 = \alpha_3 = 0$	11.23	3.83	9.20	1.35	1.48	3.19
	(0.00)	(0.15)	(0.01)	(0.51)	(0.48)	(0.20)
$\hat{\alpha}_1$	-0.08	-0.07	-0.23	-0.09	-0.08	-0.11
	(3.04)	(6.02)	(3.45)	(5.72)	(6.54)	(7.09)

The test statistic is distributed as χ^2 with two degrees of freedom. The parentheses below the test statistics show the marginal significance levels. It turns out that the interest rate and the transaction variable are weakly exogenous. The hypothesis that for both variables the cointegration vector is insignificant, cannot be rejected, except for M1 and M2. The loading coefficients $(\hat{\alpha}_1)$ of monetary disequilibria in the $\Delta(m-p)$ equations are about -0.10 and significantly different from zero, if the critical values by MacKinnon (1991) are applied (t-values in parentheses). This indicates that the adjustment to disequilibria takes places via a changing demand for money. The loading coefficient for M2, however, is very high.

2.4 Estimation of long-run relationships

The long-run money demand function parameters are estimated separately by means of the Engle-Granger procedure as well as taking into account the short-run dynamics by means of the Stock and Johansen methods. If a cointegration vector exists, the coefficients estimated can be interpreted as elasticities or semi-elasticities of the demand for money.[24] In the SEECM equation the t-values of the long-run coefficients are calculated by the estimation of the respective Bewley-transformed equations. The Johansen procedure includes the estimation of a partial model as well, i.e. the number of cointegration vectors is restricted to unity (number of significant eigenvalues) and weak exogeneity of gross domestic product and interest rates is assumed. For the FMOLS estimations the quadratic spectral window is applied, the bandwith is set automatically using the procedure proposed by Andrews. The results for the particular aggregates are as follows.

Table 6: Survey of estimation results for the long-run parameters

	M1		M1B		M2	
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_1$	$\hat{\beta}_2$
Engle/Granger	1.61	-1.44	1.24	-1.88	1.77	0.02
Stock	1.14	-4.92	1.13	-4.37	1.30	-9.58
	(6.01)	(0.74)	(77.55)	(4.76)	(4.04)	(0.63)
Johansen	1.77	-6.11	1.30	-9.04	1.79	0.24
FMOLS	1.63	-1.42	1.27	-1.95	1.81	0.23
	(33.55)	(4.18)	(27.33)	(6.00)	(46.87)	(0.45)

	M3		M3EU		M3E	
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_1$	$\hat{\beta}_2$
Engle/Granger	1.40	-1.71	1.64	-1.93	1.62	-1.46
Stock	1.18	-3.43	1.28	-6.22	1.25	-4.15
	(69.40)	(2.97)	(22.21)	(1.99)	(25.67)	(1.46)
Johansen	1.32	-4.16	1.62	-4.80	1.60	-2.52
FMOLS	1.42	-1.74	1.67	-1.99	1.64	-1.57
	(30.41)	(2.86)	(33.10)	(3.01)	(28.60)	(2.07)

The differences of the results concerning income elasticities ($\hat{\beta}_1$) do not exhibit great divergences. The estimated long-run income elasticities are between 1.1 and 1.8 (declining trend in the velocity of circulation). With the exception of M2, the interest elasticity is significantly negative for all aggregates, with - in absolute terms - rather high elasticities in the estimations according to Stock and Johansen. M1B shows the strongest reactions on interest rate variations. The share of time deposits in M2 and M3 has increased during the

[24] If two stationary long-run relations concerning the variables are given, then the structural coefficients cannot be identified. Any linear combination of these two cointegration relations is stationary.

seventies and eighties. Hence the impact of the positive interest elasticity of time deposits on the interest elasticity of M2 increased. When the interest rate differential is used, the semi-elasticity is higher than in case of the long-term rate only, as the spread is a better representation of the opportunity costs of holding money.

The results indicate the significance of the inflation variable in the short-run relationship. Hence in the short-run, price homogeneity is not given. The Stock approach yields a significant error correction term for the various aggregates. This confirms the results of the Johansen approach, so that the existence of a long-run relationship can be assumed.[25]

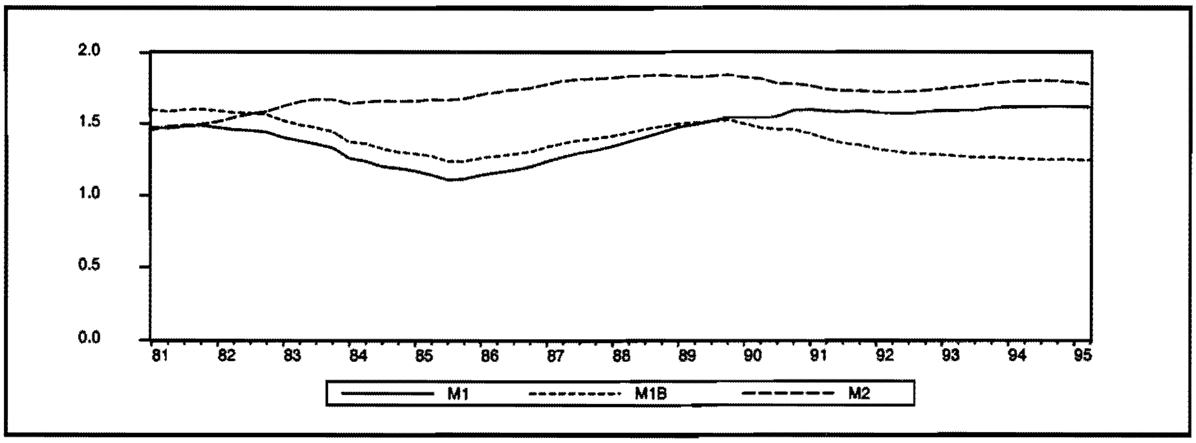
2.5 Analysis of stability

Concerning stability, particularly the stability of the long-run equilibrium relationship parameters is of interest.

2.5.1 Stability of the long-run relationship

A first visual impression of the stability can be gained by recursive estimation of the long-run parameters according to the Engle-Granger procedure. At first the long-run relationships are estimated with relatively few observations. Then the sample is gradually extended for one period each, followed by a new estimation. No or only marginal changes of the long-run parameters due to the inclusion of additional observations give a first indication for a stable relationship between the variables.

Figure 8a: Recursive estimates of long-run income elasticities (Engle-Granger)



[25] The test for cointegration is carried out by means of the t-value of the error-correction-term in the short-run dynamics. This method is superior to the DF- and ADF-test for stationarity of the residuals, as no common factor restriction is assumed (Kremers, Ericsson and Dolado (1992)).

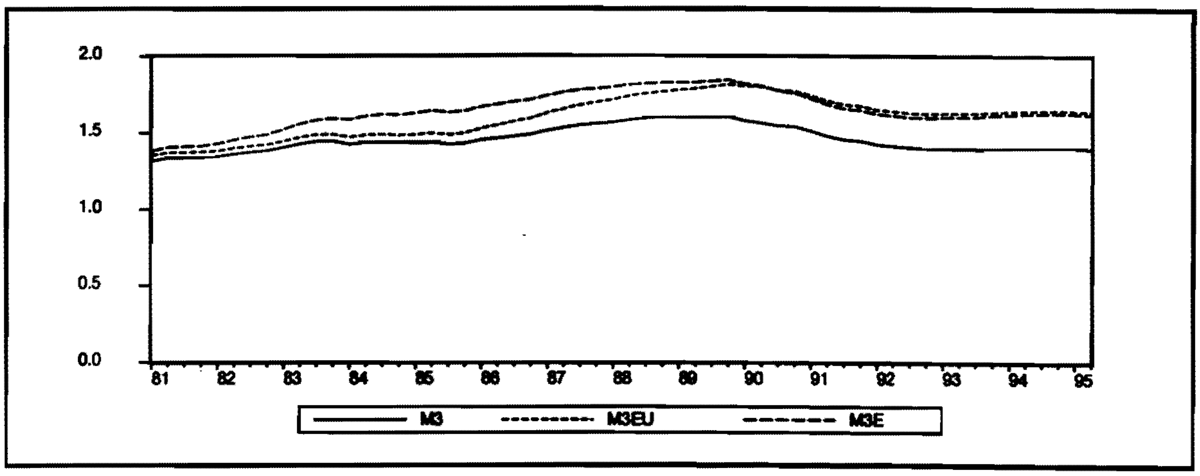
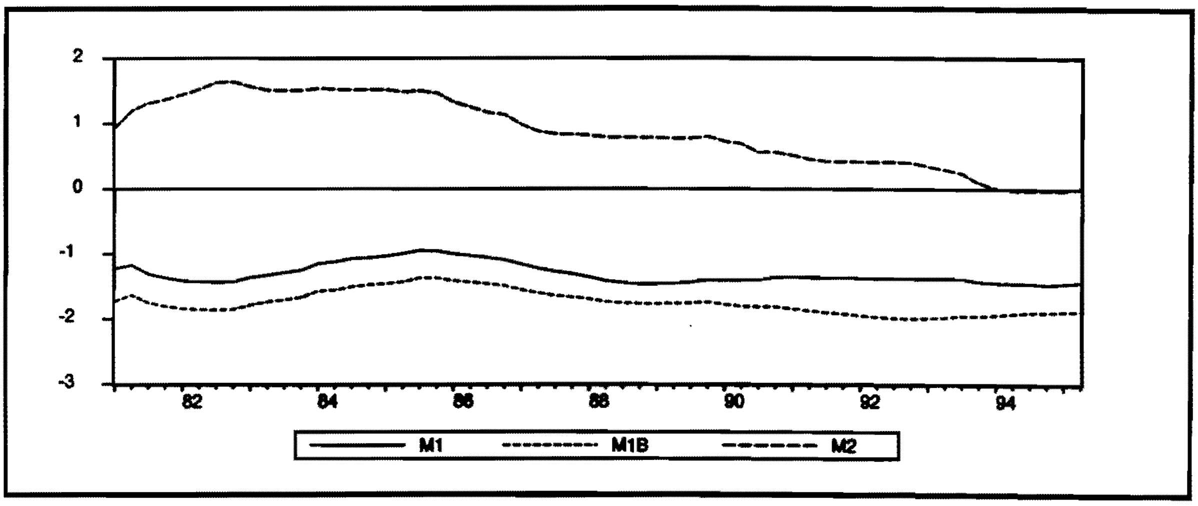
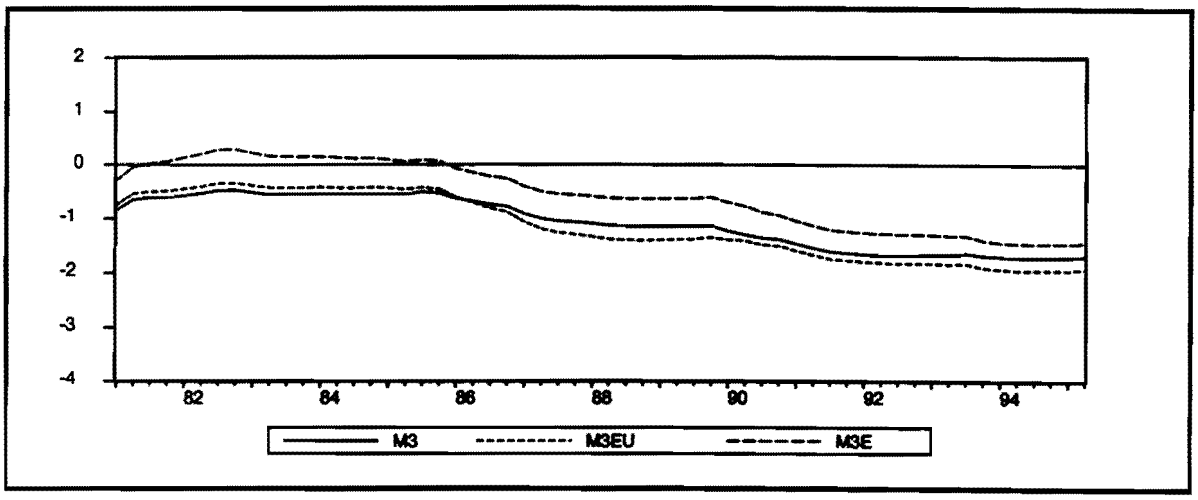


Figure 8b: **Recursive estimates of long-run interest rate (semi-)elasticities (Engle-Granger)**





Income elasticities show only marginal variation over time. In case of M2 and M3E, however, the interest elasticities change signs over time. Based on these estimates, no statements concerning the significance of these changes can be made. Therefore the constancy of the cointegration space is tested for using recursive estimation of partial VEC-models. Figures 9a to 9e show the plots of these tests for the various aggregates. BETA_Z indicates the actual disequilibrium based on the total short-run dynamics, BETA_R is the disequilibrium adjusted for the short-run dynamics.

Figure 9a: Stability test for M1

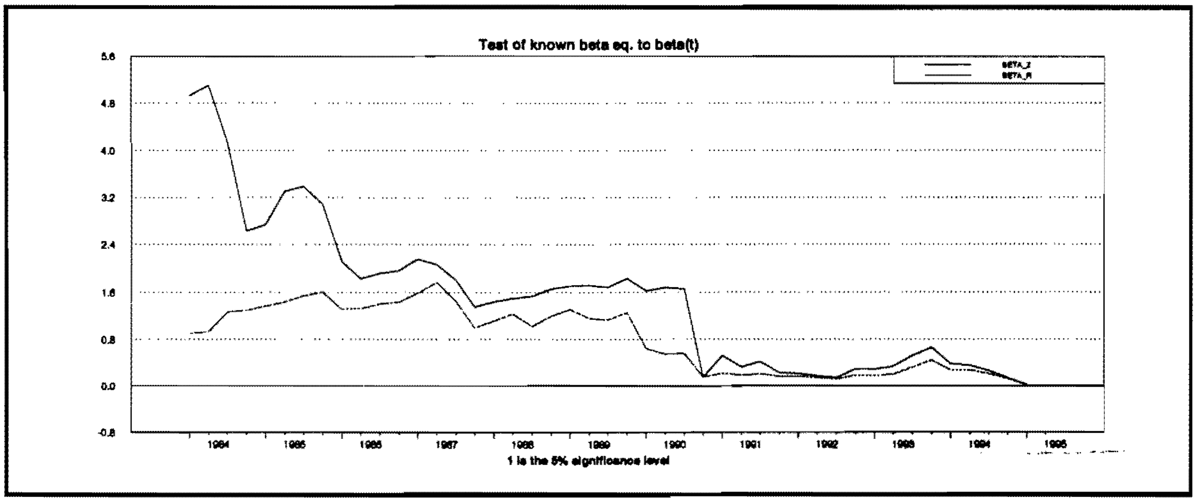


Figure 9b: Stability test for M1B

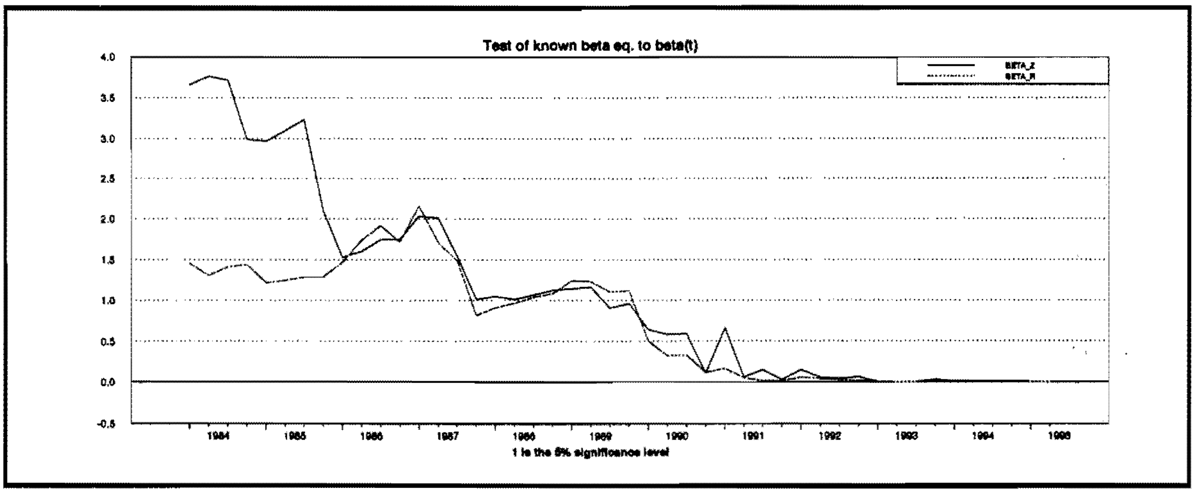


Figure 9c: Stability test for M3

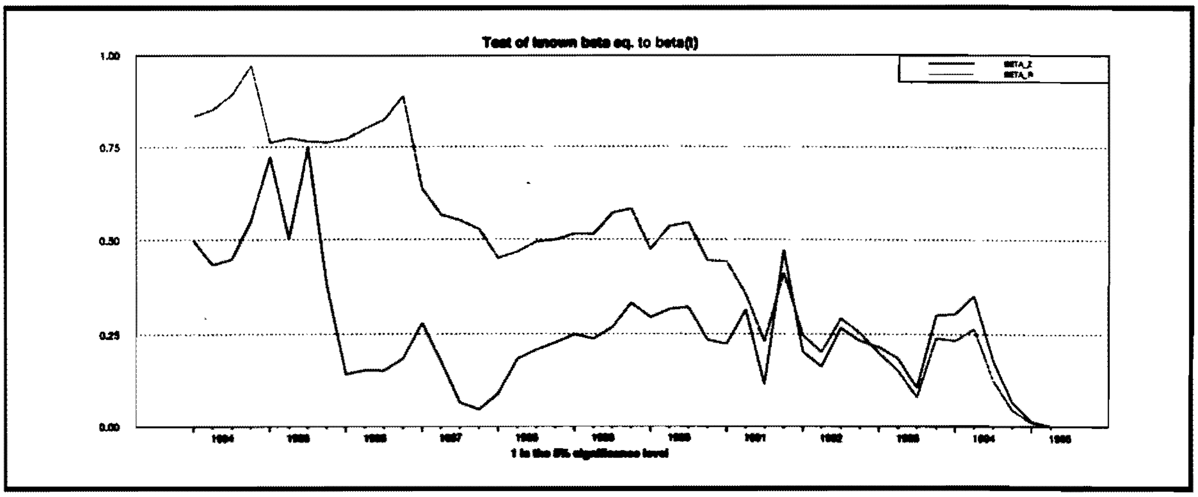


Figure 9d: Stability test for M3EU

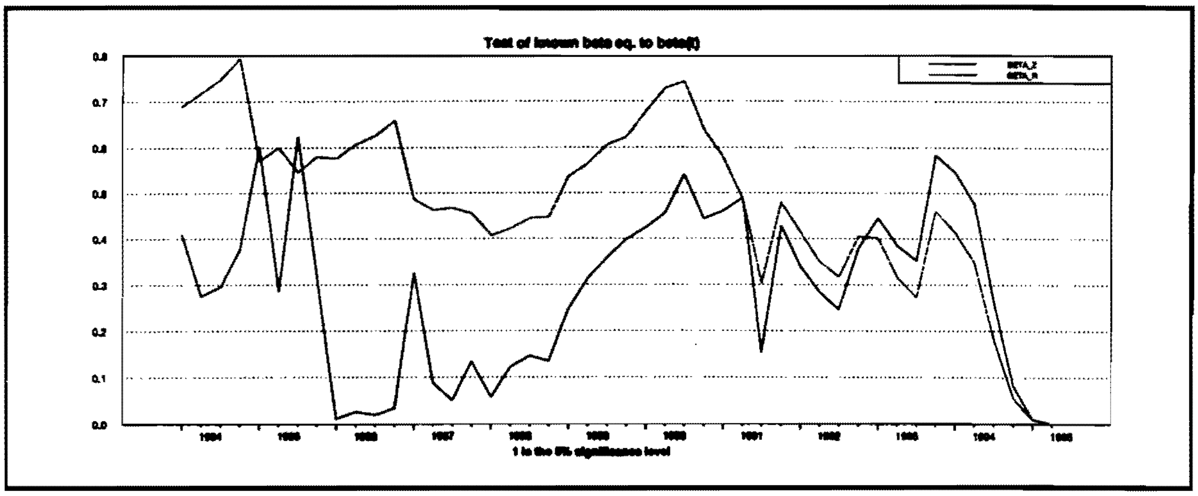
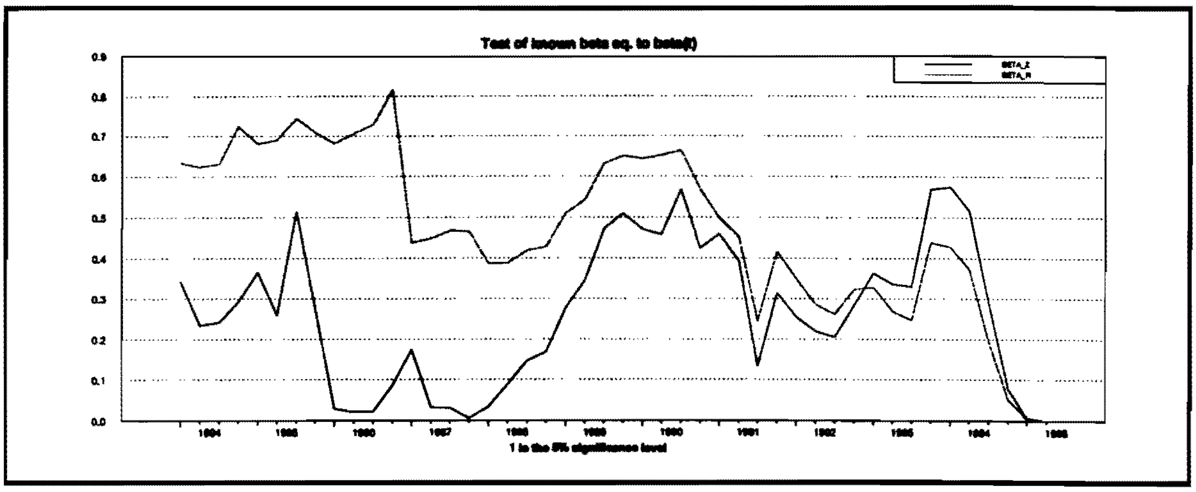


Figure 9e: Stability test for M3E



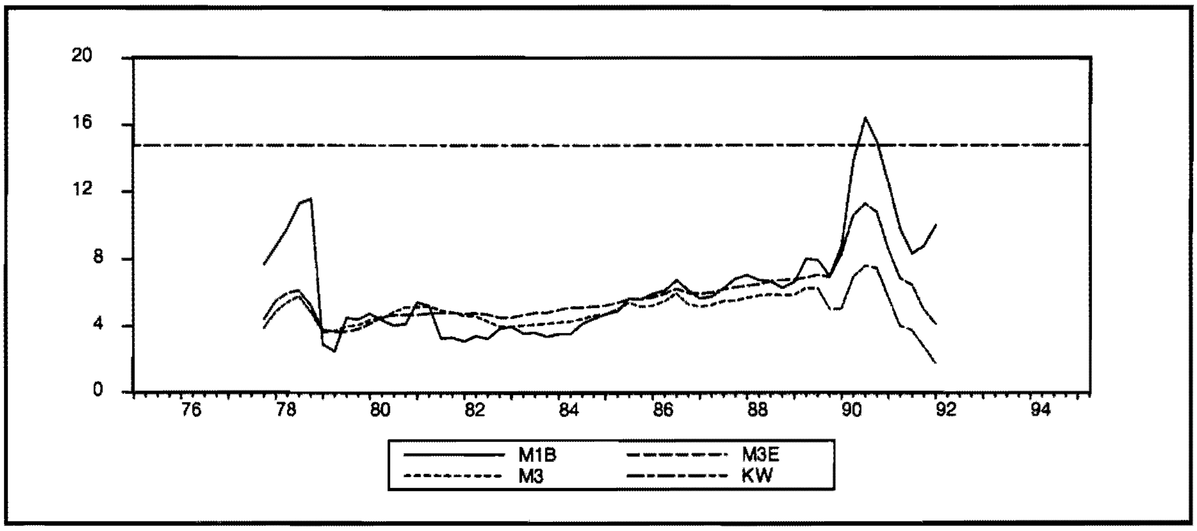
The results give evidence for instabilities concerning M1 and M1B, whereas concerning M3, M3EU and M3E neither based on BETA_Z nor on BETA_R can instabilities be observed. Alternatively stability tests are conducted based on the residuals of the FMOLS estimation.

Table 7: Tests for stability of the long-run regressors based on FMOLS

		Lc	MeanF	SupF
M1	rk	0.77*	5.87	8.45
M1B	rk	0.60	6.43*	16.45*
M3	rl	0.60	4.95	7.61
M3EU	rl	0.68	5.96	10.28
M3E	rl	0.63	5.77	11.28

These tests do confirm the results of the recursive Johansen procedure. For M3, M3EU and M3E the null hypothesis of stable parameters or the existence of cointegration cannot be rejected. In the period after 90.3 the F-statistics show a significant increase. However, for none of these aggregates the critical value of the SupF-test (14.80) is exceeded. In contrast to the Lc-test, the MeanF- and SupF-test do not take the observations of the last two years into account ($\tau_1 = 0.15$, $\tau_2 = 0.85$). Especially these observations, however, might have supported the assumption of unstable monetary relationships.

Figure 10: SupF-test



2.5.2 Stability of the short-run relationship

The results of the Johansen analysis indicate instabilities for the narrow aggregates M1 and M1B (cf. Figures 9a/9b). This does not hold for the broad aggregates (cf. Figures 9c - 9e), but the OLS estimation of the SEECM exhibits problems such as ARCH effects, which indicate that the variance of the error term in the money demand equation for M3 has increased (Table 8).

Table 8: Results of the estimation of SEECM equations

	M1	M1B	M2	M3	M3EU	M3E
	$\Delta(m-p)_t$	$\Delta(m-p)_t$	$\Delta(m-p)_t$	$\Delta(m-p)_t$	$\Delta(m-p)_t$	$\Delta(m-p)_t$
$\Delta(m-p)_{t-4}$	0.17					
Δyr_t	-0.24	-0.22	0.21	0.09	0.11	0.12
Δp_t	-1.23	-0.93	-0.65	-0.82	-0.88	-0.83
Δrk_t	-0.77	-1.10	0.79			
Δrl_t			-0.79	-0.87	-0.97	-0.90
D90.3	0.19	0.21	0.10	0.14	0.13	0.13
D1	-0.18	-0.12	-0.08	-0.07	-0.06	-0.06
D2	-0.06	-0.04	-0.04	-0.04	-0.04	-0.04
D3	-0.10	-0.07	-0.05	-0.05	-0.05	-0.05
$(m-p)_{t-1}$	-0.02	-0.11	-0.01	-0.07	-0.03	-0.03
yr_{t-1}	0.02	0.12	0.02	0.08	0.04	0.04
rk_{t-1}	-0.10	-0.47				
rl_{t-1}			-0.13	-0.24	-0.19	-0.13
NV	8.66**	0.56	1.82	2.79	0.97	0.84
LM(4)	6.67	5.43	4.75	3.52	3.54	3.98
ARCH(4)	1.04	2.53	4.21	9.22*	4.15	4.71
CUSUM	+	+	-	+	+	+
CUSUMSQ	+	+	-	-	+	+

D1, D2, D3 are seasonal dummies, D90.3 is an impulse dummy for the third quarter 1990. LM(4) is the Breusch-Godfrey-test for autocorrelation of fourth order, NV is the Jarque-Bera-test for normal distribution, and ARCH(4) is the test for conditional heteroscedasticity. CUSUM and CUSUMSQ show the results of the respective tests for short-run stability. + stands for stability, - for short-run instability.

3 Links with the ultimate target of monetary policy

An aggregate is an appropriate indicator or intermediate target, if it shows a close and stable link to the ultimate target variable of monetary policy. Usually indicator properties are tested by Granger causality tests. These tests define causality in terms of predictive ability rather than in economic terms. They are, however, subject to some shortcomings.

Accordingly, in this analysis another approach will be applied. For the explanation of the inflation rate, the following equation drawn from the P-star approach will be utilized (cf. Herrmann, Reimers and Tödter (1994)):

$$\Delta_4 p_t = \gamma_1 \Delta_4 p_{t-1} + \gamma_2 \Delta_4 p_{t-4} + \gamma_3 \Delta_4 pim_t + \gamma_4 \Delta_4 p_t^* + \gamma_4 \sum_{i=1}^{4} 0.25 \left(p^* - p\right)_{t-i} \quad (43)$$

where $\left(p^* - p\right)_{t-i}$ represents the price gap in period $t-i$. The specification implies that the long run price trend is determined by the money stock development. In the short run dynamics, the import price trend ($\Delta_4\,pim$) and variations in P-star $\left(\Delta_4\,p^*\right)$ are also taken into account. The price gap coefficient is restricted so that it corresponds with the coefficient of $\Delta_4\,p^*$. Although variations in costs (wages etc.) will explain inflation rates to a high extent, this variable has not been included, as prices and wages are highly interdependent and thus inclusion would have resulted in a simultaneity bias. As the velocity of circulation shows a declining trend, the long-run income elasticity of the demand for money is estimated by OLS for the derivation of p^*. The lag structure in (43) is determined so that the residuals are white noise.

The adjustment of the actual price level to its long run equilibrium occurs relatively slowly. In the case of M3 the adjustment coefficient has the largest value. In all other cases, it is even insignificant, i.e. the price gap calculated does not show explanatory properties in the case of any other aggregate. Only for M3 a stable relationship between money stock and price level can be assumed. An adjustment for structural breaks of time series according to the procedure of Herrmann, Reimers and Tödter yields similar results. With the approach according to Wolters, Teräsvirta and Lütkepohl (1995) for the adjustment of a (possible) break due to German unification applied, the price gap does not show significant explanatory power for any of the aggregates under perspective.

Table 9: Dynamic price equations in fourth differences

	M1	M1B	M2	M3	M3EU	M3E
	$\Delta_4 p_t$	$\Delta_4 p_t$	$\Delta_4 p_t$	$\Delta_4 p_t$	$\Delta_4 p_t$	$\Delta_4 p_t$
$\Delta_4 p_{t-1}$	0.92	0.93	0.93	0.91	0.91	0.93
	(13.69)	(13.99)	(13.33)	(13.56)	(13.57)	(13.71)
$\Delta_4 p_{t-4}$	0.01	-0.001	-0.01	-0.01	-0.001	-0.02
	(0.09)	(0.01)	(0.14)	(0.10)	(0.02)	(0.28)
$\Delta_4 pim_t$	0.04	0.05	0.04	0.05	0.05	0.04
	(3.04)	(3.23)	(2.67)	(3.27)	(3.25)	(2.93)
$\Delta_4 p_t^*$	0.02	0.03	0.02	0.05	0.04	0.04
	(2.47)	(2.72)	(1.50)	(3.04)	(2.77)	(2.42)
$\sum_{i=1}^{4} 0.25 ecm_{t-i}$	0.02	0.03	0.02	0.05	0.04	0.04
	(2.47)	(2.72)	(1.50)	(3.04)	(2.77)	(2.42)
$\overline{R}^2$	0.86	0.86	0.85	0.86	0.86	0.86
LB(4)	6.47	5.73	6.35	6.29	6.40	6.12
NV	2.28	2.45	1.39	2.13	1.88	1.93
ARCH(4)	4.05	6.79	3.44	6.88	7.13	6.95

4 Controllability

Step-by-step predictions are constructed for various horizonts, using the model desribed in section 1.2.4. Prediction errors are measured by the Root Mean Squared Error (RMSE) and the Mean Absolute Prediction Error (MAPE).

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(x_t - \hat{x}_t)^2} \qquad \text{MAPE} = \frac{1}{T}\sum_{t=1}^{T}|x_t - \hat{x}_t|,$$

where x_t is the actual value in time t and $\hat{x}_t$ is the value predicted for time t .

Figure 11 shows the recursive inflation predictions for a forecast horizont of four quarters. Deviations between prediction and actual outcome are particularly strong for the period after German unification. The high inflation rates after 1990 were primarily caused by the lift of administrative regulations. As a whole, the East German price trend converges with the one in the western states. Developments of that kind cannot be adequately described by equation (43).

Figure 11: Actual (XT) vs. predicted (XF) inflation rates (M3)

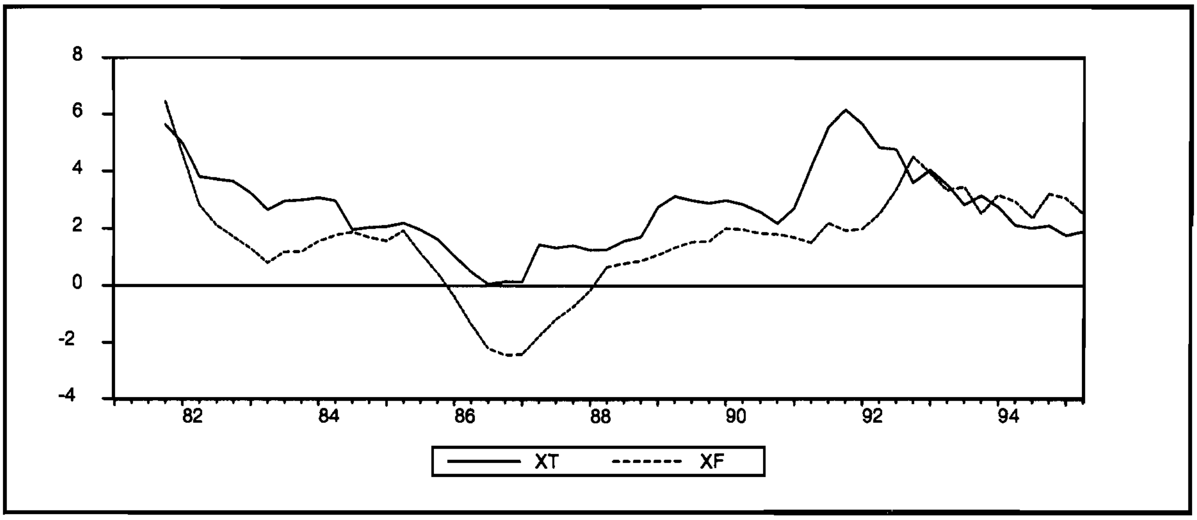


Table 10: Prediction error incl. control error

		M1	M1B	M2	M3	M3EU	M3E
1 quarter	RMSE	0.61	0.62	0.63	0.64	0.66	0.66
	MAPE	0.47	0.46	0.50	0.51	0.54	0.54
4 quarters	RMSE	1.57	1.62	1.83	1.67	1.62	1.77
	MAPE	1.22	1.22	1.50	1.39	1.34	1.49

The future price gap is predicted by means of the actually observed production potential. As it turns out, there is little difference between the prediction errors for the various monetary aggregates.

V. Conclusions

In recent years, a number of financial innovations could be observed on German financial markets. This paper deals with the question as to whether these financial innovations caused instabilities in basic monetary relationships affecting monetary policy.

The paper focuses on simple sum aggregates. In case of broad definitions, these aggregates combine various functions (medium of exchange, store of value), so that a theoretical definition of money proved to be difficult. Had the analysis referred to Divisia aggregates, this approach would have been less problematic. In this case an appropriate monetary aggregate could be defined through the liquidity service function. Applying simple sum aggregates, the focus was on empirical approaches for the definition of money.

First it was analyzed which financial assets meet the conditions for grouping into one aggregate. If weak separability is given for a subset of financial assets, then variations concerning those assets that are not part of the subset will not affect the structure of the subset under perspective. Hence a central bank can concentrate on the analysis of the aggregate's development as a whole, without having to deal with the structure of its components over time.

Stability of the money demand function over time is a crucial precondition for the appropriateness of a monetary aggregate in terms of an anti-inflationary monetary policy. Only then can the effects of monetary policy be predicted and the stock of money be controlled in the desired way. The estimation and testing procedures have to take non-stationarity of the money demand function variables into account. Here the existence of long-run equilibrium relationships, of weak exogeneity of the right hand variables, as well as the stability of the long-run relationships and the short-run dynamics have been examined.

A central bank pursuing the goal of keeping the inflation rate low and stable by means of monetary policy must not only consider the stability of the money demand function, but also the stability of the relationship between intermediate target and ultimate goal. This link has been analyzed with the P-star approach. Here it is a crucial precondition that the price gap derived for a particular aggregate shows significant explanatory power concerning the trend of inflation.

In the analysis of weak separability, it is assumed that financial assets are weakly separable from any other commodities. On this basis it is analysed as to whether weakly separable subset of assets can be identified. It can be concluded that the components of M3 and M3 plus euro deposits are weakly separable subsets. The same holds for the components of M1. It must, however, be considered that the user costs of cash and sight deposits have been fixed identically. For aggregates such as M1B (M1 plus savings deposits), this condition is not met.

In a multi-dimensional system consisting of the real money stock, gross domestic product and (for broad aggregates) the long-term interest rate or (for narrow aggregates) the money market rate the existence of a long-run equilibrium relationship can be proved. Based on the results of tests for exogeneity, this relationship can be interpreted as a money demand function. Stability tests, taking non-stationarity of the variables into account, indicate that the long-run relationships for broad aggregates (M3, M3EU, M3E) remained stable in the period from 1975 through 1995.

A stable link between money stock and prices - modelled with the P-Star approach - can only be proved for M3, even though the adjustment coefficient of the price gap is rather low. In the case of any other monetary aggregate, the adjsutment coefficient is insignificant, i.e. the price gap has no explanatory power for the inflation rate.

In the analysis of controllability, there are hardly any differences between the monetary aggregates. The prediction error is lower for narrow aggregates than for broad ones. But these differences are only marginal.

From the point of view of monetary policy, all of these criteria have to be taken into account. In this case the aggregate M3 still comes off best. If one leaves out of account that the results of the Stock estimation give some indications on instabilities in the short-run dynamics, the analyses of the long-run stability of money demand, of the link between money stock and prices, and of controllability show that for applied monetary policy M3 has the most favourable properties.

As further financial innovations and the expansion of recent new financial assets have to be expected in the future, the suitability of a particular monetary aggregate has to be reviewed time after time. Considerations of this kind have to be made particularly in view of the European Monetary Union, when the control variable is to be chosen in the framework of a strategy for monetary policy. In view of unstable money demand functions in other countries, analyses of this kind should also include Divisia indices.

VI. Bibliography

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