Sectoral Disaggregation of German M3

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The author is a member of the staff of the Bank of England. The paper was written during a six-month visit to the economics department of the Deutsche Bundesbank in Frankfurt am Main.

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Zusammenfassung

Zur sektoralen Disaggregation der Geldmenge M3 in Deutschland

Das Papier teilt die Geldmenge M3 (ohne Bargeld) nach den wichtigsten Haltern (inländische Unternehmen und private Haushalte) auf und untersucht die Bestimmungsgründe dieser Unteraggregate. Eine solche disaggregierte Betrachtung erscheint insbesondere auch für ein besseres Verständnis der gesamten Geldmenge M3 interessant.

Im ersten Teil werden die beiden Größen zunächst beschrieben. Dabei zeigen sich einige bemerkenswerte Unterschiede. Die Zusammensetzung der in M3 erfaßen Geldbestände differiert deutlich zwischen den Sektoren. Auch hat das Gewicht, das die Geldbestände am gesamten Geldvermögen haben, bei den Unternehmen im Untersuchungszeitraum merklich abgenommen, während es bei den privaten Haushalten weitgehend konstant geblieben ist.

Nach einer kurzen theoretischen Darstellung für die Begündung der Geldnachfrage in den beiden Sektoren wird in einem zweiten Teil die Geldnachfragefunktion im Rahmen eines error-correction-Modells untersucht. Dabei werden deutliche Unterschiede sichtbar. Das gilt etwa für die Zinsempfindlichkeit. Die Hypothese der Stabilität in der langen Frist kann für beide Aggregate nicht verworfen werden. Allerdings gibt es, ähnlich wie beim Gesamtaggregat, Hinweise auf kurzfristige Instabilitäten bei der Geldnachfrage der Haushalte nach der deutschen Vereinigung. Die Geldnachfrage der Unternehmen ist zwar insgesamt volatiler, und hinsichtlich der kurzfristigen Dynamik weniger stabil. Aber diese Instabilität hat im Verlauf der 90er Jahre eher abgenommen.

Insgesamt zeigt sich, daß die Entwicklung der Geldmenge M3 vor allem durch die Geldhaltung der privaten Haushalte bestimmt wird. Durch die Aggregation der beiden Komponenten ergeben sich keine eigenen Instabilitätsprobleme.

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I. Introduction

Like all economic aggregates, total M3 holdings reflect the actions of behaviourally diverse groups. In particular, households and businesses are likely to require money balances for very different reasons. The purpose of this study is to decompose M3 into personal and corporate sector balances and to examine whether sectoral disaggregation reveals substantial differences in money demand across the sectors. The ultimate aim is to gain a better understanding of aggregate M3.

This study is the first of its kind for Germany. Similar studies have been carried out for the US (e.g. Goldfeld, 1976, Jain and Moon, 1994), the UK (e.g. Fisher and Vega, 1993, Thomas, 1996) and the Netherlands (Fase and Winder, 1990), and all have found considerable divergences in money demand patterns across sectors.

While an aggregate M3 equation assumes a homogeneous set of agents, sectoral disaggregation recognises that the money demand determinants are likely to differ across sectors, as are responses to variations in scale and return variables. In the sense that an aggregate function may combine two distinct sets of demands, economic interpretation will be misleading. In particular, evidence on the stability of aggregate M3 may differ from either sector. Even if sectoral money demand is stable, aggregate elasticities will appear unstable, simply if the shares of M3 held by each sector change over time. Conversely, instabilities in each sector could, in principle, be offset through aggregation. Finally, from a monetary policy perspective, the disaggregated approach may shed further light on the monetary transmission process. A comparison of the responsiveness of each sector to interest rate changes should provide some insight into the effectiveness of monetary policy within the two subgroups. And given M3's central role as both intermediate indicator and target for monetary policy, there is therefore a particular case for studying sectoral differences in Germany.

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Since sectoral analysis is not only interesting for its own sake, but also from the point of view of how divergences feed through to the aggregate, the study not only estimates money demand functions for each sector, but also constructs an aggregate money demand function. We adopt a Bundesbank type approach, based on a single equation model and using similar explanatory variables.[1] The methodology follows along the lines suggested by Johansen (1988, 1991) which involves estimating cointegrating relationships to evaluate long-run equilibrium responses in addition to other short-term dynamic adjustments.

The outline of the paper is as follows. Section II uses simple descriptive statistics to present some important sectoral differences. The theoretical framework is set out in section III, and section IV describes the econometric methodology. Sections V and VI discuss the results of the empirical analysis for the personal and the corporate sector respectively. Section VII compares the findings with those for the aggregate money demand function, and section VIII concludes.

II. Descriptive analysis

We first define the sectors by which M3 is broken down.[2] The ***corporate sector*** (inländische Unternehmen) comprises domestic private and public enterprises, including Deutsche Bahn AG, Deutsche Post AG, Deutsche Telekom AG and the successor organisations of the Treuhand Agency[3], publicly owned and operated enterprises (legally dependent central, regional and local authority establishments), private and public insurance and investment companies (including pension funds), building associations and housing companies (other than those with savings facilities), and the investment funds of investment companies. Also included are domestic branches of foreign firms and representative offices of foreign credit institutions. The ***personal sector*** is made up of self-employed persons, employees, the unemployed, housewives, children, students and pensioners. Non-commercial organisations, e.g. charitable institutions are also included. ***Public authorities*** (and social security funds) are not included in either sector, and their M3 holdings (approx. 5% of M3) are therefore not discussed.

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1 See e.g. Deutsche Bundesbank, Empirical study of the stability of money demand in Germany, Monthly Report, July 95. Further work currently being undertaken to appear in a forthcoming discussion paper.

2 See also 'Guidelines for credit institutions' reports for the Monthly Balance Sheet Statistics', Deutsche Bundesbank.

3 Except BVS - 'Bundesanstalt für vereinigungsbedingte Sonderaufgaben'.

There is no unique way of defining the sectors. In particular, self-employed persons who currently hold 7% of M3 (excluding cash), could equally well be included in the corporate sector. The argument for counting them towards the personal sector is that their money holding patterns compare reasonably well with those of private individuals, although bank lending to this group is more in line with corporate sector borrowing.[4] A further question arises over whether or not to include insurance companies in the corporate sector, since insurances will hold money for very different reasons to firms. M3 holdings by insurances comprise only 5% of corporate sector M3 (most of their financial assets are in time deposits, bonds and shares not in M3), and their inclusion is unlikely to have a significant influence on the results. Finally, although the total amount of cash in circulation is known, it is not possible to determine the precise proportions held by the personal and the corporate sector or indeed how much is circulating abroad.[5] Therefore, rather than estimate the split, cash which represents 12% of M3 is excluded altogether. Sectoral M3 holdings are defined here as including domestic sight deposits, time deposits with less than 4 years to maturity and savings deposits at 3 months statutory notice.[6]

The remainder of this section discusses a few descriptive statistics and stylised facts, as a means of introducing the reader to behavioural differences across the two sectors.

1. Components of sectoral M3

The largest proportion of M3 is held by the personal sector; approximately 70% of M3 is currently in private sight, time or savings deposits (Q2 1995). This share has slightly increased over the last two decades and compares with 58% in 1974. Corporate sector holdings (excluding cash) comprise 15% of M3 (17% in 1974). Annual growth of personal sector M3 holdings has on average been higher than firms' holdings - between Q1 1974 and Q2 1995, average annual growth of personal sector M3 was 9.5% compared with 8.1% for the corporate sector. However, corporate sector M3 growth was stronger between 1987 and 1991, and following German monetary unification, corporate sector M3 increased by as much as 27%, whereas personal sector M3 in Q3 1990 increased by 15%.

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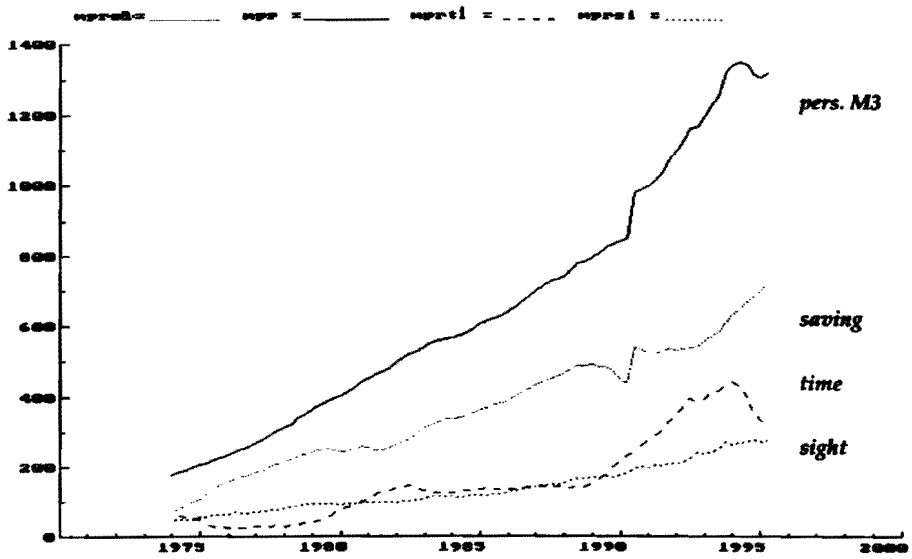
4 The econometric study also considered corporate sector M3 including self-employed persons. The study only refers to the results when they provide interesting additional information. Generally, corporate sector M3 turns out to be considerably less stable in the short term if self-employed persons are excluded from the sector. Since one of the aims of the study is to identify potential sources of instability, this is not an argument for leaving them in. The properties of personal sector M3 are largely unaffected by the inclusion of self-employed persons' balances.

5 For difficulties in identifying the latter, see also Franz Seitz, The circulation of Deutsche Mark abroad, Discussion Paper 1/95, Deutsche Bundesbank.

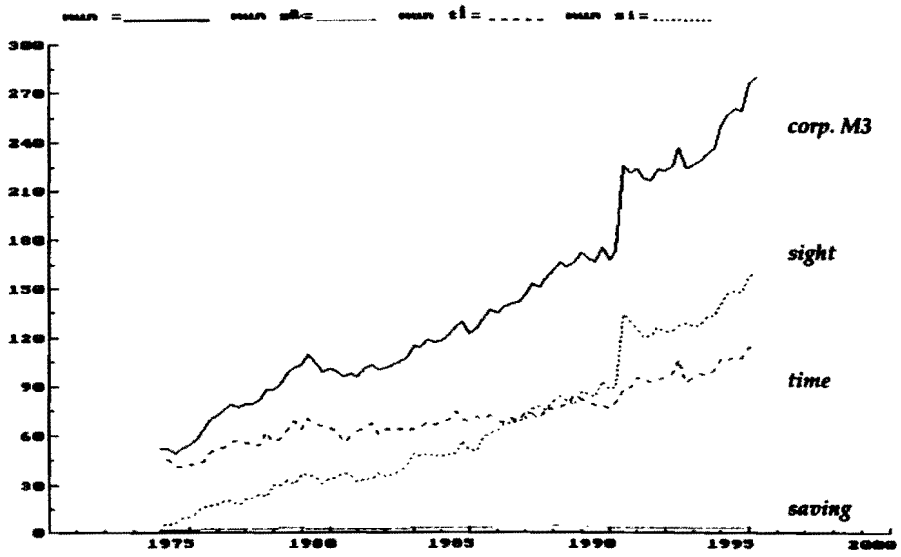
6 See Bundesbank Monthly Reports, Statistical Section IV.II.

Chart 1 Sectoral M3 (DM bn)

Personal sector



Corporate sector



A breakdown of sectoral money demand by different deposit types reveals further divergences between the corporate and the personal sector (Chart 1). The largest proportion of personal sector M3 (55% or DM 678 bn in Q2 1995) is in savings deposits at statutory notice, whereas firms hold only a very small proportion in this form (DM 3.9 bn). One reason is that before the amendment of the Banking Act on 1 July 1993, 'sums intended for use in business operations or payments' were not allowed to be held in savings deposits (KWG §21(2)). Although this rule no longer applies, the proportion of corporate sector M3 held in savings deposits remains insignificant. The personal sector currently holds similar

amounts in time and sight deposits - DM 318 bn and DM 321 bn respectively in Q2 1995. Particularly marked was the large build-up in the private sector of time deposits between 1990 and 1993. This reflected the large liquidity overhang post unification, an inverse yield curve and was possibly also due to large inflows of speculative funds during the EMS currency turmoil in 1992. Firms, on the other hand, have increased their sight deposit holdings much more than time deposits, with a marked jump around unification. The comparative slowdown in growth of time deposits held by firms is associated with a corresponding shift into euro-deposits (not included in M3). More recently, the decline in interest rates and the introduction in January 1993 of a new flat rate tax on interest income has seen a considerable shift out of time deposits in both sectors. Currency holdings as a proportion of total M3 have increased marginally over time (from 10.9% in Jan 1974 to 12.0% in September 1995), but there is no reason why relative holdings in the two sectors should not have remained the same.

Corporate sector holdings of M3 are more volatile than personal sector balances, providing further statistical support for sectoral disaggregation. Interestingly, this difference in volatility was more marked during the 1980s than since German monetary unification. Personal sector M3, and similarly aggregate M3, have been subject to increasing fluctuations during the 1990s, while the volatility of businesses' money holdings has not noticeably changed.[7] The erratic nature of corporate sector M3 is mainly caused by large fluctuations in sight deposits, whereas in the personal sector it is time deposits that are by far the more volatile.

Strong divergences across the two sectors are further confirmed by the relatively low correlation coefficient (0.2) between quarterly growth in personal and corporate sector money balances. Decomposing M3 holdings by asset types shows marginally higher correlation between sight deposits (0.4) but zero correlation between time deposits. This could suggest that the motives for holding very liquid deposits (mainly transactions) are to some extent comparable across sectors, and hence, sight deposits respond similarly to external influences, but that time deposits are held for very different purposes (e.g. precautionary versus portfolio considerations). We return to this in section III.

Finally, correlations between different deposit types within each sector (Table 1) point to sectoral divergences in substitution within M3. While private households tend to substitute between time and savings deposits (-0.58), firms are more likely to switch between time

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[7] Volatility in corporate sector money holdings was highest during the late 70s and early 80s.

deposits, which are remunerated close to market rates, and non-interest-bearing sight deposits (-0.34).

Table 1 Correlation of growth rates of sectoral M3 deposits[8] 1974Q1-1995Q2

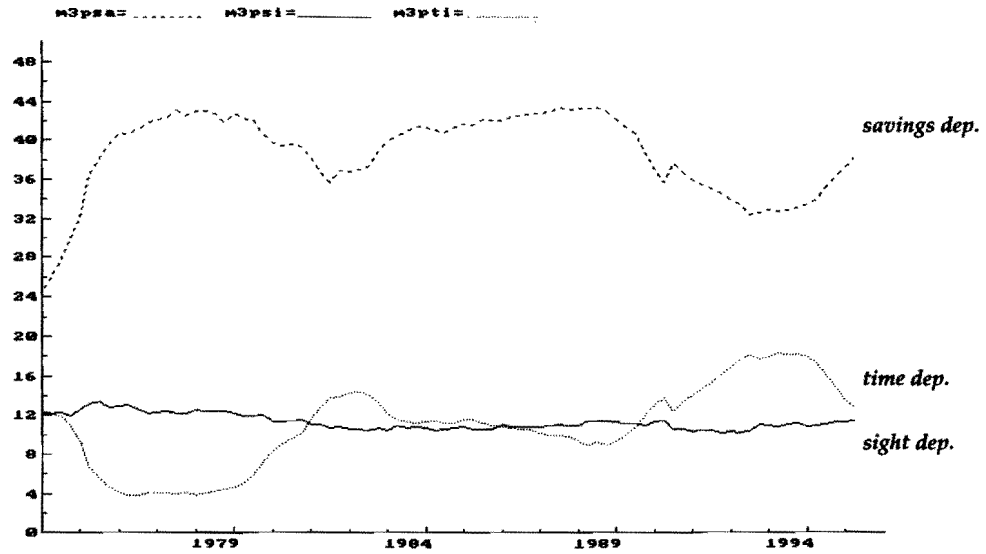
	Personal sector M3			**Corporate sector M3**		
	sight deposit	time deposit	savings deposit	sight deposit	time deposit	savings deposit
sight deposit	1			1		
time deposit	-0.38	1		**-0.34**	1	
savings deposit	0.34	**-0.58**	1	0.32	0.07	1

Chart 2 shows the various subcomponents as a proportion of aggregate M3. The chart is a further illustration of how personal sector savings deposits are associated with relative shifts into time deposits, with the proportion in sight deposits remaining fairly stable, while there is clear evidence in the corporate sector of substitution between time and sight deposits, and savings deposits remain insignificant. The chart also highlights the greater volatility with respect to changes in corporate sector deposit holdings compared with personal sector money balances. Firms act quickly as they switch between deposit holdings, but deposit shifts within personal sector M3 extend over several periods.

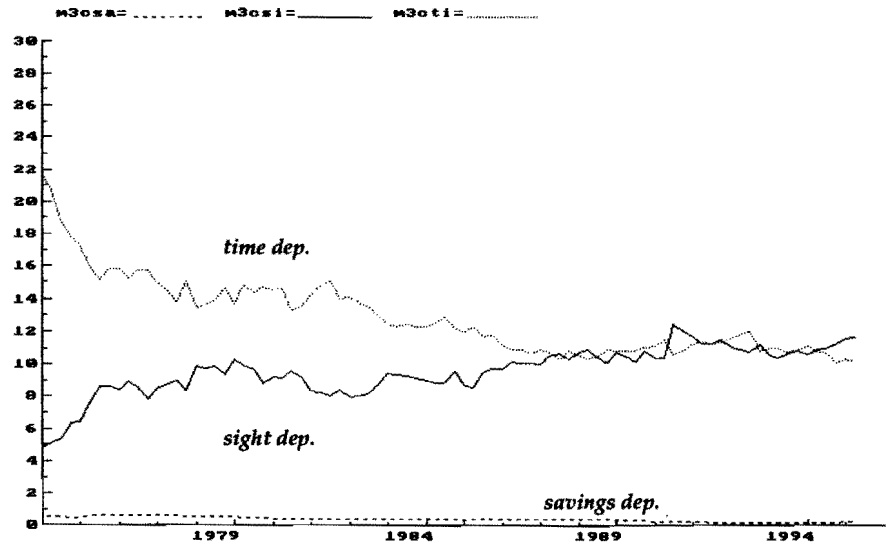
8 Adjusted for the jump due to German monetary unification.

Chart 2 Sectoral deposit holdings as a proportion of M3 (%)

Personal sector



Corporate sector



2. Sectoral M3 as a component of total sector (gross) wealth

Persons and especially firms do not hold their entire wealth in the form of M3 balances. Not only is the extent of substitution within M3 different across sectors, but so also is the nature of substitutes outside M3. Especially with a broad measure like M3, it is important

to consider M3 in this wider context of portfolio allocation. If, for example, the personal and corporate sector's choice of alternative to M3 differs then so also will the interest foregone i.e. the opportunity cost of holding liquid balances. This in turn will affect our choice of suitable alternative rate of return as a proxy for the opportunity cost of holding M3 balances.

The personal sector holds approximately one third and the corporate sector only one sixth of its financial assets in M3 balances. The pie charts show total wealth allocation of the personal and corporate sector at the end of 1994. [9]

Chart 3 Personal sector wealth

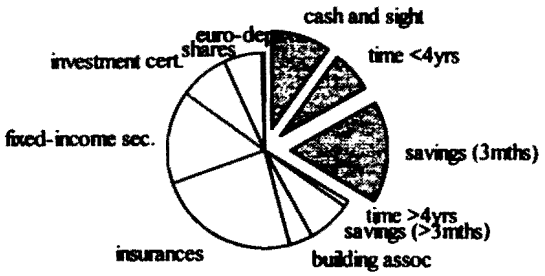
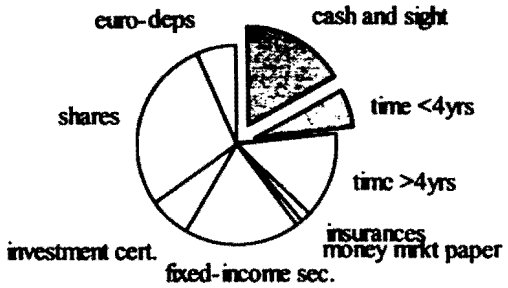


Chart 4 Corporate sector wealth

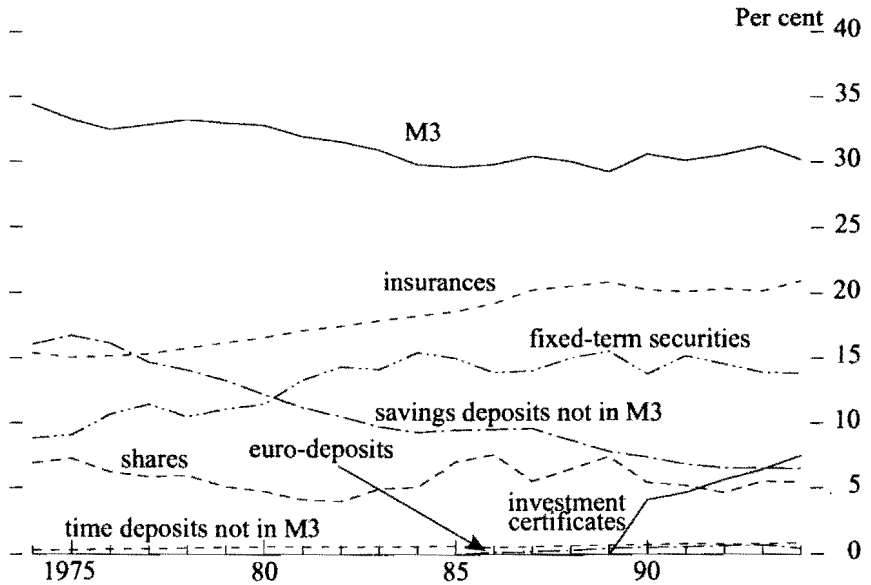


9 For annual data, see, for example, Deutsche Bundesbank, Overall financial flows in Germany in 1994, Monthly Report, May 1995, p.38. The sectoral split of currency in circulation is estimated and therefore not listed separately but included in sight deposits.

Outside M3, private households hold a large proportion of their wealth (23%) with insurance companies (pension, health, life). Another 15% is in fixed-income securities (bonds), over 8% in investment certificates, 7% in savings deposits not included in M3 and 6% in shares. Firms hold 21% of their wealth in shares (of other companies), considerably more than in M3.[10] Large amounts are also held in bonds (13%) and time deposits not included in M3 (10%). However, the latter are predominantly held by insurance companies with relatively small shares in M3 (and are therefore unlikely to form a substitute to M3). A significant proportion of corporate sector wealth is also held in euro-deposits (5%), against only ½% of personal sector wealth.

Chart 5 shows the movements over time in the amount of assets held by the personal sector as a proportion of total personal sector wealth. The M3 to wealth ratio has declined marginally over the last two decades. Savings deposits both in and outside M3 have fallen as a proportion of wealth, while the amount held in insurances and in fixed-income securities has risen steadily. Even more striking is the rapid rise in the proportion of wealth held in new investment certificates during the 90s, and these are likely to continue to offer an attractive alternative to M3. Surprisingly perhaps, the proportion of wealth held in equities has not changed significantly.

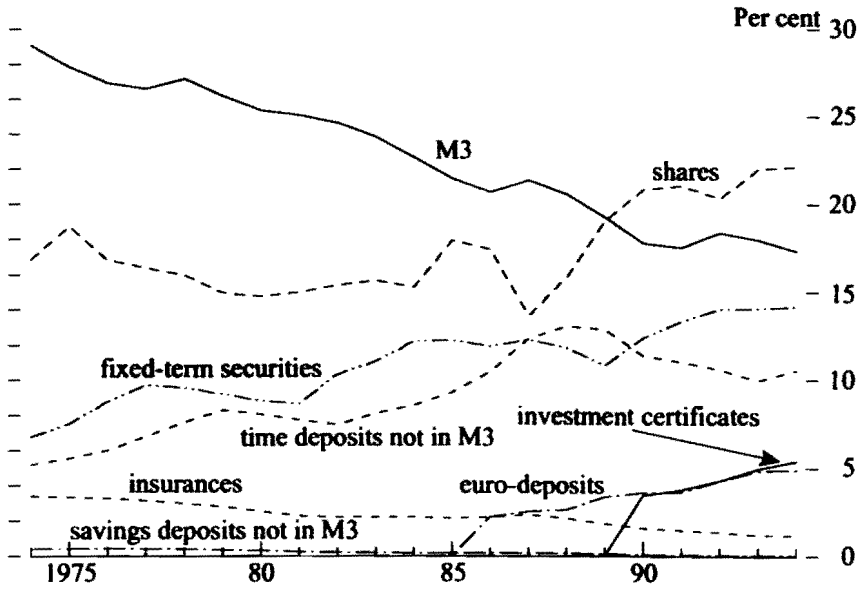
Chart 5 Personal sector assets as a proportion of wealth



[10] Arguably, corporate sector share holdings should not count towards total corporate sector wealth, as they represent a mere transfer of assets between firms.

In contrast to the personal sector, chart 6 shows a steady decline in the proportion of corporate sector wealth held in the form of M3 balances. The total amount in equities has grown rapidly over the last five years and first exceeded M3 holdings in 1990. The proportion held in fixed-income securities has also risen steadily, as have investment certificates and euro-deposits.

Chart 6 Corporate sector assets as a proportion of wealth



There is some evidence in the personal sector of substitution between M3 and other assets, in particular bonds and to a lesser extent shares. Annual changes in M3 (as a proportion of total wealth) are negatively correlated with securities and shares (with a correlation coefficient between 1974 and 1994 of -0.68 and -0.37 respectively, based on annual data).

There is less substitution between M3 and bonds in the corporate sector. Instead, since 1986, there has been a tendency to move out of M3 into euro-deposits (with a corresponding correlation coefficient of -0.1). The facilities offered in the euro-markets are particularly tailored towards large investors, and businesses have invested over ten times as much in the euro-markets as private households. Previous studies[11] have found that the switching out of M3 into euro-deposits was mainly tax-induced. Large portfolio shifts occurred in 1989 with the, albeit temporary, introduction of a withholding tax on domestic interest income and then again in 1992, in anticipation of a flat rate tax on interest income

[11] Deutsche Bundesbank, Recent trends in, and the pattern of, domestic non-banks' Euro-deposits, Monthly Report, May 1995, pp. 59.

from January 1993. However, even the attraction of euro-deposits for the personal sector must not be underestimated. Euro-deposits held by private individuals have expanded more rapidly, albeit from a lower base.[12] But, unlike corporate sector balances, growth in personal sector euro-deposits is not associated with substitution out of M3 but runs complementary with growth in M3 (with a correlation coefficient of +0.28).

The problem remains to quantify these influences. One-off tax incentives rather than interest rate advantages arising from the absence of minimum reserve requirements on euro-deposits - which could be proxied - appear to be the major reason why firms shift out of M3 into euro-deposits. There is no obvious proxy to capture this effect.

3. Sectoral M3 and bank lending

In the previous section we discussed M3 balances in the context of portfolio management. Similarly, we cannot separate the wider concept of asset management from liability management. In other words, it is important to draw on information from both sides of the balance sheet.

Banks play an important role in the German system of finance for investment, and, although firms finance most of their investment through internally generated funds (retained profits - depreciation[13]), bank lending is still the largest external source of investment finance. Small- and medium-sized businesses, especially, rely heavily on bank lending. A particular feature of the German banking system is the close involvement of banks with firms; so-called house banks may have representatives on the supervisory board, personnel in top management positions or equity holdings in the company. As a result, these banks have an informational advantage over other creditors and will therefore be more willing to supply funds. A high proportion of bank finance is long-term.

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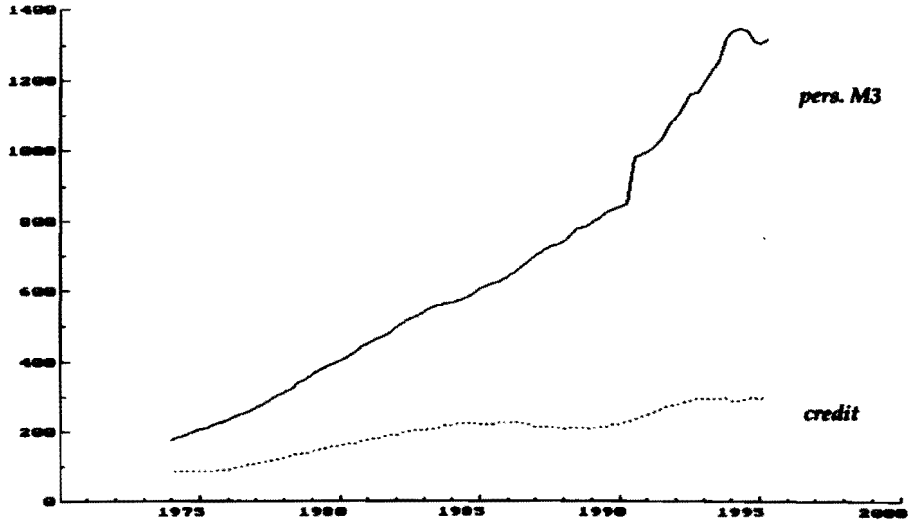
12 Also, the recorded data may understate the amounts held, as only transactions of more than DM ½ million have to be reported, and individuals are more likely to fail to comply with their reporting obligations than enterprises.

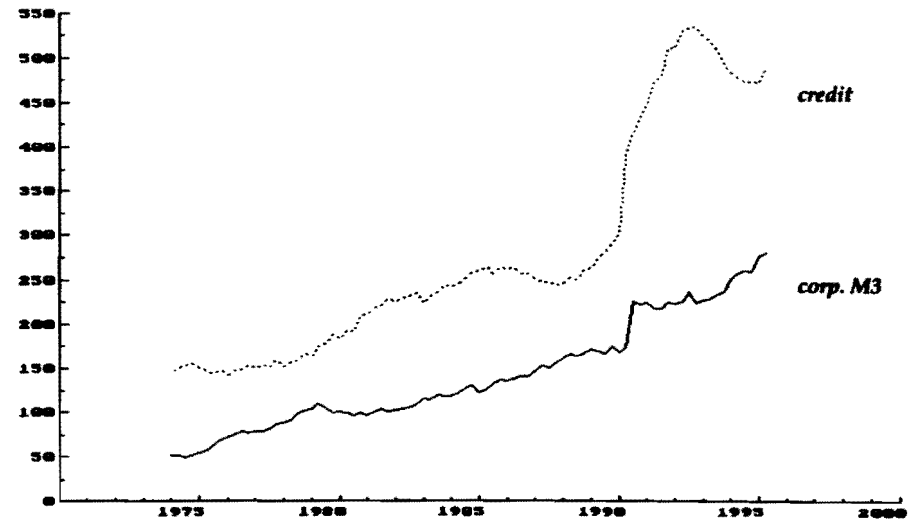
13 Included also are the all-important enterprise pension schemes, financed from the firm's own resources. Although the accounting profits are correspondingly reduced, the funds remain at the enterprise's disposal for the finance of its investments.

Chart 7 Sectoral M3 and short-/medium-term credit (DM bn)

Personal sector



Corporate sector



For the purpose of our study we wish to examine credit in the context of its effects on sectoral holdings of M3. Therefore, we consider only bank loans with a maturity of up to four years.[14] The corporate sector holds a significantly higher proportion of debt relative to

[14] The data refer to the original and not the residual maturity of the loan. Lending to both sectors includes housing loans, and for the corporate sector lending to 'housing enterprises'. However, for the maturities 1-4 yrs, this constitutes only a small proportion of overall lending. Data available from Bundesbank Monthly Reports, Section IV.7.

M3 than the personal sector - see Chart 7.[15] Bank lending to the corporate sector grew sharply in the years following unification,[16] but has since declined. In contrast, growth in bank lending to the personal sector has been consistently below personal sector M3 growth.

Given the importance of credit in the financing decisions of the corporate sector, it is necessary, for a better understanding of M3, to consider the channels through which credit and money are connected. In the standard IS-LM case, there are only two assets, money and bonds. Bank loans are assumed to be perfect substitutes for bonds (as a means of borrowing). Therefore their effect on the economy cannot be separated from the effect of money. Such an analysis is too simplistic as it does not take account of capital market imperfections, nor does it allow for sectoral differences that arise through different relative holdings of credit and bonds. But as always, it is difficult to know how to incorporate such a dependence into a simple model of money demand.

One possibility, given the extent of firms' borrowing, would be to carry out a further study of the credit aggregate. A detailed analysis of sectoral bank lending may provide additional information over aggregate bank lending. Furthermore, if investment spending is considerably limited by borrowing restrictions, then credit effects may provide further insight into the transmission of monetary policy.

The other possibility, and the one that is pursued here, is to capture all-important credit effects via the interest rate term (a credit rate) or the transactions variable in the money demand equation. Both terms are already acknowledged as forming the main determinants of money demand. If credit effects are adequately captured by these terms, then sectoral money demand will also reflect sectoral differences in bank lending. The two channels, interest rates and activity, through which credit and money are connected are discussed in turn.

Money and the credit rate

As a first step, we examine whether the interdependence between credit and money can be captured via the credit rate.

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[15] For consistency with the way in which M3 is broken down, self-employed persons are again counted towards the personal sector, although the extent to which they borrow from banks is more in line with corporate sector behaviour. In the Bundesbank Monthly Reports, credit of the self-employed is included in corporate sector borrowing.

[16] Many loans benefited from interest subsidies.

Again, there are substantial differences across sectors. The corporate sector exhibits a direct relationship between changes in the credit rate and movements in money balances, while such a direct link cannot be identified in the personal sector. In the corporate sector, a rise in the credit rate is associated with a fall in corporate sector M3 relative to output. This may suggest that in the event of a rise in the cost of borrowing, firms use liquid money balances to pay off their loans. However, there is no evidence of a corresponding reduction in outstanding debt; although changes in money balances and the credit rate are negatively correlated, changes in credit and the credit rate are not. A plausible explanation is that at the same time there is more distress borrowing by firms, and that the money balances only go some way towards settling the increased debt service costs and therefore do not lead to a contraction in existing loans. The personal sector, on the other hand, which has less short-term debt is not as responsive to credit rate changes.

Drawing together the results from section II.2 and above, we find that the credit rate certainly has an impact on corporate sector money holdings, but that in the personal sector, wealth considerations are probably more important. While the heavily indebted corporate sector uses cash balances as part of credit management, private households decide how best to invest their surplus funds in or outside M3. Under this scenario, the opportunity cost of holding M3 in the personal sector is the interest foregone on alternative investments (bonds), but for the corporate sector a more appropriate measure would be the cost incurred of not paying the outstanding bank loans, measured in terms of the credit rate. We will see later how these differences bear on the estimated models.

Money, credit and activity

The second approach is to argue that the main link between credit and money is via activity. Constraints on credit availability reduce investment expenditure and ultimately affect total output and money demand. This process does not necessarily rely on a change in interest rates but could also arise through credit rationing. We examine which is more closely related: money and output or credit and output. Benjamin Friedman (1983), for example, advocated the use of credit as an intermediate policy target for the US, on the grounds that the net credit aggregate exhibited a closer relationship to nominal income than broad measures of the money stock. In this context, we consider both short-, medium- and long-term bank borrowing of both sectors. Simple correlations show that in the personal sector, money and activity/consumption are undoubtedly more (positively) correlated than credit and activity. But for the corporate sector, the result is not as clear-cut. After unification, for example, a prolonged rise in economic activity was consistent with a

marked increase in corporate sector debt, yet during this period, corporate sector money balances remained fairly flat. Nevertheless, this correlation between corporate sector credit and activity means that the credit effect is to some extent captured in the corporate sector money demand equation via the transactions variable.

III. Theoretical framework

Broadly speaking, there are three conceptually distinct justifications for holding money: transactions demand with money as a medium of exchange, precautionary demand with money as a liquid reserve and, for a broad measure like M3, asset demand where money serves as a store of value. Even if the two sectors show divergent money demand behaviour, the underlying theoretical foundation is considered to be similar. Baumol's inventory model of cash management (1952) serves as the point of departure for analysing the transactions demand by both sectors. Here, the demand for real money balances is determined by real income and the opportunity cost of obtaining cash, either by borrowing it (loan rate) or withdrawing it from an investment (return on alternative investments). In addition, both agents will also treat money as a financial asset, albeit to a different degree, and substitute between assets of relatively similar liquidity and return characteristics. But even assuming a similar framework, theory also allows for sectoral divergences.

As Miller and Orr (1966) point out, Baumol's model applies reasonably well to much of the household sector, particularly to salary-earning households, but is much less satisfactory when applied to firms. The model assumes periodic receipts of income and a steady flow of expenditures, and therefore, the optimal operating cash balance has a 'saw-tooth' form. But for many firms and even households, the typical pattern of cash management is a much more complex one, as both receipts and expenditures fluctuate irregularly over time. Apart from the standard operating cash flows from income and expenditure on goods and services, cash flows also arise as a result of agents' funding activities (e.g. receipt and payment of loans), investment expenditure (physical or financial), taxation or dividend distribution, each of which is associated with a particular aspect of organised economic activity. The Miller and Orr model allows for this stochastic nature of cash flows, and the result is that money demand depends not on the level but on the variance of income (as well as the opportunity cost). Empirically, level of sales and variability are closely related and therefore hard to distinguish.[17] But at least the model allows for a greater possible

[17] We did try entering a variance term in our model for firms, but to no avail.

range of income elasticities compared with earlier models, depending on the extent to which increases in income bring about a change in the frequency of transactions, and thus may help to explain sectoral differences in elasticities with respect to scale variables.

A broad aggregate like M3 is also held as a (partly interest-bearing) component of wealth, and models of money therefore include terms such as permanent income, wealth and relative rates of return. Money is viewed as one of many forms of assets, and therefore, the returns of alternative assets will form an integral part of individuals' portfolio management considerations (Tobin). In the case of the firm, the cost of capital (relative to the internal rate of return on capital) is the ultimate determinant of investment. However, since firms arguably have more ready access to near-money assets, it is hard to see any direct relevance for the concept of wealth in the decision process at the level of the firm. But this does not rule out the possibility that aggregate wealth might nevertheless be an effective proxy for the level of transactions in macro-models of the demand for money.

While private individuals consider M3 as a long-term financial asset, firms are more likely to temporarily hold larger money balances relative to their expenditures as they search for new investment opportunities. Simple transactions models assume that portfolio transfers take place instantaneously, but in reality, there is always a time-lag. Money is therefore kept aside to reduce the costs of adjustment of the loan portfolio and minimise the delay, in other words, as a precautionary 'buffer stock'. Many firms will also hold liquid reserves in case the opportunity should arise of a future acquisition or take-over (so-called 'Kriegskassen') which would require them to have the necessary means to act quickly.[18]

IV. Econometric methodology

The study uses standard cointegration techniques to separate out the long-run money demand relationship from the short-run dynamics. In terms of the inventory theory of the demand for money, the cointegration model is an econometric representation of an equilibrium-correction mechanism, with the upper and lower bands determined by the

[18] For the US, both C Sprenkle (1969) and Goldfeld (1976) argue that business money is held also as 'compensating balances' against loans and other lines of credit. Firms pay for bank services by leaving deposits rather than paying fees. But empirically, Goldfeld is unable to identify a separate effect for commercial loans. Given the nature of the German banking system and from speaking to a number of investment institutions, this does not appear to be an important factor in Germany.

long-run relationship and the short-run movements showing how agents move into and out of money according to short-run changes in the regressors.

The methodology follows the approach by Hendry and Mizon (1993) to modelling non-stationary time-series with cointegrating relationships. This involves reducing a general unrestricted vector autoregression (a closed VAR) in I(1) space to an open structural representation and then mapping it from I(1) to I(0) space.[19]

The closed (unrestricted) VAR can be represented by

$$A(L)\, x_t = K\, q_t + \varepsilon_t \qquad (1)$$

where $\varepsilon_t \sim N(0,\Omega)$
$A(L) = I+A_1L+A_2L^2+...+A_pL^p$ is a matrix polynomial of order p in the lag operator
x_t is the vector of dependent and independent variables, in our case, $x_t=(m_t, y_t, w_t, rs_t)$,
q_t contains intercept and dummies.

If $x_t \sim I(1)$ we need to transform the VAR into I(0) space. We can rewrite (1) in vector error-correction form (VECM):

$$\Delta x_t = \Pi\, x_{t-1} - \sum_{i=1}^{p-1} \Gamma_i\, \Delta x_{t-i} + K\, q_t + \varepsilon_t \qquad (2)$$

where
$\Pi = -A(1)$

$$\Gamma_i = \sum_{j=i+1}^{p} A_j$$

The rank $r>0$ of Π gives the number of cointegrating vectors. If the variables are integrated of order 1 but not cointegrated then $\Pi=0$ ($r=0$) and we obtain a model in differences.

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[19] The econometric package used was PCFIML, developed by A. Doornik and D. Hendry (1994).

The approach follows 7 main steps:

1. Test x_t for order of integration

Carry out unit root tests on individual elements of x_t. (Annex 1)

2. System formulation

Specify the unrestricted VAR (equation 1): choose variables x_t and determine maximum number of lags (p). Choices are made according to finding the most congruent system, tested for parameter constancy and vector residual autocorrelation, normality and homoscedasticity.[20]

3. Determine number of cointegrating vectors

Use trace and maximum eigenvalue tests to estimate the rank r of Π (Johansen 1988).

4. Identify the cointegrating vectors.

The cointegrating relationships derived from the Johansen approach are any linear combination representative of the cointegration space and are unlikely to coincide with the structural relations. To uniquely identify the cointegration vectors requires testing for identifying restrictions. Further tests for overidentifying restrictions (based on theoretical priors) use the switching algorithm of Johansen and Juselius (1992).

5. Test for stability of long-run relationships

By examining whether the eigenvalues from a recursive estimation are reasonably constant over time.

[20] The ordering for testing hypotheses is not clear. To be meaningful, cointegration requires the constancy of the long-run parameters, but the tests on the initial system will not be in I(0) space. We adopt the strategy of first ensuring system congruency and analysing constancy and then investigating cointegration. However, since the variables are non-stationary, the constancy statistics are rather more descriptive than inferential.

6. Test for weak exogeneity

Ultimately, we wish to partition x_t into (u_t, z_t) where u_t is the set of endogenous (modelled) variables conditioned on the (weakly) exogenous (non-modelled) set z_t. Following Urbain (1991), a variable is weakly exogenous (i) in the long-run parameters if the cointegrating vectors are not present in the marginal system z_t, and (ii) in the short-run parameters if the residuals of the marginal system z_t are not significant in the conditional system u_t.[21]

7. Map the I(1) system into I(0) space.

Once the long-run relations are established, the analysis can proceed as a reduction of the system to a parsimonious econometric model in I(0) space (equation 2). Evaluate the system by testing for vector residual autocorrelation, normality and homoskedasticity. Delete insignificant regressors using the F-test and the Schwarz and Hannan-Quinn information criteria.

The above approach is applied separately to each sector. An alternative would be to estimate personal and corporate sector M3 as a system to capture the joint correlation. As noted in section 2.1, correlation is a low 0.2. Furthermore, it turns out that the correlation between the residuals of the short-run equations for the personal sector ε_{pt} and the corporate sector ε_{ct} (in equation 2) is as low as 0.09. Therefore, little is gained by adopting a systems approach.[22] We proceed with separate estimation of each sector's money demand.

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21 Ideally, 4 and 6 should be carried out simultaneously. The cointegrating vectors are best identified after partitioning the set into exogenous and endogenous variables, but dividing exogenous and endogenous variables, requires correct identification of cointegrating vectors. 4 is therefore repeated with the resulting open VAR, and outcomes compared.

22 The estimates, though not efficient, are still consistent.

V. Personal sector M3

1. Data

A sectoral breakdown of M3 is available from 1976, but the data between 1976 and 1980 are partly estimated.[23] The data are useful for determining the long-run equilibrium, but analysis of the short-run dynamics focuses on the period after 1980. Real consumption expenditure is chosen as transactions variable y_t.[24] The implicit deflator of consumption expenditure is used to deflate all nominal variables and in the definition of the inflation rate. Personal sector wealth w_t is equivalent to personal sector holdings of gross financial assets (including shares, investment certificates, fixed-income securities, bank deposits, and insurance holdings, data as in section II.2). The opportunity cost rs_t of holding M3 is measured as the spread between the yield on public bonds[25] and an own rate of return, where the latter is calculated as an average of the returns on M3 deposits, weighted by the shares of the various deposits in personal sector M3. The weights are time-varying to capture the relative shifts within M3, as depicted for example in Chart 2.

The data are quarterly, seasonally adjusted values over the sample period 1976 Q1 - 1995 Q2. All variables, except the interest rate spread, are in logarithms. M3 data, scale variables and the deflator are based on west German figures until 1990 Q2 and all German figures thereafter, so there are large unification 'jumps' in 1990 Q3. Wealth is only available annually, and quarterly figures are obtained through (log-)linear interpolation. The series are seasonally adjusted through the widely-used method X-11.

2. Unit root tests

On the basis of unit root tests (Annex 1), all variables are treated as integrated of order 1 over the sample period. An ambiguity arises over the interest rate spread and over the deflator (p) of consumption expenditure which is used to deflate all nominal variables, including money. The interest rate spread is treated as I(1) over the sample, although theoretically it should be I(0), and the deflator is arguably I(2). However, real money is unambiguously I(1).

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[23] More specifically, banks' shares of M3 holdings by sectors are estimated, but on a very disaggregated level, assuming constant shares as of 1981.

[24] The choice is between real consumption expenditure and real disposable income. We chose the former on the basis that changes in M3 are more correlated with changes in consumption expenditure than with changes in disposable income. The theoretical argument is that consumption is a better proxy for permanent income.

[25] From the previous section we saw that private households tend to consider fixed-income securities as the most suitable alternative to M3 balances.

3. System formulation

We model a four-dimensional closed VAR with $x_t=(m_t, y_t, w_t, rs_t)$. Four lags (p=4) of each variable are included to control for residual autocorrelation. The constant is entered unrestrictedly i.e. is not restricted to lie in the cointegrating space. Additionally, three impulse dummy variables are added for Q3 1990, Q4 1993 and Q4 1994.[26] The dummies are deemed necessary for system congruency and obtaining a meaningful cointegrating relationship. Interestingly, they all relate to the period after unification, since when the short-run stability of M3 has come under increasing scrutiny. Like the intercept, the dummy variables are entered unrestrictedly, and hence captured as part of the short-run dynamics. The model satisfies the condition of no residual autocorrelation and normality (only slight evidence of non-normality in the spread residuals), and of parameter constancy, and the system appears to be reasonably well-specified.

4. Long-run relationship

The number of cointegrating vectors is estimated following the maximum likelihood method proposed by Johansen (1988) which looks at 'trace statistics' and the 'maximum eigenvalue statistic', critical values for which have been tabulated by inter alia Osterwald-Lenum (1992). The outcome supports the hypothesis that there is only one cointegrating vector (Annex 2).

The resulting cointegrating vector is recognisably a money demand relation, with positive effects from consumption and wealth and a negative effect from the interest rate spread. Finally, we test for long-run homogeneity in consumption expenditure and in wealth, i.e. whether the coefficients on expenditure and wealth sum to unity. The hypothesis is not rejected.[27] The large coefficient on the wealth term (relative to the consumption

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[26] D90q3 is zero except for unity in Q3 1990, similarly for the other two dummies. These impulses adjust for the largest residuals and are justified as follows: D90q3 is attributed to the distortion caused by unification. In particular, monetary unification formally occurred on 1 July 1990, but seasonally adjusted M3 shows a break in June (and hence Q2) 1990, which is shifted to Q3 to correspond with the quarter from which all-German consumption figures are available. D93q4 captures 'special factors', in particular tax changes causing a shift back into M3 from abroad, and d94q4 controls for a considerable slowdown in growth in December, in part caused by heavy purchase of money market funds.

[27] If $m=\alpha y + \beta w + \gamma rs$, and $\alpha+\beta=1$, then $m=\alpha y + (1-\alpha)w + \gamma rs$, whence $m-w = \alpha(y-w) + \gamma rs$, explicitly setting money demand in a portfolio allocation framework. Equally, we can write $m=y + (1-\alpha)(w-y) + \gamma rs$, and this allows us to reparameterise velocity in terms of the wealth to income ratio. Thus for the above, we could write $m-w = 0.28(y-w) - 0.09$ rs, or $m=y + 0.72(w-y) - 0.09rs$. The statistics given are distributed χ^2, with the degree of freedom given by the number of over-identifying restrictions (Johansen and Juselius, 1992). Here, $\chi^2= 1.36$, and we cannot reject the null of homogeneity and rank=1.

expenditure coefficient) underlines the fact that private households hold money not only for transactions purposes but also as one of many alternative forms of wealth.[28]

The resulting long-run money demand relation is

m = 0.28 y + 0.72 w - 0.09 rs

Chart 8 Estimated long-run relationship

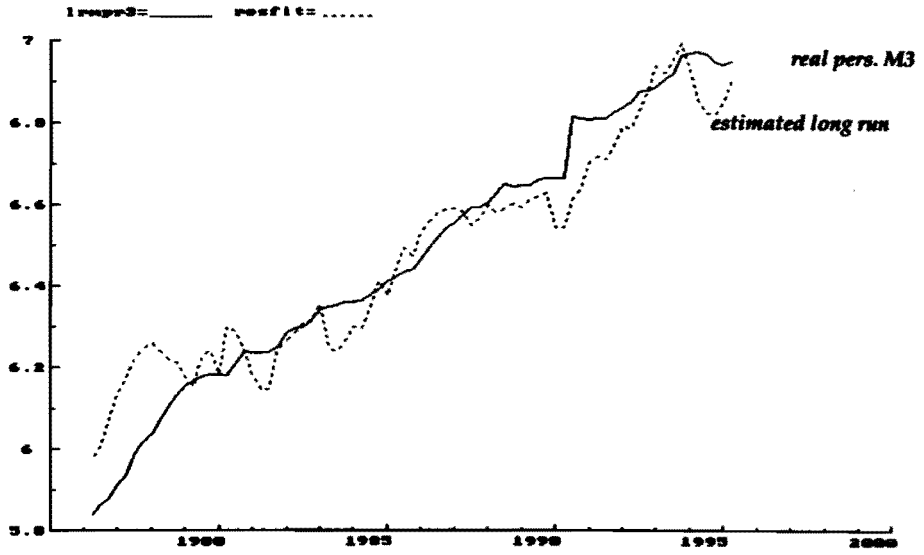


Chart 8 plots the estimated long-run money demand relation (0.28 y + 0.72 w - 0.09 rs) against the log of real personal sector M3. The estimated disequilibria in money demand are large, consistent with small benefits of adjusting. The recent decline in M3 growth would appear to represent convergence towards the steady state path.

The recursive parameter estimates in the long-run model are reasonably constant. On this basis we cannot reject the hypothesis that personal sector money demand is stable in the long run. We return to the question of stability in section VI.

5. Testing Exogeneity

Weak exogeneity is an essential concept required for efficient inference on the conditional model u_t (= m_t). The variables of the marginal model z_t (= (y_t, w_t, rs_t)) are weakly

---

[28] The coefficient is even larger if self-employed persons' M3 holdings are excluded.

exogenous if they can be taken as given without losing information when modelling the conditional model. Otherwise we need to analyse the full system. If, in addition, u_t does not Granger cause z_t then z_t is *strongly exogenous* in the conditional model. This is an important condition for predictive accuracy, but is unnecessary for efficient model estimation. We therefore focus on tests of weak exogeneity.

Tests of long-run weak exogeneity involve assessing whether or not the cointegrating vector is cross-linked between equations. If the error correction term does not enter the marginal model z_t then z_t can be treated as given in the estimation of the long-run money demand relationship; in other words, the coefficients on the error-correction term ('loadings') corresponding to the equations for private consumption, wealth and the interest rate spread equal zero. The results show a fairly large loading of the ECM in the interest rate equation. The implication is that the interest rate spread should be explicitly modelled, maybe in terms of a policy reaction function: if the policymaker reacts to the same cointegrating vector as appears in the economic agent's conditional model (in the case of Germany by changing interest rates), then weak exogeneity for that cointegrating vector is lost.

However, weak exogeneity of the marginal model z_t is not rejected (Annex 2). OLS estimation of the four equation system in VECM form (2) reveals that the ECM only has a significant t-ratio in the money demand equation.

VECM equation	**T-ratio of ECM**
Δ m	-6.2 **
Δ w	0.7
Δ y	0.3
Δ rs	-1.2

Finally, recursive parameter estimates of the long-run relationship and the recursive eigenvalues are reasonably constant, suggesting no evidence of instability in long-run money demand of the personal sector. We proceed with a single-equation money demand model.

6. Dynamic equation

The next stage is to reduce the conditional money demand equation to I(0) and to simplify the model by excluding any variables that are insignificant (F-test, Schwarz and Hannan-

Quinn information criteria). In addition, inflation is entered as a significant determinant.[29] The reduction yields (standard errors in brackets):

$$\Delta m = \underset{(0.0015)}{-0.004\,\Delta p} - \underset{(0.0019)}{0.003\,\Delta rs_{-2}} - \underset{(0.0080)}{0.08\,ECM_{-1}} - \underset{(0.0026)}{0.002}$$
$$+ \underset{(0.008)}{0.14\,d90q3} + \underset{(0.0076)}{0.03\,d93q4} - \underset{(0.0079)}{0.02\,d94q4}$$

$R^2 = 0.87$ $\sigma = 0.0075$ DW=1.8
non-normality $\chi^2(2) = 0.08$ (0.96)
heteroscedasticity $F(12,59) = 0.58$ (0.85)
autocorrelation $F(5,67) = 0.58$ (0.72)
Chow test of parameter constancy over 90q4-95q2 $F(19,53) = 1.38$ (0.18)

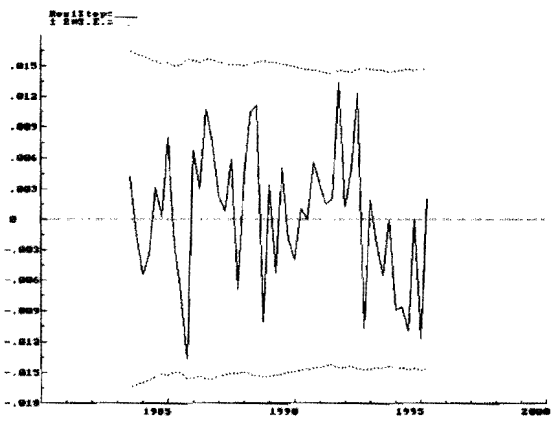
with Δ denoting quarter-on-quarter changes. All parameters have interpretable signs. Inflation causes agents to shift out of real money balances, possibly in favour of other real assets / physical goods. Somewhat surprisingly, the expenditure term does not enter significantly and is presumably captured by the error correction mechanism. The ECM induces 8% adjustment per period. The equation provides a reasonably good fit with a standard error of 0.75% per quarter. There are no signs of residual non-normality, heteroscedasticity or autocorrelation. The equation passes the Chow test for parameter constancy over the post-unification period.

Given the stationary nature of the differenced data, valid inferences can be made with standard one-step, break-point (N↓-step Chow) and forecast (N↑-step Chow) tests (Annex 3). The statistics are scaled by the 5% critical values from the F-distribution, adjusted for changing degrees of freedom, so that the significance values become a straight line. Chart 9 shows scaled residuals and the sequence of Chow tests. It is not possible to reject the hypothesis that the model has acceptably constant parameters. This is not true if the dummies are omitted (see section VII).

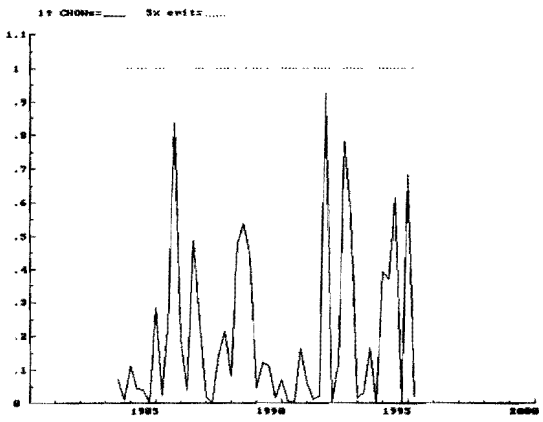
[29] This allows for the fact that price homogeneity need not hold in the short run, although price homogeneity is imposed in the long run. There is a problem with knowing how best to deal with inflation. If inflation is included unrestricted from the outset, we obtain two cointegrating vectors, but it is not clear what additional long-run relationship is being captured, especially if inflation is taken to be I(0). Therefore, inflation is entered at a later stage.

Chart 9 Scaled residuals and Chow tests

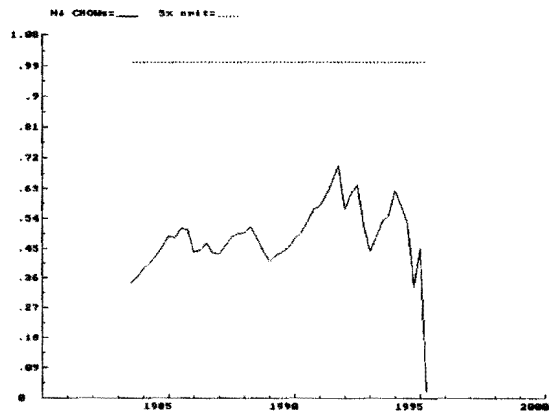
1 step residuals



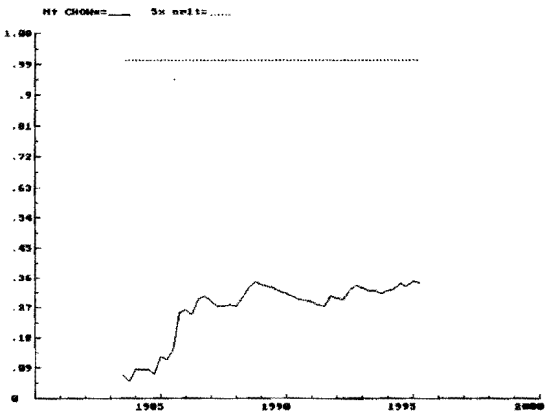
1 ↑ Chow



N ↓Chow



N ↑ Chow



VI. Corporate sector M3

1. Data

Instead of real consumption expenditure, real business GDP (Bruttowertschöpfung) is chosen as transactions variable for the corporate sector. The implicit deflator of business GDP is used to deflate all nominal variables. Corporate sector wealth includes gross financial assets held by the corporate sector (including shares of other companies). Two proxies for the opportunity cost are considered. First, the spread between the public bond yield and an own rate of return, and secondly, the spread between an interest rate on

loans[30] and the own rate of return, where the latter is calculated as an own weighted average interest rate on corporate sector deposits. As with the personal sector, the data are quarterly, seasonally adjusted values, based on west German figures prior to and all German figures after unification (1976 Q1-1995 Q2). Corporate sector wealth is again obtained by interpolating between end-year figures. Unit root tests allow us to treat all variables as integrated of order 1 over the sample period (Annex 1).

2. System formulation

To obtain congruency of the initial closed VAR, four lags of each variable are included and 3 impulse dummies entered unrestrictedly for Q3 1990, Q4 1993 and Q4 1994. There are no benefits of including wealth, either in terms of the stationarity properties of the long-run cointegrating vector, long-run stability properties or goodness of fit in the short-run dynamics. Wealth is therefore excluded altogether, confirming our belief that firms hold M3 less as part of their portfolio and more as a buffer for short-term spending and investment. Despite theoretical priors (section 2.3), the spread measured in terms of the long bond yield and not the credit rate yields a better fit - in the sense that it enters significantly in the short-run dynamics. The high correlation between the credit rate and the own rate (0.7) presumably accounts for the inability to identify (statistically) a separate effect for the credit rate. Another problem is that a wide variety of terms and conditions on loans may affect the costs of bank finance (including quantity constraints) that cannot be measured by a single loan rate. The spread between the bond yield and the own rate arguably captures the credit effect just as well but also any additional portfolio effects. Models that only include the credit rate, the bond yield or the own rate are also less satisfactory. We therefore proceed with the spread as measured by the bond yield, although our interpretation of the results differs to that of the personal sector. On the basis of residual autocorrelation, normality and parameter constancy, the system appears to be reasonably well-specified (slight evidence of residual non-normality in the spread equation).

3. Long-run relationship

Trace and maximum eigenvalue tests suggest there is one and only one cointegrating vector (Annex 2). Long-run income homogeneity is rejected, and the resulting long-run money demand relation is

$$\mathbf{m = 1.18\,y - 0.03\,rs}$$

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[30] 'Kontokorrentzins', average credit rate for bank loans under DM 1 million.

Chart 10 Estimated long-run relationship

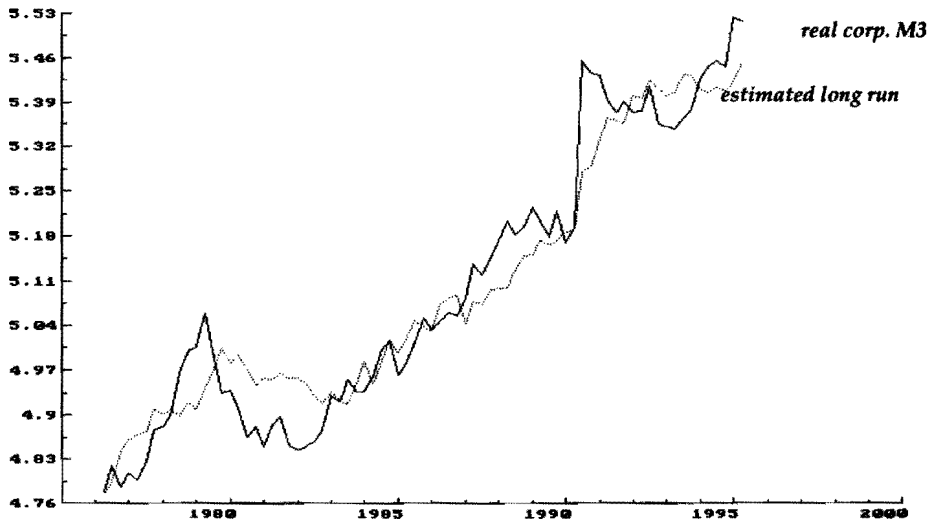

Chart 10 plots the estimated long-run money demand relation. M3 holdings in Q2 1995 seem to have exceeded the steady state.[31] On the basis of parameter constancy, the hypothesis that corporate sector money demand is stable in the long run cannot be rejected.

4. Exogeneity

The hypothesis of exogeneity of the variables in the marginal model is rejected. The loading of the ECM is non-zero for both the output and spread equation.[32] Explicit representation in unrestricted VECM form reveals that the ECM has a significant (positive) t-ratio in the output equation. If money is above equilibrium then investment expenditure and ultimately output increase - strictly speaking, y should be treated as endogenous to the system.[33]

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31 The last two values for 1995 are partly estimated, in the sense that only the raw data, but not seasonally adjusted data were available.

32 $\chi 2$ (1) = 13.02 **, a rejection of the null hypothesis of zero loading of ECM in output equation at 5% CL. $\chi 2$ (1) = 7.26 **, a rejection of the null hypothesis of zero loading of ECM in spread equation at 5% CL.; see also Annex 2.

33 In the UK, attempts are being made to separate out the effects of investment expenditure and income for the corporate sector by setting up a two-equation system in money and investment expenditure, with income treated as exogenous (Thomas, 1996).

VECM equation	T-ratio of ECM
Δ m	-2.3 **
Δ y	3.9 **
Δ rs	-0.4

We nevertheless proceed on the basis that money demand can be captured by a single equation (for one, we only have one long-run relationship). The question the study then addresses is whether distortions emerging from the corporate sector adversely affect the aggregate M3 equation.

5. Dynamic equation

Mapping of the money demand equation to I(0) space and subsequent simplification yields:

$$\Delta m = \underset{(0.233)}{0.66\,\Delta y} + \underset{(0.197)}{0.40\,\Delta y_{-2}} - \underset{(0.0059)}{0.012\,\Delta p} + \underset{(0.0065)}{0.020\,\Delta rs_{-1}} + \underset{(0.0064)}{0.018\,\Delta rs_{-3}} - \underset{(0.060)}{0.24\,ECM_{-1}} - \underset{(0.123)}{0.48} + \underset{(0.035)}{0.18\,d90q3}$$

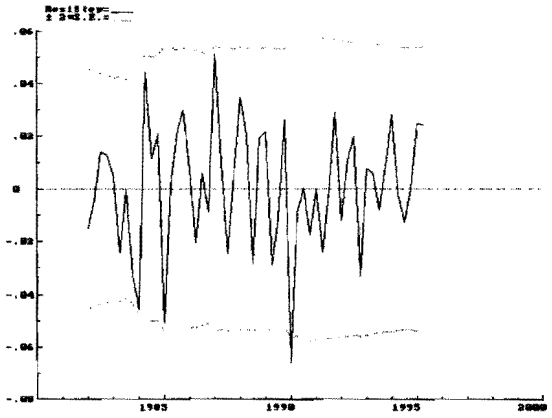
$R^2 = 0.63$ $\sigma = 0.027$ DW=1.81
non-normality $\chi^2(2) = 0.0763$ (0.58)
heteroscedasticity $F(14,55) = 2.33$ (0.013) *
autocorrelation $F(5,45) = 1.37$ (0.25)
Chow test of parameter constancy over 90q4-95q2 $F(19,51) = 0.49$ (0.95)

The ECM induces as much as 24% adjustment per period, with intermediate adjustments captured by the differenced terms, in particular real business GDP and the interest rate spread. No signs of residual non-normality or autocorrelation are detected (slight evidence of heteroscedasticity).

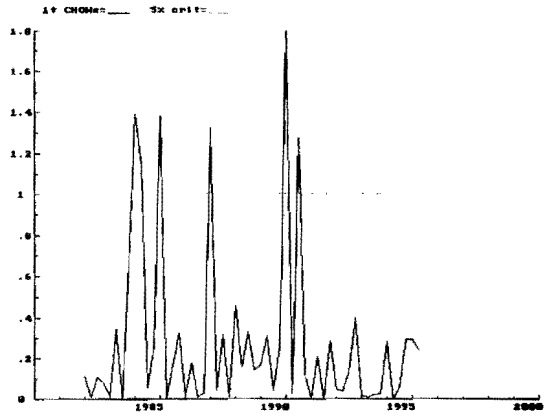
The equation passes the Chow test for parameter constancy over the post-unification period, even without the dummies d93q4 and d94q4 which are statistically insignificant. However, chart 11 shows that the sequence of 1-step Chow tests rejects at several points before unification. All in all, the model does not fully capture firm behaviour, although it has improved during the 1990s.

Chart 11 Scaled residuals and Chow tests

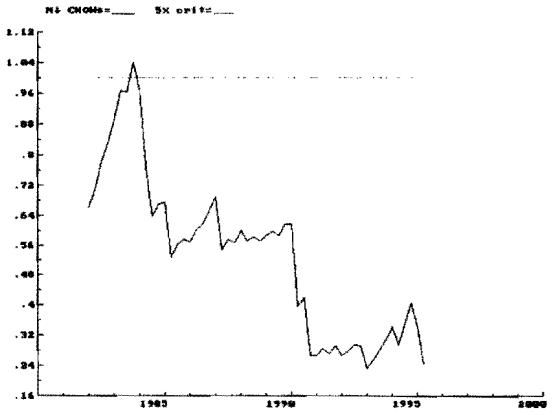
1 step residuals



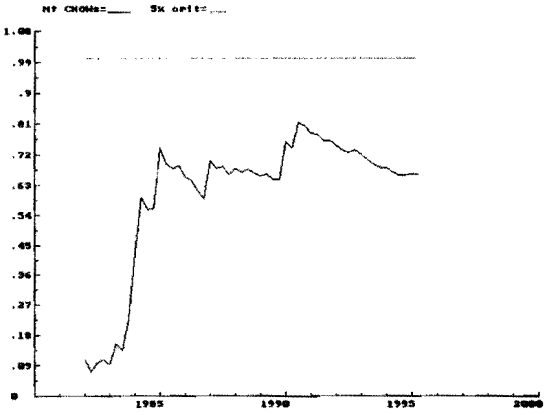
1 ↑ Chow



N ↓Chow



N ↑ Chow



VII. Comparison of sectors

The discussion so far has been on econometric differences in estimated sectoral money demand equations. We encountered particular problems with the weak exogeneity assumption in corporate sector money demand. A single money demand equation does not fully capture the interactions between money and output. The focus of the current section is to discuss *behavioural* differences that emerge from a comparison of the sector-specific models. We also estimate an aggregate M3 equation: the purpose is to assess whether distortions arising from corporate sector behaviour adversely affect aggregate M3.

Real GDP is chosen as the transactions variable for aggregate M3, with the implicit deflator used to deflate all nominal variables. Total wealth is obtained as the sum of personal and corporate sector wealth and the interest rate spread is constructed analogous to the individual sectors. Evidence of a long-run relationship is weak. The cointegrating vector (setting rank = 1) passes the test for weak exogeneity in the conditional money demand equation (Annex 2).

The results are summarised in table 2.

Table 2 Estimated money demand equations

	Aggregate M3		**Personal sector M3**		**Corporate sector M3**	
Long-run money demand						
y	**0.37**		**0.28**		**1.18**	
w	**0.63**		**0.72**			
rs	**-0.04**		**-0.09**		**-0.03**	
Short-run money demand						
		t - ratio		*t - ratio*		*t - ratio*
Δm_{-1}	**0.14**	*2.2*				
Δy					**0.66**	*2.8*
Δy_{-1}	**-0.20**	*-2.4*				
Δy_{-2}					**0.40**	*2.1*
Δp	**-0.007**	*-3.4*	**-0.004**	*-2.8*	**-0.012**	*-2.1*
Δrs_{-1}					**0.020**	*3.1*
Δrs_{-2}			**-0.003**	*-1.4*		
Δrs_{-3}	**0.005**	*2.2*			**0.018**	*2.8*
ECM_{-1}	**-0.13**	*-6.7*	**-0.08**	*-9.5*	**-0.24**	*-4.0*
dum90q3	**0.15**	*17.7*	**0.14**	*18.0*	**0.18**	*5.2*
dum93q4	**0.02**	*2.4*	**0.03**	*4.2*		
dum94q4	**-0.03**	*-3.2*	**-0.02**	*-3.1*		
constant	**-0.04**	*-4.8*	**-0.00**	*-0.8*	**-0.48**	*-3.9*
R^2	0.86		0.87		0.63	
σ residual std	0.0081		0.0075		0.0269	
RSS	0.0043		0.0041		0.0507	
DW	2.2		1.8		1.8	

The table indicates substantial sectoral differences with respect to scale and interest elasticities. This raises the question, to what extent the discrepancy is attributed to different choice of explanatory variable and deflator, and how much of it reflects 'genuine' divergences in money demand behaviour across sectors. For this purpose, a similar estimation for personal sector M3, but using GDP instead of private consumption expenditure as deflator and transactions variable, was also carried out. The main difference compared to the above results was in long-run money demand,[34] and the diagnostics for the initial system (the closed VAR, equation 1) are considerably worse, e.g. evidence of residual non-normality. However, the short-run dynamic equations are qualitatively similar. We conclude therefore that the divergences in the models to a large extent reflect behavioural differences across sectors and not method of estimation. Our final choice of consumption expenditure was made on the basis of a better fit in terms of R^2, a lower standard error and greater stability, but the improvement is small.

1. Goodness of fit

The best fit in terms of highest R^2 and lowest standard error is obtained for personal sector M3, followed closely by aggregate M3. The standard error of quarterly growth is 0.75% for the personal sector and as high as 2.7% for the corporate sector. This would translate into a standard error for aggregate M3 of around 1.1% (assuming constant shares and elasticities), worse than the 0.8% obtained for aggregate M3 without decomposition. In other words, the decomposition has not improved the overall fit of our money demand equation.[35] Chart 12 shows changes in real M3 against the fitted values, with no noticeable deterioration in fit post unification (albeit with the two dummies for Q4 1993 and Q4 1994). Note the obvious similarity between changes in aggregate and personal sector M3.

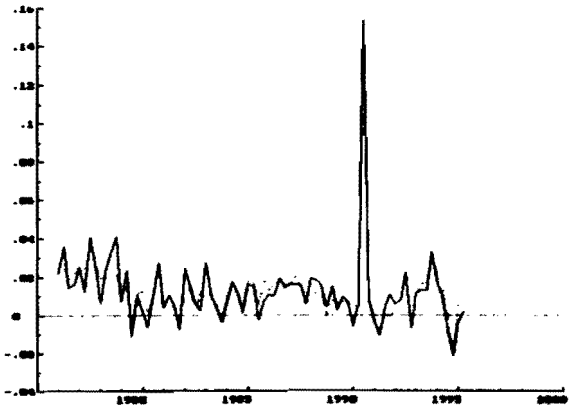
---

[34] $m = 0.14\ y + 0.86\ w - 0.06\ rs$; the coefficient on the interest rate spread is not as high and more easily interpretable. Since the only difference is in the deflator and expenditure term, uncertainty in the long-run coefficients is presumably due to interactions between money and inflation not fully captured by a single equation.

[35] This is not altogether surprising; the aggregate residuals will generally have a variance which is lower than for the individual sectors. This is a statistical phenomenon, known also as statistical averaging. The effect will be even greater if, in addition, the covariances between the sectoral residuals are negative or 'less positive'.

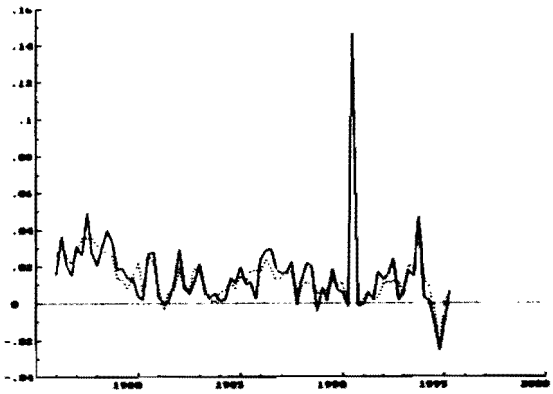
Chart 12 Quarterly changes in real M3, actual and fitted

Aggregate

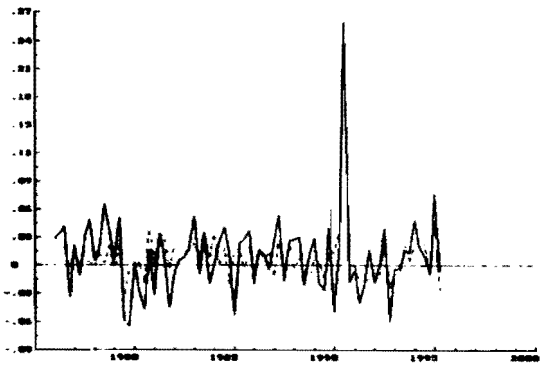


actual (solid line) and fitted (dotted) Δ M3

Personal sector



Corporate sector



2. Elasticities

The coefficient on the wealth term in the long-run aggregate M3 equation is not as large as for personal sector M3 (regardless of choice of deflator). This reflects the fact that private households consider large proportions of their M3 deposits as a long-term investment, while the corporate sector places more weight on money balances for conducting business transactions.

Another important distinction between the two sectors is the number of significant difference terms in the short-run money demand function. ***Corporate sector money demand is determined by a number of short-run adjustment processes, while adjustment in the personal sector is comparatively low.*** Firms respond to changes in output, inflation and interest rates, and personal sector M3 adjusts to inflation alone. This implies that personal sector money demand is governed more by the long term, while businesses have a greater scope for conducting active and systematic cash management, for hoarding and dishoarding in response to current activity and costs.

For the same reason, the speed of adjustment from disequilibrium to the long-term steady state - measured by the coefficient on the ECM in the dynamic equation - is higher in the corporate than in the personal sector. The ECM induces 24% adjustment per period in the corporate sector, compared with 8% in the personal sector. The coefficient on the ECM for aggregate M3 (13%) is approximately the weighted average of the corresponding sectoral parameters, weighted by their respective shares of M3. For the same reason, the disequilibria (measured in terms of the percentage deviation of actual from estimated long-run real M3) are largest in the personal sector (up to 25%), while in the corporate sector they reach a maximum of only 18%.

The sectors respond differently to interest rate movements. As the opportunity cost falls, both private households and firms increase their M3 holdings over the long term. There is also evidence (though statistically insignificant) of this in the short run for the personal sector. In contrast, firms are more inclined, over the short term, to *reduce* their holdings of real money balances on account of a fall in the spread. We offer two possible explanations which are not mutually exclusive. One is consistent with a buffer stock explanation of money demand. If a fall in the spread is associated with a rise at the short end of the yield curve, then this at the same time may signify an increase in the loan rate and the cost of borrowing. Firms will have to meet any cashflow shortfall and higher debt service costs either by taking out further credit or by liquidating their assets (reducing deposits). As a consequence, corporate sector M3 will decline. Alternatively, if a fall in the spread is associated with a fall in bond yields at the long end, firms with large bond holdings may anticipate a further decline in yields, at least over the immediate future. To take advantage of a corresponding rise in bond prices, firms will move their holdings out of M3 into bonds, at least temporarily. The personal sector on the other hand appears immune to such short-term considerations. Both factors would explain why the spread in terms of the bond yield and not the credit rate is a better proxy for the opportunity cost of corporate sector holdings of M3: it captures both the credit effect as well as possible portfolio adjustments.

To the extent that a flattening of the yield curve may signify tighter monetary policy, one might argue that movements in corporate sector M3 show a more timely response to rate changes than personal sector balances. Given the more pronounced contraction in firms' deposits over the short term, corporate sector M3 might therefore be considered a better indicator, at least short-term, of the transmission mechanism.[36]

3. Stability

On the question of stability of money demand it is important to note that the study is concerned with comparing the extent of possible instabilities across sectors and does not provide a definitive answer as to whether or not M3 is stable. In other words, the study discusses *relative* rather than *absolute* stability of money demand across sectors.

The analysis so far has related to models estimated with dummies. The reason was to avoid undue distortion and misinterpretation of the elasticities. In the following discussion (and charts), the dummies (except for unification) are omitted from the estimated dynamic equations, as it is precisely the periods of instability that provide the focus of our comparison. Stability of the money demand functions is compared by examining the following:

a) Constancy of the eigenvalues obtained from recursive OLS estimation of the closed VAR (equation 1), conditional on having partialled out the full-sample dynamics and unrestricted variables. - Chart 13.
b) Stability of the recursive coefficients in the dynamic equations. - Chart 14.
c) Standard deviation of the residuals of the estimated dynamic equations. -Table 3.
d) One-step (1↑-step Chow), break-point (N↓-step Chow) and forecast (N↑-step Chow) tests (without the additional dummies) (Annex 3). - Chart 15.

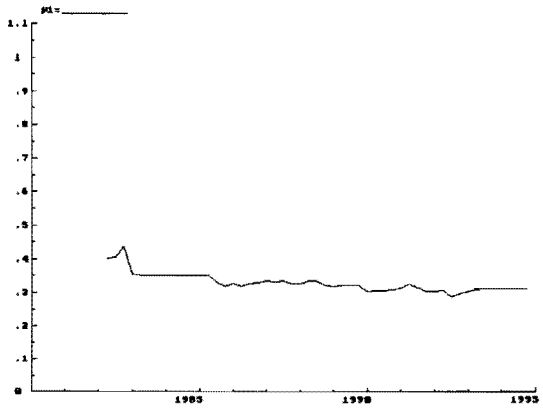
a) provides an assessment of long-run stability,
b) to d) examine the stability and performance of the dynamic equation.

---

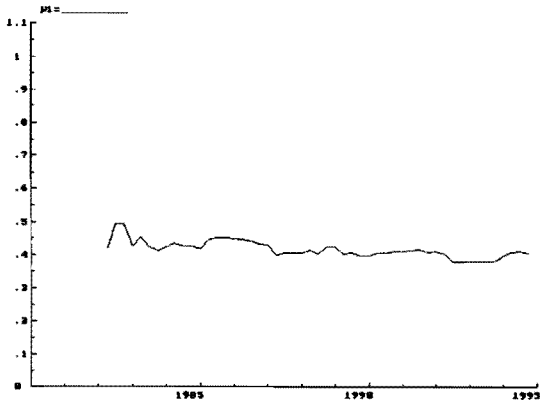
[36] Dale and Haldane (1993) find similar evidence in the UK. They go even further to say that monetary tightening causes loans to initially rise (we do not examine this relation for Germany, although simple correlations - section II.3 - do not find any evidence that this holds) and deposits to fall for companies and vice versa for persons. From this they conclude that credit is superior to money as an indicator of the transmission mechanism for small borrowers (persons) and deposits (money) for large firms.

Chart 13 Recursive eigenvalues

Aggregate



Personal sector



Corporate sector

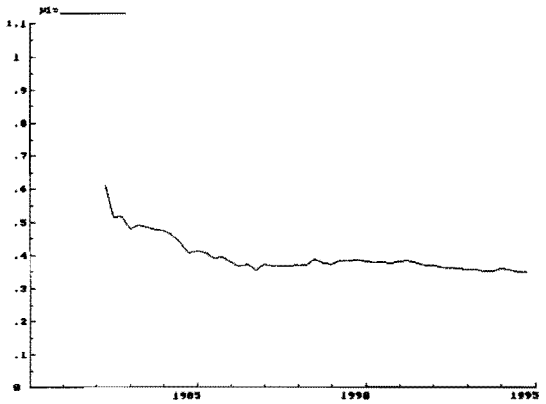
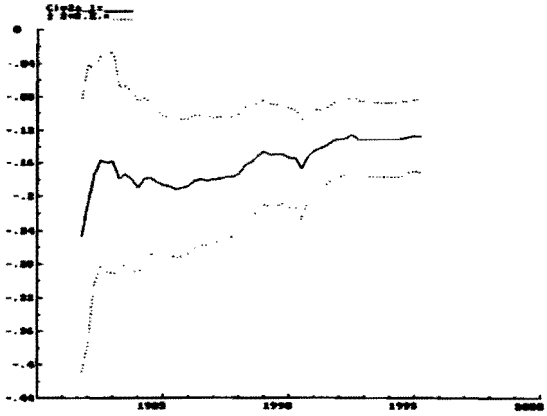
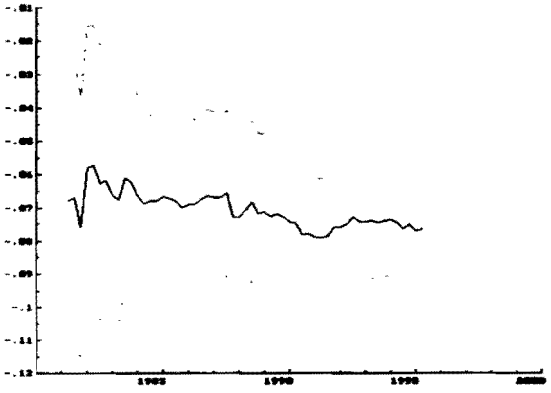


Chart 14 Recursive coefficient on the ECM

Aggregate



Personal sector



Corporate sector

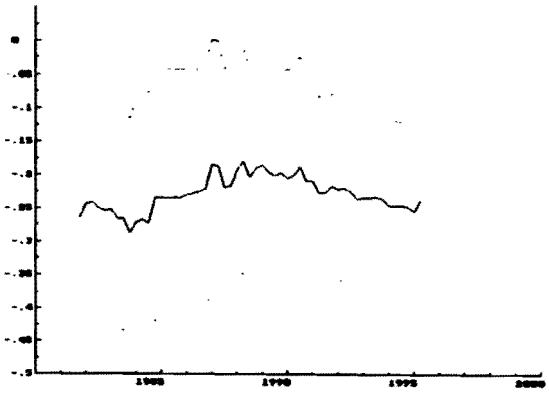
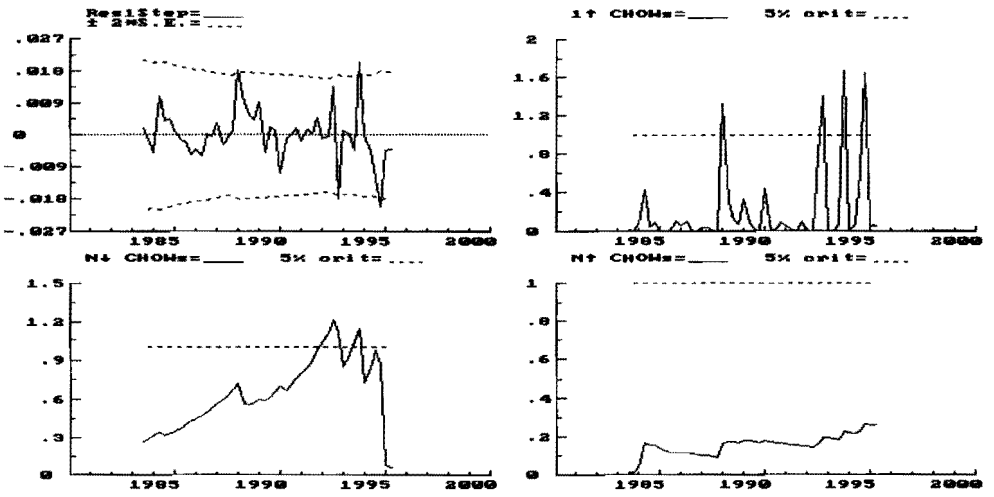


Table 3 Standard deviation of residuals

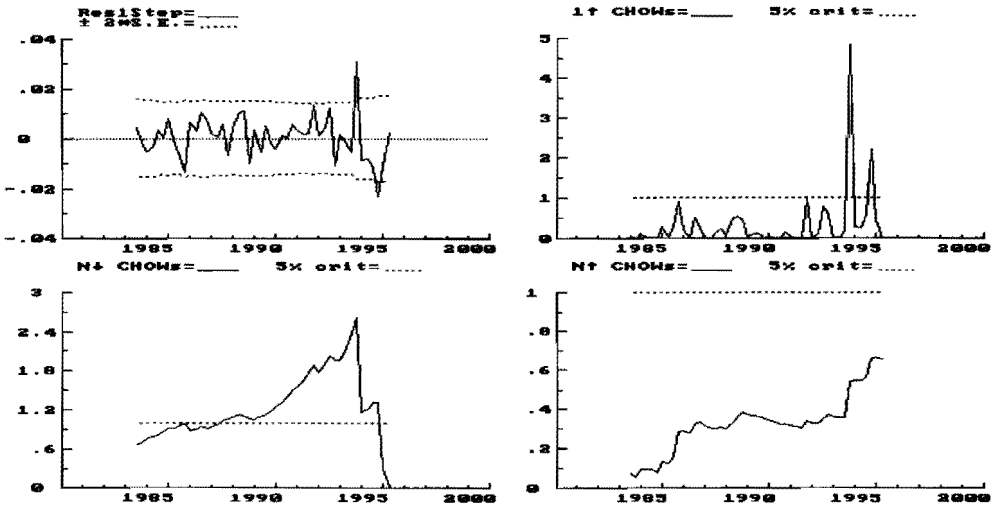
	1981 Q1 -1990 Q2	1990 Q4 -1995 Q2
aggregate M3	**.0066**	**.0071**
personal sector M3	**.0060**	**.0067**
corporate sector M3	**.0261**	**.0171**

Chart 15 Scaled one-step residuals and Chow tests

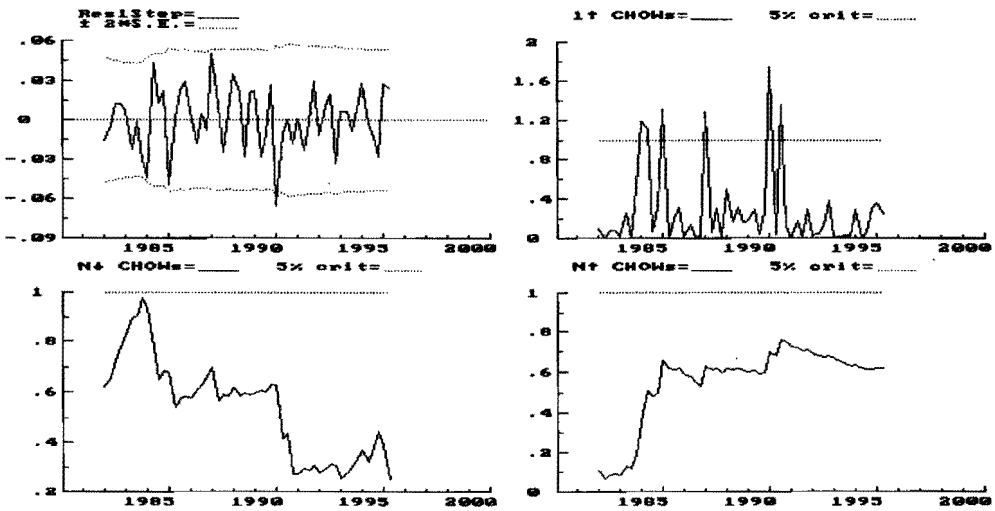
Aggregate M3



Personal sector M3



Corporate sector M3



The following points emerge from the analysis:

There is no evidence of long-run instability in aggregate M3 or in money demand of either sector. Chart 13 depicts reasonably constant eigenvalues in all three cases.

The personal sector and aggregate money demand functions show an increase in short-term instability after German monetary unification. The standard error of the residuals (Table 3) have increased and the Chow tests in Chart 15 mark a clear deterioration in the short-run stability properties. This result may be related to the fact that, increasingly, portfolio decisions of the personal sector have been influenced by speculative and short-term considerations that, given the short sample, are not yet being captured by the models.

Although corporate sector M3 is generally the least stable, firms' money balances have become relatively more stable since unification. Corporate sector balances are more volatile and the coefficient on the ECM term (Chart 14) is less stable than for the personal sector. But the Chow tests show increased stability during the 1990s, and the standard error of the residuals has fallen. This is consistent with section II where, unlike for the personal sector, we found no increase in volatility of actual corporate sector M3.[37] However, only limited interpretation of the corporate sector money demand function is possible, as it does not capture firms' behaviour as well.

Aggregate M3 is no less stable than sectoral money demand, and the results for aggregate M3 closely mimic those of the personal sector. One problem with aggregation is that parameter constancy in both sectors does not necessarily rule out instabilities in aggregate demand, for example if sectoral elasticities are constant, but each sector's share of M3 changes. However, this does not seem to apply here. The Chow tests in Chart 15 show a certain correspondence between the results for personal sector and aggregate M3. In particular, we consider two specific examples; a) unexpectedly high growth of M3 in Q4 1993 and b) a deceleration in Q4 1994, which, according to the 1↑ Chow test present the largest outliers for aggregate M3. A corresponding outlier for Q4 1993 is found in the 1↑ Chow test of personal sector M3. Short-term destabilising or frequently quoted 'special' factors, including tax effects, seem to have had a greater distortionary influence on the personal sector. Slow growth in Q4 1994 appears again to have originated from the personal sector. The only difference is perhaps that these factors have a slightly weaker

[37] It is difficult to find a plausible explanation for this. Perhaps firms are making greater use of modern cash management techniques, and therefore, their cash holdings are subject to fewer short-term fluctuations.

influence through aggregation. The 1↑ Chow test does show one 'spike' for aggregate M3 in 1988 that does not arise in either sector's demand. But our general conclusion is that short-run instability of aggregate M3 is to a large extent brought about by 'genuine' instabilities in individual sectors and is not a result of the aggregate approach. Sectoral disaggregation has enabled us to locate points of instability but not eliminate them.

VIII. Conclusion

The focus of this study has been to uncover money holding behaviour in the two major sectors of the economy, personal and corporate sector. As a second step, the estimated sectoral money demand functions were contrasted against an aggregate money demand function.

The paper identifies substantial behavioural divergences across the two sectors which is justification enough for a disaggregated approach. A large proportion of personal sector wealth remains in the form of M3 balances, while the M3 to wealth ratio in the corporate sector has declined. Firms continue to raise their share holdings (in value terms) with other companies, and there is evidence of shifts out of M3 in favour of euro-deposits.

Further sectoral differences emerge from the estimated money demand functions. The personal sector's money holdings tend to be determined by longer-term considerations, whereas businesses are far more responsive to short-term influences, like changes in activity and interest rates. There is evidence that a flattening of the yield curve leads to a fall in corporate sector M3 deposits over the short term, but that this is not true for personal sector M3. A single aggregate function is unable to capture these differences. On the question of stability, the hypothesis of long-run stability cannot be rejected in either sector. Personal sector and aggregate M3 do show signs of short-term instability after reunification, however, while corporate sector holdings of M3, though generally more volatile and less stable over the short term, have become relatively more stable during the 1990s.

Aggregate M3 closely mimics personal sector money demand, and there is no clear evidence of greater short-term instability on account of aggregation. In other words, any instabilities that emerge in M3 are 'genuine' instabilities arising from mainly the personal sector. The fact that corporate sector M3 is a relatively unstable component of aggregate M3 does not lead to significant distortion of the aggregate. We therefore conclude that

there is no reason to reject the aggregate approach. Although it cannot reveal sector-specific details, the results show that we do not lose stability through aggregation. The sectoral approach does not resolve the key empirical difficulties of estimating an aggregate money demand function, and the problems of finding a money demand relationship, which is also stable in the short run, remain.

Unit root tests

To test whether x_t is integrated of order 1 (non-stationary) or 0 (stationary), consider

$$\Delta x_t = \alpha + \mu t + \beta x_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta x_{t-i} + \varepsilon_t$$

An augmented Dickey-Fuller test is provided by the t-statistic on β. The null hypothesis is H0: $\beta=0$. Rejection of the null is rejection of a unit-root (non-stationarity) in favour of stationarity. The second column is the t-value, which is the adf statistic. The critical values are based on MacKinnon (1991); 5% and 1% significance are marked by * and **, respectively. The selected strategy is to choose the highest lag i (max n=5) with a significant γ_i (conventional student-t distribution, fourth column) and consider the corresponding null. The highest lag is given in the third column, c denotes inclusion of a constant. Unit root tests are on log-levels and log-differences. Unless otherwise stated the variables refer to the aggregate M3 case, but results for sectors are similar.

Variable	t-adf	lag i	t-lag
m	-1.2917	0 , c	
Δm	-8.0329**	0 , c	
y	-0.0068093	0 , c	
Δy	-9.0325**	0	
w	0.04298	1	3.2635
Δw	-5.8468**	0	
r	-0.67648	0	
Δr	-5.1086**	4	2.0992
r	-4.4304**	3, c	2.5361
Δr	-5.0837**	4, c	2.0982
p - GDP defl	-1.3872	0, c	
Δp	-4.5598**	1	-2.0027
ΔΔp	-8.8460**	2	2.5028
p - cons. defl.	-0.78614	4	2.7985
Δp	-1.8137	3	2.9113
ΔΔp	-9.4038**	2	3.6063
p - bus. GDP defl.	-1.3261	2	2.4134
Δp	-4.0882**	1	2.5397
ΔΔp	-8.8460**	2	2.5028

Cointegrating rank

	Maximum Eigenvalue test			Trace test		
H0: rank=r	-Tlog(1-λ)	T-nm	95%	-TΣlog(1-λ)	T-nm	95%
Aggregate M3						
r == 0	28.09*	22.25	27.1	52.86*	41.87	47.2
r <= 1	18.93	15	21.0	24.77	19.62	29.7
r <= 2	5.056	4.006	14.1	5.835	4.622	15.4
r <= 3	0.7783	0.6166	3.8	0.7783	0.6166	3.8
Personal sector M3						
r == 0	45.08**	35.71**	27.1	76.47**	60.58**	47.2
r <= 1	19.94	15.8	21.0	31.39*	24.87	29.7
r <= 2	9.931	7.867	14.1	11.45	9.068	15.4
r <= 3	1.516	1.201	3.8	1.516	1.201	3.8
Corporate sector M3						
r == 0	34.46**	29.09**	21.0	43.05**	36.34**	29.7
r <= 1	8.569	7.234	14.1	8.593	7.254	15.4
r <= 2	0.02427	0.02049	3.8	0.02427	0.02049	3.8

Exogeneity tests

	α_0 loading (loading of ECM in money dem. eqt.)	restriction: α_1=...=0, LRtest (r=1 & 0 loading in y, w and r eqts)
Aggregate M3	-0.123	$\chi^2(4)=1.74$
Personal sector M3	-0.079	$\chi^2(4)=7.28$
Corporate sector M3	-0.196	$\chi^2(2)=28.79^{**}$

Stability tests (Chow tests) **Annex 3**

Carry out recursive OLS on

$y_j = x_j' \beta_t + v_t$ $\quad j=1,.....,t$ for each $t = M-1, \quad ,T,$ and where $v_t \sim N(0,\Omega)$

Let b_t denote the k parameter estimates of β_t estimated from a sample size t, and $y_j - x_j'b_t$ the residuals at time j based on the parameter b_t estimated over the sample 1,....,t.

$$RSS_t = \sum_{j=1}^{t} (y_j - x_j' bt)^2$$

Parameter constancy test (Chow-test) - a single statistic

tests for constancy over period M, ... ,T

$$\frac{(RSS_T - RSS_{M-1})(M-k-1)}{RSS_{M-1}(T-M+1)} \quad \approx \quad F(T-M+1, M-k-1)$$

where the 1-step forecasts are calculated for t = M,.....,T

1-step F-test (1↑ Chow-test) - a sequence of statistics

A typical statistic is calculated

$$\frac{(RSS_t - RSS_{t-1})(t-k-1)}{RSS_{t-1}} \quad \approx \quad F(1, t-k-1)$$

t = M, ... ,T

Break-point F-test (N↓-step Chow-test) - a sequence of statistics

A typical statistic is calculated

$$\frac{(RSS_T - RSS_{t-1})(t-k-1)}{RSS_{t-1}(T-t+1)} \quad \approx \quad F(T-t+1, t-k-1)$$

t = M, ... ,T

The forecast is called N↓ because the number of forecasts goes from N=T-M+1 to 1

Forecast F-test (N↑-step Chow-test) - a sequence of statistics

A typical statistic is calculated

$$\frac{(RSS_t - RSS_{M-1})(M-k-1)}{RSS_{M-1}(t-M+1)} \quad \approx \quad F(t-M+1, M-k-1)$$

t = M, ... ,T

The forecast is called N↑ because the number of forecasts increases from M to t.

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The following papers have so far been published:

May	1995	The Circulation of Deutsche Mark Abroad	Franz Seitz
June	1995	Methodology and technique for determining structural budget deficits	Gerhard Ziebarth
July	1995	The information content of derivatives for monetary policy – Implied volatilities and probabilities	Holger Neuhaus
February	1996	Sectoral disaggregation of German M3*	Vicky Read

* Available in English only.