The role of wealth in money demand

Dieter Gerdesmeier

Discussion paper 5/96
Economic Research Group
of the Deutsche Bundesbank

May 1996

Deutsche Bundesbank, Wilhelm-Epstein-Strasse 14, 60431 Frankfurt am Main,
P.O.B. 10 06 02, 60006 Frankfurt am Main, Federal Republic of Germany

Telephone (0 69) 95 66-1
Telex within Germany 4 1 227, telex from abroad 4 14 431, fax (0 69) 5 60 10 71

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address, or via fax No. (0 69) 95 66-30 77

ISBN 3–932002–13–X

Contents

List of tables and charts

Tables

Charts

The role of wealth in money demand*

I. Introduction

The discussion about the role of wealth as a determinant of the demand for money is not a new one. Already in the early 1960s an animated discussion developed on the relevance of various scale variables for the money demand in the wake of Friedman's permanent income hypothesis and Tobin's theory of portfolio selection.[1] From the point of view of monetary theory, the inclusion of wealth was accompanied by a move away from traditional approaches, which had been based more on a transactions-oriented concept,[2] and towards theories which viewed the holding of money as a process of portfolio allocation. The implications for monetary policy are no less significant, for the ability to control the money supply presupposes a very detailed knowledge of money demand and its determinants. Rather accurate forecasts of the demand for money are necessary in order to determine the monetary policy course for the future. With a view to minimising forecasting errors, it has to be ensured that the money demand can be captured by just a very few economic variables.[3]

If wealth can be shown to have an influence on the pattern of money demand, that variable must also contribute to the trend in the velocity of circulation since money demand and the velocity of circulation are simply different aspects of the same phenomenon.

It should be pointed out (though here only in passing) that wealth is also sometimes considered to have far-reaching implications for fiscal policy. For example, if an expansionary fiscal policy is financed by the issue of government securities and if those

---

* I would like to thank R. Fecht, H. Hansen, P. Kugler, M. Scharnagl, C. Willeke and the participants in a workshop at the Deutsche Bundesbank for valuable comments and suggestions.

1 See Friedman (1957) and Tobin (1958).

2 See, for example, the works of Baumol (1952) and Tobin (1956), but also Miller and Orr (1966).

3 Judd and Scadding (1982), page 993.

securities form part of the assets of private economic agents, the public debt increases the stock of assets held by individuals, which may in turn lead to an increase in the demand for goods and money. In such a situation the restoration of money market equilibrium (given a non-accommodating monetary policy stance) necessitates, over and above the inevitable increase in interest rates in response to the expansionary fiscal policy course, an additional rate rise, thereby further dampening investment demand.[4] The two effects thus have a positive and a negative impact, respectively, on national income. If the wealth effect on the money market exceeds that on the goods market, the result is a "*portfolio crowding-out effect*".[5] Hence the existence of wealth effects could largely neutralise the effects of fiscal policy.

The stock of assets held by the non-bank sector in the Federal Republic of Germany has expanded rapidly over the past few decades. Whereas at the end of 1960 the financial assets of households and of producing enterprises had totalled DM 170 billion and DM 114 billion, respectively, the corresponding figures at the end of 1994 were DM 4.3 trillion for households and DM 2.2 trillion for producing enterprises.[6] If wealth does indeed constitute an explanatory variable in the money demand, it may be presumed - given the magnitudes involved - that its influence has grown in importance over time.

This study focuses on attempting to examine in greater depth the importance of wealth for money demand. In particular, the theoretical hypotheses are to be tested empirically as well. To that extent the present study represents one of the first of its kind for Germany. Following some introductory remarks, the basic hypotheses of a theory of money demand are briefly outlined in section II. As an exhaustive account would exceed the bounds of this work, such an attempt must be confined of necessity to the basic features. No clear-cut definition of the relevant wealth variable can be derived from theory. The main thrust of section III is therefore an attempt to quantify this variable for Germany. Section IV

---

4 It is perhaps useful at this point to spell out the distinction between "*conventional crowding-out*" and "*portfolio crowding-out*". In the former an increase in public spending totally or partly crowds out private expenditure. The latter leads to an increased demand for goods and money on the part of individuals and, as the money supply is constant, to higher interest rates in order to restore the equilibrium of the money market.

5 See Blinder and Solow (1974, page 45 ff.), but also Friedman (1985).

6 Deutsche Bundesbank (1995), May Monthly Report, page 33 ff. The data for 1994 relate to Germany as a whole. All figures are based on a valuation of securities at market prices.

comprises an empirical analysis. In the following section its results are implemented into a model in which the determinants of the velocity of circulation are derived and tested for the M3 aggregate. The closing section consists of a summary of the results and a brief discussion of the monetary policy implications.

II. Theoretical foundations

Any meaningful econometric study must be based on theoretical hypotheses which can then be verified (or negated, if appropriate) by the data.

The starting point for the following considerations is the Fisher equation:[7]

(1) $M \cdot V \equiv P \cdot T$ which transforms into

(2) $M \equiv \frac{1}{V} \cdot P \cdot T$

where M denotes the money stock, V the velocity of circulation, P the price level and T the transaction volume. The two equations have a tautological character, for the aggregate volume of transactions in an economy over a given time can be measured both on the goods side (the number of transactions conducted multiplied by the average price at which they take place) and on the money side (the amount of money in circulation multiplied by the average number of times it changes hands over the same period). Only the hypothesis of a constant velocity of circulation ($1/V = k =$ constant) transforms the identity (2) into a behavioural equation (3) which can be interpreted in the sense of a money demand function:

(3) $M = k \cdot P \cdot T$ where k = cash holding coefficient = constant

7 See Fisher (1922), especially page 21.

In this older form of the quantity theory,[8] the velocity of circulation is determined by institutional factors whose behaviour - according to the decisive assumption - is subject to a certain inertia over time.[9] However, the mere observation of this time series over the course of the business cycle, particularly the experience of periods of pronounced inflation rates, has shown demonstrably that the assumption of a constant velocity of circulation is by no means warranted.[10] It is customary in the empirical literature to replace the unknown transaction volume by the real national product (Y^r):

(4) $$M \cdot V = P \cdot Y^r$$

In this case V represents not the transaction velocity but the income velocity of money.

One of the cornerstones of the Keynesian liquidity preference theory is the explicit inclusion of the return from holding other assets. For this purpose money demand is subdivided into an interest-related speculative demand for money (M^S), an income-related precautionary demand for money and an income-related transaction demand for money (M^T). Given these assumptions, the demand for money will take the following form:[11]

(5) $$M = M^S + M^T = l_1\left(i^A\right) + l_2\left(P \cdot Y^r\right)$$

where i^A is the interest rate of an alternative asset. The derivation of the money demand from two independent determinants has to be interpreted in the sense of a "*mental construct*" and not in the sense of a mechanical segregation.[12] This consideration suggests the following functional form:

---

8 This form is sometimes referred as the "*rigid*" version of the quantity theory.

9 Friedman takes a different view, however (1979), page 18.

10 Friedman (1979), page 27 ff.

11 See Keynes (1936), page 199. The precautionary demand for money and the transaction demand for money are usually combined.

12 Keynes (1936, page 195) observed "Money held for each of the three purposes forms, nevertheless a single pool, which the holder is under no necessity to segregate into three water-tight compartments; for they need not be sharply divided even in his own mind, and the same sum can be held primarily for one purpose and secondarily for another".

(6) $M = f\left(i^A, P \cdot Y^r\right)$

The post-Keynesian approaches adhere in principle to the analytical segregation of the money demand into the three purposes. One initial group of works takes a closer look at the transaction purpose, arriving at the so-called "*inventory models*". The demand for transaction funds is basically determined by the changes in the aggregate transaction volume and the degree of synchronisation (between inpayments and outpayments). Given the assumption of growing economies (and, therefore, a steady increase in the transaction volume), a continuous increase in the money demand for transaction purposes could be inferred from this. The fact that this is not the case is due to the cost of holding money instead of interest-earning assets. These costs can be lowered by temporarily investing part of the transaction funds in higher-yielding assets. The higher the interest yield the more frequent are portfolio shifts and the smaller are the cash balances held for transaction purposes (on average over a given period).[13] From these considerations it follows that changes in the money demand for transaction purposes can be ascribed to changes in the aggregate transaction volume and the cost of holding cash.[14] In formal terms this gives us:

(7) $M^T = f(i^A, P \cdot Y^r)$

The elaboration of the Keynesian speculation purpose led to the theory of "*portfolio selection*" in the mid-fifties. The key feature of this approach is to analyse the demand for money within the framework of utility maximisation subject to certain constraints. It concentrates on the search for an optimum portfolio structure under a constraint imposed by the amount of wealth held.[15] The criteria for dividing assets between money and bonds

---

13 To be more precise, it is the net interest yield, i.e. the difference between the interest yield and the cost of the portfolio switch.

14 The interest elasticity of the transactions demand for cash was the object of the basic research of Baumol (1952), Tobin (1956) and Miller and Orr (1966).

15 The budget constraints of (static) portfolio models do not as a rule contain any flow variables such as income. In Tobin's model, for example, (1969, page 24) the budget constraint embraces the stocks of cash, securities and physical capital goods.

are the risk involved and the expected yield.[16] It follows that the demand for money as an asset is determined by the size of the assets (W^r), by the own rate of interest of money (i^E) and by the rate of interest payable on an alternative asset (i^A). This gives us:

$$(8) \quad M^S = f\left(i^E, i^A, \ldots\right) P \cdot W^r$$

If account is taken of both purposes, it is logical to incorporate both income and wealth as independent variables in the money demand function. Under this constellation the aggregate demand for money would be a function of interest rates, income and wealth:[17]

$$(9) \quad M = M^T + M^S = f\left(i^E, i^A, P \cdot Y^r, P \cdot W^r\right)$$

In his reinterpretation of the quantity theory, Milton Friedman modified the assumption of a constant velocity of circulation.[18] Money is treated as a good, just like any other; the demand for money is then likewise analysed in line with the concept of utility maximisation under given constraints.[19] As is the case for all goods, the price of the good demanded, the resources available and the preferences of economic agents must then be taken as the determinants of demand. This gives:[20]

$$(10) \quad M = f\left(i^E, i^B, Y / P, u, w\right) P$$

where i^E and i^B represent the different interest rates, w the ratio of non-human wealth to human wealth and u the preferences of economic agents.

---

16 The probable yield from holding debt securities can be captured by a frequency distribution whose first two moments, i.e. the yield and the distribution, reflect the relevant parameters for holding securities. Tobin (1958, page 74) remarks "It is a simplification to assume that the investor chooses among the alternative probability distributions (...) available to him on the basis of only two parameters of those distributions".

17 Teigen (1979), page 108 and Johnson (1962), page 355.

18 See Friedman (1956).

19 Friedman (1956, page 4) wrote: "The analysis of the demand for money (...) can be made formally identical with that of a demand for a consumption service".

20 Friedman (1956), page 11. Some of the nomenclauture has been adapted to the present work.

Although post-Keynesian approaches and neo-quantity theory follow different methodologies, they arrive at similar money demand functions. Assuming constant elasticities, the corresponding equation could then read:

(11) $$M = e^{\beta_0} \cdot (1+i^E)^{\beta_1} \cdot (1+i^A)^{\beta_2} \cdot (P \cdot Y^r)^{\beta_3} \cdot (P \cdot W^r)^{\beta_4} \cdot e^{\varepsilon}$$

where ε denotes the residual term of a corresponding estimation. If it is further assumed that the economic agents are not subject to money illusion, a real specification is appropriate:

(12) $$M/P = e^{\beta_0} \cdot (1+i^E)^{\beta_1} \cdot (1+i^A)^{\beta_2} \cdot Y^{r^{\beta_3}} \cdot W^{r^{\beta_4}} \cdot e^{\varepsilon}$$ or, in logarithmic form,

(13) $$m - p = \beta_0 + \beta_1 \cdot \ln i^E + \beta_2 \cdot \ln i^A + \beta_3 \cdot y^r + \beta_4 \cdot w^r + \varepsilon$$

Both theoretical and empirical objections have been raised to such a specification. Both types of objections emanate from the fact that the variables income and wealth are not independent of one another. If, taking a theoretical approach, it is assumed that wealth also comprises all capitalised labour ("*human capital*"), income can be defined as earnings from wealth and wealth as capitalised income. With the aid of a corresponding interest rate an exact functional relationship between the two variables can be derived:

(14) $$Y^r = W^r \cdot i$$

Should this relationship hold, the money demand approach could be interpreted both in the sense of the income hypothesis and of the wealth hypothesis.[21] In this case any attempt to estimate the correlations between money demand, income and wealth would be pointless. On the other hand, it can be argued that, while no one denies that the two variables are linked to one another via saving, they do not necessarily stand in the exact functional relation to one another defined above. No empirical evidence can be furnished anyway as neither time series on "*human wealth*" nor on an income variable defined in this way, nor on a corresponding interest series exist. The econometric reservations are based on the fact that, given a close correspondence between the interest series of wealth and of income, the

---

21 Meltzer (1963), page 220.

inclusion of both variables in the money demand function would inevitably lead to technical estimation problems. We shall return to this problem later.

The assumption of constant interest elasticities, as posited in the double logarithmic model (13), implies that an increase in the interest rate by a given percentage leads to a (constant) decline in the money demand which is independent of the interest rate level. In the semi-logarithmic model, by contrast, the interest elasticity varies (with constant interest semi-elasticity) with the level of the interest rate. For this reason the interest rate is sometimes included in the estimation in the form of a semi-elasticity:[22]

$$(15) \qquad m-p=\beta_0+\beta_1\cdot i^E+\beta_2\cdot i^A+\beta_3\cdot y^r+\beta_4\cdot w^r+\varepsilon$$

where all variables except the interest rates are expressed in logarithms.

Another important specification decision is the question of whether the equation is to be estimated in nominal or in real form, as the reduced form was derived under the assumption that cash balances are held not so much because of their nominal value as because of their purchasing power. Moreover, since it was doubted that economic agents can be subject to money illusion in the long run, it seemed sensible to consider money demand as a real variable. Consequently, the following variant of the estimation

$$(16) \qquad m=\beta_0+\beta_1\cdot i^E+\beta_2\cdot i^A+\beta_3\cdot y^r+\beta_4\cdot w^r+\beta_5\cdot p+\varepsilon$$

ought to result in a price elasticity of $\beta_5 = 1$. However, a series of studies have rejected the assumption of price homogeneity for Germany.[23] Such results have also been found for other countries, too, and some commentators have even pointed out that the restriction to price homogeneity leads to implausible coefficients.[24] Both theoretical and empirical

---

[22] Both approaches are possible. For a model using a constant interest semi-elasticity see, for example, Boughton (1991b), and for a model using a constant interest elasticity see, for example, Hoffman, Rasche und Tieslau (1995).

[23] See Boughton (1991a), Boughton (1991b), Sauer (1992) and Gerlach (1994).

[24] See Angelini, Hendry und Rinaldi (1994) page 19. The authors explicitly point out that the inclusion of the seventies leads to the rejection of the hypothesis of price homogeneity. Brookes et al. (1991, page 135) comments as follows on one of their results: "When the price elasticity is restricted to one, the income elasticity becomes unacceptably low".

reasons are conceivable for that. While it is agreed theoretically that the transaction demand for money should show linear homogeneity of prices, as a doubling of the nominal transaction volume should lead to a doubling of cash balances held for transaction purposes, it is debatable whether this also holds for the speculation pool. Although this is often assumed for the sake of simplicity, it certainly need not be the case. Empirically this result has been ascribed, firstly, to aggregation problems which cause errors in estimating the parameters, but sometimes also (especially in the context of cointegration methods) to distortions due to the brevity of the estimation period.[25] It is also conceivable that the price index employed does not correspond to the one used by economic agents for deflating prices. In this case there is no conflict with the theory. To sum up, it may be said that, particularly when dealing with more broadly defined aggregates, price homogeneity cannot be assumed *a priori.*

Before the relationships derived above are subjected to empirical testing, the question of determining the relevant wealth variable must be examined more closely.

[25] Boughton (1991b), page 24. However his estimation period encompasses 25 years.

III. Definition of wealth

III.1 Fundamental considerations

So far in this work the definition of the wealth variable has not been analysed in great detail. But for empirical purposes this variable needs to be specified more precisely.

If we take as our starting point a broadly defined concept as used, say, by Friedman, the definition of wealth would need to comprise not only financial assets and fixed assets but also "*human wealth*". Attempts to quantify the latter variable, however, meet with insuperable difficulties. It therefore seems appropriate to confine the definition to the sum of financial assets and fixed assets, known as "*non-human wealth*".

Particularly in the context of explaining money demand, it may further be presumed that the degree of liquidity of the assets plays a certain role. If the degree of liquidity is included as one of the defining criteria for wealth, an even narrower definition would be justified, for financial assets have a higher degree of liquidity than fixed assets. That is due to their extensive separability, homogeneity and fungibility. Although the degree of substitutibility between financial assets and fixed assets varies with the time horizon, there can be no doubt that fixed assets, too, can be converted into more liquid forms over a longer time frame. Over the shorter term, however, financial assets undoubtedly have a higher degree of liquidity than fixed assets, while human wealth cannot be turned into liquid assets at all in the short run. This would suggest that the aggregate financial assets should be the focus of portfolio allocation.

The question of choosing the appropriate aggregation method is of particular importance in this context. If the figures are aggregated on a consolidated basis, the claims which domestic economic agents have on each other are eliminated since total claims on the one side are offset by an equal amount of liabilities on the other side. That would result in net wealth. If, on the other hand, simple summation is chosen as the aggregation method, gross wealth ("*portfolio wealth*") has to be the focal point of attention.[26]

---

[26] A similar line of thought is to be found in Fields and Hall (1987), page 1040.

The choice of aggregation method can be based either on statistical criteria or on economic considerations. On the basis of statistical criteria, the answer is quite clear: as a rule net wealth displays better estimation properties. Consequently, empirical studies for other countries have mostly been based on net wealth.[27]

From an economic point of view the result is much less clear-cut, however. Money demand functions are ultimately the product of the aggregation of individual microeconomic cash holding motives. If individual economic agents optimise their portfolios independently of one another, that would be an argument in favour of choosing gross wealth. Taking account of mutual dependencies, by contrast, results in net wealth.

One drawback of using net wealth is that, in the final analysis, the degree of consolidation has to be chosen more or less arbitrarily. In the extreme case of complete consolidation the only value which remains for an open economy are that country's net claims on the rest of the world. It is not immediately obvious why this variable should represent a principal determinant of the demand of domestic economic agents for domestic currency.

Another possibility would be to view cash holdings as a temporary investment vehicle within the process of shifting between different forms of assets. In this case the portfolio structure must be considered the principal determinant. This determinant cannot be captured by net wealth, which makes further investigation impossible. For these reasons the present work focuses on a gross wealth variable.[28]

III.2 The definition used in this study

The financing patterns in Germany are regularly reported and commented upon by the Deutsche Bundesbank.[29] The financial flows account, which attempts to trace the flows of

---

[27] For example, Angelini, Hendry and Rinaldi write (1994, page 19): "We opted for net financial wealth which, (...), should not give rise to simultaneity bias".

[28] The theoretical models of Tobin (1969), Blinder and Solow (1974), Brunner and Meltzer (1993; page 83 ff.) and Friedman (1956, page 4 ff.) likewise appear to be based on simple summation.

[29] See, for example, Deutsche Bundesbank (1995), May Monthly Report, pages 17 to 43.

funds during the period under review, is supplemented by the financial assets and liabilities account. The latter records the stocks of claims and liabilities on a given reporting date valued in monetary units. That enables balance sheets of assets and liabilities to be drawn up both at the macroeconomic level and by sector. Economic agents are basically subdivided into four non-financial sectors (households, enterprises, government, non-residents) and three financial sectors (banking institutions, building and loan associations, insurance enterprises).[30] The Bundesbank customarily treats housing as a separate sub-sector of the enterprise sector as it is subject to different considerations than are producing enterprises.[31]

A definition of non-human wealth which seeks to be relevant in terms of a conventional definition of the money stock would need, in principle, to encompass the financial and fixed assets of the non-bank sector, i.e. those of households, enterprises (excluding housing), insurance enterprises, investment funds and building and loan associations. The financial flows and financial assets and liabilities accounts contain fairly precise figures on corporate fixed assets but not on the fixed assets of other economic agents.[32] Consequently, the present study is based on portfolio wealth. While it cannot be denied that fixed-asset variables likewise represent relevant determinants, such studies are not made owing to the lack of data.[33]

In turn, the portfolio wealth recorded in the financial accounts mentioned above consists of funds invested with banks, funds invested in the securities markets and funds invested under savings schemes with building and loan associations. Specifically, it comprises cash, sight deposits, time deposits, current deposits and savings deposits, savings bonds, debt securities, balances with building and loan associations and claims on insurance

30 The sectoral classification is based on the residence concept. Foreign economic agents domiciled in Germany are counted as domestic economic entities, whereas German economic entities domiciled abroad are treated as non-residents.

31 More detailed reports on the financial accounts and their macroeconomic implications can be found in Schlesinger (1972) and each May issue of the Bundesbank's Monthly Report.

32 Estimates of individual components of households' fixed assets are contained in Deutsche Bundesbank (1993), October Monthly Report, in the literature quoted in that article and in Schäfer and Bolleyer (1993).

33 Properly speaking, financial assets implicitly comprise part of the stock of fixed assets as well since, as ultimately money is owed to households by enterprises, households also have a claim on the latter's fixed assets.

enterprises.[34] Funds held in the form of shares have a dual character. Strictly speaking, they are not claims but rather shares in the capital of an enterprise. From an economic point of view, however, they are a form of acquisition of financial assets which competes with other possible forms of investment, which justifies their inclusion under portfolio wealth. Moreover, this approach is in line with international practice.[35]

A further modification had to be made for statistical reasons. The end-of-year figures shown in the financial assets and liabilities account were recalculated on the assumption of equal increases on a quarterly basis. The break in the time series caused by German reunification in 1990 was handled as follows. For the first and second quarters the corresponding rates of growth for western Germany were taken. The third quarter comprises the all-German rate of increase which is calculated retrospectively from the end-of-year figure. This ensured that the break in the data occurred in the third quarter. The portfolio wealth and its individual components calculated in this way are shown in the following table.

One striking feature is that the financial assets of non-banks in Germany have grown substantially during the past twenty years. This considerable and continuous build-up of financial assets is due mainly to the specific behaviour of German households. That is based in turn on a comparatively high propensity to save by international standards which, among other things, is doubtless a positive consequence of the low inflation rate. An increasing contribution to the accumulation of private financial assets has also been played by capital income.

---

34 The enlargement of the financial flows and financial assets and liabilities accounts, which was undertaken in August 1995 in conjunction with the change-over to Germany-wide reporting, was accompanied by a fundamental change in valuation methods. Instead of valuing debt securities at nominal values and shares at cumulative issue prices, as before, market prices are now the valuation criterion and hence also the basis of the calculations. The concept of wealth is therefore now based on the actual market value of the assets held. See Deutsche Bundesbank (1995), Special Statistical Publication 4, August.

35 See Deutsche Bundesbank (1995), Special Statistical Publication 4, August, page 22.

Table 1:

The growth of portfolio wealth over time

End-of-year levels; DM billion

Year	Portfolio wealth					
	Households	Enterprises[1)]	Insurance enterprises	Builiding [2)] and loan association	Investment funds	Total
1975	942.9	433.1	159.7	86.3	27.1	1649.0
1976	1049.0	477.5	179.1	94.2	30.4	1830.3
1977	1159.0	519.3	200.5	101.5	33.8	2014.2
1978	1259.6	574.4	224.1	111.1	37.2	2206.4
1979	1366.5	611.0	251.9	121.9	40.6	2392.0
1980	1483.5	657.3	281.2	132.3	44.0	2598.3
1981	1605.4	725.4	314.0	142.0	62.4	2849.2
1982	1758.0	788.8	349.4	148.0	80.8	3125.0
1983	1890.9	872.8	386.4	154.0	99.2	3403.2
1984	2044.0	948.9	425.9	158.8	117.6	3695.2
1985	2214.7	1057.3	469.0	158.8	136.0	4035.8
1986	2361.4	1105.7	515.9	155.6	154.4	4292.9
1987	2443.5	1090.4	562.8	153.6	172.8	4423.1
1988	2635.9	1224.7	612.9	154.0	191.2	4818.7
1989	2832.2	1425.4	666.7	158.6	209.6	5292.5
1990	3187.2	1593.5	824.6	165.8	228.0	5999.3
1991	3467.4	1714.3	898.5	175.9	274.4	6530.4
1992	3723.0	1848.5	981.9	190.3	294.6	7038.3
1993	4099.1	2067.1	1154.2	205.3	394.3	7920.0
1994	4320.0	2197.8	1207.1	216.5	454.7	8396.2

All figures rounded, from 1990 for Germany as a whole

1) Excluding housing

2) Figures partly interpolated.

Source: Deutsche Bundesbank

IV. Empirical studies

As already mentioned, attempts to quantify the influence of wealth on the money demand are not new. The bulk of such studies, however, relate to the United States. The first papers were published by Stedry and by Bronfenbrenner and Mayer. The works of Meltzer, Brunner and Meltzer, Laidler and Chow also deserve mention.[36] More recently some studies have sought to clarify whether income or wealth is better suited to explaining the movement in the money stock M1 in the United States.[37]

Studies of countries other than the United States are much rarer. A series of studies have shown that for the United Kingdom the inclusion of a variable representing the influence of financial innovations (and, for broad monetary aggregates, of an additional wealth variable) can certainly lead to money demand functions with long-run stability, whereas no long-run relation can be established without the two variables.[38] In Italy, too, a stable long-run relation for the aggregate M2 was demonstrated using wealth as a variable.[39] A similar impact of wealth appears demonstrable for Japan as well.[40]

Other works have attempted to integrate wealth into an equation for the velocity of circulation.[41] An early work in Germany related to the period of fixed exchange rates.[42] More recent analyses have been published by the Deutsche Bundesbank and the US Federal Reserve Bank.[43]

---

36 See Stedry (1959), Bronfenbrenner and Mayer (1960), Meltzer (1963), Brunner and Meltzer (1963), Laidler (1966) and Chow (1966).

37 See Johannes and Nasseh (1985), Smith (1988) and Fields and Hall (1988).

38 See Hall, Henry and Wilcox (1987) and Brookes, Hall, Henry and Hoggarth (1991). Wealth was included in estimations of M3 and M4.

39 See Angelini, Hendry and Rinaldi (1994).

40 The estimations of Ueda (1990) appear to verify this for M2.

41 See Kole and Leahy (1991).

42 See Bergen (1970).

43 See Deutsche Bundesbank (1995), July Monthly Report, and Kole and Meade (1995).

The hypotheses presented in section II suggest that it is appropriate to use a log-linear estimation function as the starting point of the study:

(17) $m^r = \beta_0 + \beta_1 \cdot i^A + \beta_2 \cdot i^E + \beta_3 \cdot y^r + \beta_4 \cdot w^r + \varepsilon$

with the following partial derivatives

(18) $\beta_1 < 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0$

Except for the two interest rates, lower-case letters denote logarithmic values, while the suffix r represents real variables. Hence, with the exception of the interest rates, the estimated slope coefficients can be interpreted in the sense of elasticities.

The choice of the data requires a brief explanation. M3 was chosen as the monetary aggregate (*M*). This aggregate has been the focal point of the Bundesbank's monetary policy since 1988. In portfolio approaches each variable depends on the own rate of interest and on an alternative interest rate.[44] The abbreviation i^E stands for the own rate of interest of M3, i^A for a representative alternative interest rate reflecting the opportunity cost and hence substitution effects. A suitable measure of this is the yield on domestic bearer debt securities outstanding.[45] On the other hand, the own rate of interest is captured by an artificial interest rate. For this purpose the interest rates of the individual components, weighted by their respective shares in the aggregate, are added together. A value of zero was assumed for the own rate of interest of cash and sight deposits. The measure used for the interest rate on time deposits was the rate on fixed-term deposits with an agreed maturity of one to three months inclusive and an investment amount of DM 100,000 to less

44 It is also conceivable that the exchange rate could represent a determinant of money demand. However, the results of corresponding analyses carried out by the Bundesbank do not indicate that currency substitution effects might have played a major role. Consequently, this variable is omitted from the further analysis. See Deutsche Bundesbank (1995), January Monthly Report.

45 The question of the appropriate opportunity cost variable has attracted a lot of attention, especially in US literature. Hafer and Jansen (1991) discuss the issue of whether short or long-term interest rates provide better results for the United States.

than DM 1 million. The measure chosen for savings deposits were the rates payable on savings deposits at three months' notice.[46]

Most empirical studies usually take gross national product or gross domestic product as the relevant scale variable.[47] In the present case *Y* stands for gross domestic product while portfolio wealth (*W*), as defined in the previous chapter, is used as the wealth variable. That still leaves the question of the relevant price index. Essentially, the available options are the GDP deflator, the deflator for expenditure on goods and services and the cost-of-living index. Since gross domestic product is included as the transactions variable, it seems appropriate to use the deflator of gross domestic product in the present work.

As mentioned in section II, however, some more recent works have expressed serious doubts about the validity of the hypothesis of price homogeneity for various indices in the context of multivariate cointegration models.[48] For this reason nominal and real specifications are included. Gross domestic product, the price level and the money stock are included in the analyses in the form of seasonally adjusted data.[49] The first quarter of 1975 to the fourth quarter of 1994 was chosen as the investigation period. It precisely encompasses the period during which the Bundesbank has pursued a policy of pre-announced monetary targets. West German data are used up to the second quarter of 1990 and all-German data from the third quarter of 1990 on.

The focus of interest from the point of view of monetary theory and monetary policy is the long-run behaviour after the end of the adjustment process ("*steady state*") as such steady states usually form the contents of economic models. Naturally, the short-term behaviour of

---

46 That gives us $i^{E} = i^{TE} \cdot (TE / M3) + i^{SP} \cdot (SP / M3)$ where TE represents the time deposits, SP the savings deposits and i^{TE} and i^{SP} the corresponding interest rates. It should be mentioned, though, that the deposit rate payable on savings deposits probably no longer adequately reflects actual interest rates paid, given the growing importance of special savings schemes.

47 Mankiw and Summers (1986) have argued, however, that consumption expenditure constitutes a more relevant transaction variable than gross domestic product. A number of studies appear to have found corresponding dependencies for the United Kingdom, too. See Fisher and Vega (1994).

48 See the literature cited in section II. A more detailed description of the Johansen method used and of the testing procedure can be found in annex 2.

49 Some objections have been raised in the literature to using seasonally adjusted data rather than unadjusted values (and corresponding seasonal dummies). Ericsson, Hendry and Tran (1994), for instance, have expressed reservations about using seasonally adjusted data.

economic agents is relevant, too. Error correction models are the appropriate econometric instrument for identifying the differences between short-run dynamics and long-run equilibrium.[50] The error correction model (EC model) was chosen not least because some studies have shown that these models seem to be clearly superior to other alternatives such as buffer-stock approaches.[51] It has further been demonstrated that the EC model is consistent with an optimisation behaviour on the part of economic agents.[52]

In selecting the econometric estimation procedure, a key role is played by the statistical properties of the time series. If the time series employed turn out to be integrated processes, conventional regression methods can lead to the problem of spurious regressions.[53] Stationarity is usually tested by means of an Augmented Dickey-Fuller test (ADF test). In our case the Phillips-Perron test (PP test) was used as well. The table below gives the results of these estimations.[54]

---

50 The derivation of an error correction model from a general dynamic approach is shown in annex 3.

51 See Muscatelli (1989).

52 See Nickell (1985).

53 See Granger and Newbold (1974).

54 Various works have shown that autocorrelation in a time series can lead to distortions of the test level in the context of Dickey-Fuller tests. The null hypothesis of a unit root is then not rejected often enough. The augmented form of the Dickey-Fuller test (ADF test) therefore includes lagged endogenous variables which take account of the possibility of autocorrelated processes in the disturbance term. The Phillips-Perron test (1988) is a modified version of the ADF test. In this case a non-parametric correction of the Dickey-Fuller statistics is performed (e.g. by using a Bartlett window).

Table 2: Results of the stationarity tests

Variable	Level			Differences			Interpretation
	Specification	ADF	PP	Specification	ADF	PP	
m	c, t, 0	- 1.96	- 1.93	c, 0	- 8.85	- 8.91	I (1)
m^r	c, t, 0	- 1.75	- 1.40	c, 0	- 6.52	- 9.74	I (1)
i^A	c, 1	- 2.92	- 2.93	c, 0	- 6.12	- 6.11	?
i^E	c, 1	- 2.23	- 2.16	c, 0	- 4.96	- 4.81	I (1)
y	c, t, 3	- 1.95	- 1.87	c, 1	- 5.61	- 10.2	I (1)
y^r	c, t, 0	- 1.24	- 1.46	c, 0	- 9.86	- 9.86	I (1)
w	c, t, 2	- 2.43	- 2.84	c, 0	- 5.87	- 6.08	I (1)
w^r	c, t, 2	- 3.18	- 2.94	c, 0	- 8.38	- 8.44	I (1)
p	c, t, 4	- 1.43	- 1.37	c, 0	- 11.0	- 11.1	I (1)

Note: Within the specification, the figure denotes the number of lagged endogenous variables, c stands for a constant, t for a time trend.[55] The null hypothesis was tested using the critical values after MacKinnon (1991) for a significance level of five per cent, with the null hypothesis indicating non-stationarity. All estimations in levels apart from interest rates include the time trend, whereas all estimations in differences exclude the time trend.

All variables show first-order integration. Thus simple differencing confirms the stationarity of the time series. The long-term interest rates clearly constitutes a borderline case.[56] That is in line with the differing results in the literature.[57] It is also striking that wealth follows a I (1) process, for if wealth mirrors households' saving behaviour and if this saving is integrated of order one, a I(2) process would also be conceivable for wealth interpreted in the sense of cumulative saving.

55 The hypothesis of a change in the trend pattern caused by German reunification was tested additionally using Perron's approach (1989). It showed no evidence of such a break.

56 The critical value for a corresponding ADF test in levels is about -2.90.

57 The findings of Wolters (1995, page 155) support the hypothesis that (short-term) interest rates follow I(1) processes. Lucke (1995) takes the opposite view.

Economic times series are very rarely orthogonally correlated. For this reason multicollinearity is a relatively common phenomenon in the economic context.[58] In the present case both a broadly parallel trend in yield rates and the simultaneous inclusion of income and wealth could give rise to collinearity problems. The more stable the correlation between the corresponding variables, the harder it is to distinguish between the separate influences of the two variables. In the case of strict proportionality the partial influences of the variables cannot be estimated at all.[59] In the case of imperfect multicollinearity the separate influences of the individual determinants cannot be estimated as precisely as in the case of no multicollinearity. It is worth noting in this context that in such a case the estimations still remain unbiased. Nor, as a rule, is the overall fit of an equation affected by the existence of multicollinearity. Hence no impact on the forecast quality is to be expected either.[60] If all coefficients have the expected sign and are (individually) significant, the problems are likely to be fairly small anyway.

The degree of multicollinearity between wealth and income can be demonstrated by plotting the differential between (logarithmic) portfolio wealth and (logarithmic) gross domestic product.[61] If the resulting time series displayed a steady upward slope along the inserted trend line, perfect multicollinearity would exist. The chart below shows the behaviour of the time series.

---

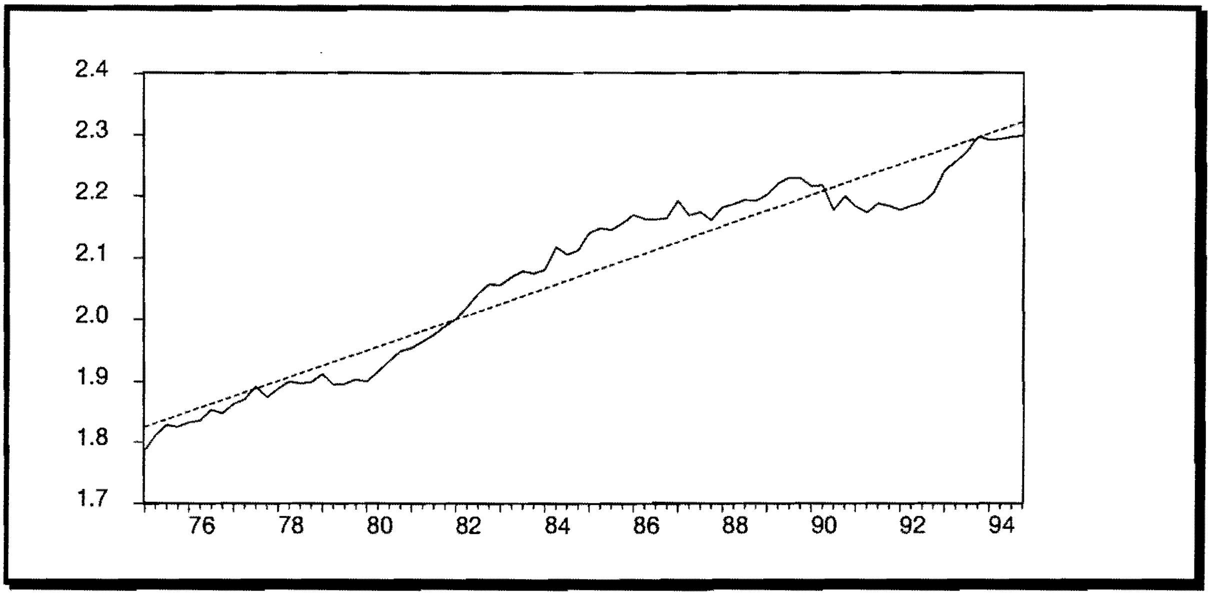
58 Gujarati (1988, page 298) observes: "Multicollinearity is a question of degree and not of kind." To give just one other example: if consumption is specified as a function of income and wealth, similar problems arise.

59 Expressed in technical terms, the coefficients cannot be derived from the estimation in this case as the coefficient matrix is a singular matrix. A more detailed explanation is given in annex 1.

60 Judge et al. (1980, page 453) emphasize that a deterioration of the quality of the forecasts only arises if the multicollinear variables follow a completely different pattern in the forecast period than in the estimation period.

61 This is equivalent to the logarithmic quotient of portfolio wealth and gross domestic product.

Chart 1: Differential between portfolio wealth and gross domestic product (in logarithms)



Source: own calculations

Clearly, the slope of the differential is not that perfectly steady. Major and protracted deviations from the trend line occur repeatedly. That means that the equation can be estimated in principle in the specification given; the only problem is to minimise the negative consequences outlined above.

If multicollinearity is present, the usual recommendation is to expand the estimation period. In our case that would mean including the period prior to 1975. But that would imply using a sample consisting of two completely different monetary policy regimes. That is unsatisfactory from the point of view of economic theory. Assuming a stable correlation between national product and wealth, some researchers deliberately choose not to explicitly include a wealth variable so as to reduce the multicollinearity problems. But then the remaining coefficient contains a combination of influences of the two variables, which is likewise theoretically unsatisfactory. Some studies seek to overcome this problem by choosing a transactions variable with a less pronounced correlation with wealth, e.g.

domestic demand or consumption.[62] No evidence has been found so far for Germany, however, that a different transactions variable may have a better explanatory content.

Portfolio models usually cope with the problem by formulating relative variables. The advantage of this is that the technical problems mentioned can be very much reduced, if not eliminated altogether, and that the coefficients remain interpretable in terms of monetary theory. Such a transformation would have the following form:

(19a) $m=\beta_0+\beta_1\cdot(i^A-i^E)+\beta_2\cdot y+\beta_3\cdot w+\varepsilon$ or

(19b) $m^r=\beta_0+\beta_1\cdot(i^A-i^E)+\beta_2\cdot y^r+\beta_3\cdot w^r+\varepsilon$

If a model contains more than two non-stationary variables, several stationary linear relations may exist between these variables. In the extreme case up to n-1 (linearly independent) cointegration vectors may exist between n non-stationary variables. It is therefore necessary to determine in a first step the number of these long-run relations between the variables examined or, technically speaking, to determine the rank of the cointegration matrix. If several cointegrating relations existed but the estimations (erroneously) assumed only one such relation, the latter would represent a mixture of different cointegration vectors. Possible solutions to this problem have been proposed, for example, by Johansen[63] and by Stock and Watson.[64] The following table shows the results of corresponding tests according to the Johansen method.

Given an error probability of 5 %, there is a significant long-run relation in all cases between the money stock, the interest rate differential, gross domestic product and portfolio wealth. It is interesting, however, that various estimations turn out to be less robust.[65] Furthermore, the hypothesis of price homogeneity turned out to be rejected by the

---

62 Angelini et al. (1994, page 23) use domestic demand, while Brookes et al. (1991, page 141) sometimes use consumption.

63 See Johansen (1988) and (1991). It should be pointed out that the existence of stationary variables is not a precondition of the Johansen test as the Johansen method implicitly includes a test for stationarity.

64 See Stock and Watson (1988).

65 In the case of the specification in real terms, in particular, even small changes in the length of the lag lead to the existence of a second cointegration relation.

data. It is possible, however, that these results are due more to the low power of the Johansen method. It therefore seems appropriate to carry out supplementary tests at a later stage.

Table 3: Rank of the cointegration matrix (trace statistic)

H_0	H_A	LR-statistic	95%	99%	Interpretation of the null hypothesis
a)	$m, i^A - i^E, y, w$				
$r=0$	$r \geq 1$	50.1	47.2	54.5	rejected
$r=1$	$r \geq 2$	22.7	29.7	35.7	not rejected
$r=2$	$r \geq 3$	4.5	15.4	20.0	not rejected
$r=3$	$r=4$	0.1	3.8	6.7	not rejected
	$m^r, i^A - i^E, y^r, w^r$				
$r=0$	$r \geq 1$	55.8	47.2	54.5	rejected
$r=1$	$r \geq 2$	19.5	29.7	35.7	not rejected
$r=2$	$r \geq 3$	7.8	15.4	20.0	not rejected
$r=3$	$r=4$	0.1	3.8	6.7	not rejected
b)	m, i^A, y, w				
$r=0$	$r \geq 1$	54.9	47.2	54.5	rejected
$r=1$	$r \geq 2$	26.9	29.7	35.7	not rejected
$r=2$	$r \geq 3$	9.0	15.4	20.0	not rejected
$r=3$	$r=4$	0.1	3.8	6.7	not rejected
	m^r, i^A, y^r, w^r				
$r=0$	$r \geq 1$	72.5	47.2	54.5	rejected
$r=1$	$r \geq 2$	26.2	29.7	35.7	not rejected
$r=2$	$r \geq 3$	9.7	15.4	20.0	not rejected
$r=3$	$r=4$	2.6	3.8	6.7	not rejected

1) Estimates with three dummy variables[66] restricted to the dynamics, figures rounded to one decimal place.

66 The first dummy variable has the value one in the third quarter of 1990, otherwise zero. The second dummy variable has the value one in the fourth quarter of 1993 and in the first quarter of 1994, whereas the third dummy variable assumes the value one in the fourth quarter of 1994. See Deutsche Bundesbank (1995), July Monthly Report.

The above results imply in turn that the next steps can be based on the approaches that were derived for the existence of exactly one cointegration relation.[67] Two such approaches, in particular, are very popular in the literature. According to Engle and Granger's two-step procedure,[68] the long-run relation is first estimated by means of a static OLS regression. If the residuals of this estimation turn out to be stationary, they are inserted into the dynamic model in the second step. Under the null hypothesis, the OLS estimated figures in the long-run relation do not follow a normal distribution. It can be shown, however, that they converge relatively quickly towards their true values (so-called "*super consistency*").[69] Even so, considerable distortions may occur, especially in small samples ("*small sample bias*"[70]). This could result in substantial inference problems. Even major tests can be falsified as a consequence. In order to minimise or avoid the possible occurrence of these distortions, Stock has suggested estimating the cointegration parameters and the parameters of the short-run dynamics by a one-step process.[71] [72] Using Monte Carlo simulations it can then be demonstrated that the small sample bias is much smaller. This result is questioned by later studies, however. They point out that the quality of the estimation results relies heavily on the properties of the data-generating process.[73] What is more, the simultaneity bias proves to be comparatively unproblematical if the determination coefficient of the long-run equation approximates to the value of one.[74] In the present case that condition holds for all estimations. Consequently, we can make use of Engle and Granger's two-step estimation procedure. That gives us the following equation:

---

67 The additional assumption of exogeneity is examined below.

68 See Engle and Granger (1987).

69 See Stock (1987).

70 See Banerjee et al. (1986) and Stock (1988).

71 See Stock (1987), page 6 f.

72 Under the null hypothesis the error correction term is integrated, so that the long-run coefficients are not normally distributed. As a rule, therefore, a Bewley transformation is used to carry out coefficient tests. See Hansen (1993), page 142 ff. and Banerjee et al. (1993), page 53 ff. A detailed exposition is given in annex 3.

73 See Engle and Yoo (1987, 1991).

74 See Davidson and MacKinnon (1993), page 724.

$$\text{(20a)}\quad \alpha_1(L)\Delta m_t = [\beta_0 \cdot m + \beta_1 + \beta_2(i^A - i^E) + \beta_3 y + \beta_4 w]_{t-1} + \alpha_2(L)\Delta(i^A - i^E)_t + \alpha_3(L)\Delta y_t + \alpha_4(L)\Delta w_t + \varepsilon_t$$

where the term in square brackets denotes the long-run relation estimated in the first step and the $\alpha_i(L)$ stand for polynomials in the lag operator L. As mentioned earlier, the significance of the cointegration term is assessed on the basis of the t-value of the error correction term.[75] In our case this yields the following results:[76]

---

75 As residual-based stationarity tests have a low power owing to common factor restriction, the presence of cointegration has been assessed in the recent past on the basis of the t-value for the error correction term in the dynamic approach. See Kremers, Ericsson and Dolado (1992).

76 Non-significant variables were eliminated. A comparison of the results of similar estimations with the corresponding values arising for an estimation up to and including the second quarter of 1990 can be found in Deutsche Bundesbank (1995), July Monthly Report.

Table 4: Estimations of error correction models

Estimation with interest rate differential in nominal units

$$\Delta m_t = \underset{(3.36)}{0.21}\cdot\Delta m_{t-1} + \underset{(1.73)}{0.07}\cdot\Delta m_{t-4} + \underset{(-3.39)}{(-0.16)}\cdot\left[m_{t-1} - 0.16 + 0.50\cdot(i^A - i^E)_{t-1} - 0.75\cdot y_{t-1} - 0.29\cdot w_{t-1}\right]$$

$$+\underset{(2.51)}{0.16}\cdot\Delta y_t \underset{(-3.06)}{-0.21}\cdot\Delta y_{t-1} + \underset{(7.28)}{0.56}\cdot\Delta w_t + \underset{(11.3)}{0.10}\cdot Dummy1 + \underset{(2.99)}{0.01}\cdot Dummy2 \underset{(-2.32)}{-0.02}\cdot Dummy3$$

$R_k^2 = 0.87$, SER = 0.006, AR(8) = 1.32, White = 0.80, ARCH(8) = 0.66

Estimation with long-term interest rate in nominal units

$$\Delta m_t = \underset{(3.44)}{0.21}\cdot\Delta m_{t-1} + \underset{(1.67)}{0.07}\cdot\Delta m_{t-4} + \underset{(-3.56)}{(-0.17)}\cdot\left[m_{t-1} - 0.17 + 0.35\cdot i^A{}_{t-1} - 0.78\cdot y_{t-1} - 0.27\cdot w_{t-1}\right]$$

$$+\underset{(2.41)}{0.16}\cdot\Delta y_t \underset{(-3.23)}{-0.23}\cdot\Delta y_{t-1} + \underset{(7.59)}{0.57}\cdot\Delta w_t + \underset{(11.4)}{0.10}\cdot Dummy1 + \underset{(3.02)}{0.01}\cdot Dummy2 \underset{(-2.41)}{-0.02}\cdot Dummy3$$

$R_k^2 = 0.87$, SER = 0.006, AR(8) = 1.20, White = 0.79, ARCH(8) = 0.60

Estimation with interest rate differential in real units

$$\Delta mr_t = \underset{(3.35)}{0.20}\cdot\Delta mr_{t-1} + \underset{(-3.01)}{(-0.14)}\cdot\left[mr_{t-1} + 0.47 + 0.52\cdot(i^A - i^E)_{t-1} - 0.73\cdot yr_{t-1} - 0.35\cdot wr_{t-1}\right]$$

$$+\underset{(1.87)}{0.13}\cdot\Delta yr_t \underset{(-3.32)}{-0.24}\cdot\Delta yr_{t-1} + \underset{(7.28)}{0.60}\cdot\Delta wr_t - \underset{(-1.98)}{0.16}\cdot\Delta p_t + \underset{(11.2)}{0.10}\cdot \mathrm{Dummy1} + \underset{(3.09)}{0.01}\cdot \mathrm{Dummy2}$$

$$\underset{(-2.19)}{-0.02}\cdot \mathrm{Dummy3} + \underset{(1.20)}{0.05}\cdot\Delta mr_{t-4}$$

$R_k^2 = 0.88$, SER = 0.007, AR(8) = 1.65, White = 0.83, ARCH(8) = 0.63

Estimation with long-term interest rate in real units

$$\Delta mr_t = \underset{(3.39)}{0.21}\cdot\Delta mr_{t-1} + \underset{(1.14)}{0.05}\cdot\Delta mr_{t-4} + \underset{(-3.05)}{(-0.14)}\cdot\left[mr_{t-1} + 0.51 + 0.31\cdot i^A{}_{t-1} - 0.75\cdot yr_{t-1} - 0.34\cdot wr_{t-1}\right]$$

$$+\underset{(1.73)}{0.12}\cdot\Delta yr_t \underset{(-3.45)}{-0.25}\cdot\Delta yr_{t-1} + \underset{(8.56)}{0.61}\cdot\Delta wr_t - \underset{(-1.90)}{0.15}\cdot\Delta p_t + \underset{(11.3)}{0.10}\cdot Dummy1 + \underset{(3.14)}{0.01}\cdot Dummy2$$

$$\underset{(-2.27)}{-0.02}\cdot Dummy3$$

$R_k^2 = 0.88$, SER = 0.007, AR(8) = 1.50, White = 0.90, ARCH(8) = 0.57

R_k2 = adjusted determination coefficient, SER = standard error of the regression, AR = Breusch-Godfrey test for autocorrelation,[77] White = White's test for heteroscedasticity,[78] ARCH = ARCH test,[79] the figures in brackets are the t-values of the coefficients.

---

77 See Breusch (1978) and Godfrey (1978).

78 See White (1980).

79 See Engle (1982).

At first the residuals display the desired properties of a Gaussian error term. The results of the estimations further indicate that both income and wealth represent determinants of money demand. In all cases the variables show the expected positive signs and plausible orders of magnitude in the long run. In addition, they are individually significant.[80] The adjustment to this equilibrium amounts to about 15% per quarter. The interest semi-elasticity, as a measure of the opportunity cost, has the expected negative sign, although in both cases the value is rather small and not too significant. The upper two equations also show that, if wealth is included, price homogeneity may be assumed in the long run; but, as the lower equations show, that does not hold in the short run. More surprising is the result that in the estimation of the long-run money demand function the sum of income and wealth elasticities comes to around one - a phenomenon which, in estimations of production functions, is usually referred to as "*constant return to scale*".[81] That signifies the property of linear homogeneity of the money stock in relation to income and wealth. In other words, for a given interest rate level a rise in income and wealth at the same rate will be accompanied by monetary growth at that rate. Finally, all dummy variables prove to be significant.[82]

The results of cointegration tests cannot distinguish between the various possibilities of causal interpretation. Additional tests are needed for that. In contrast to the Johansen approach, in which each variable is considered to be endogenous, the Engle-Granger approach and the Stock approach assume exogeneity of the right-hand variables. According to Engle, Hendry and Richard, three types of exogeneity can be distinguished: "*weak exogeneity*", "*strong exogeneity*" and "*superexogeneity*".[83] Depending on the form of

---

80 This was tested by means of an additional Fully Modified OLS estimation which will not be further discussed here.

81 This result is in line with Tobin's model (1969). The remarkable thing about this result is the fact that the equation can be incorporated into a portfolio approach. For if we say by way of simplification that $m = \alpha \cdot y + (1-\alpha) \cdot w$, it follows that $m - w = \alpha \cdot (y - w)$ and hence after removing the logarithms $M / W = \alpha \cdot (Y / W)$. And this specification corresponds exactly to an estimation in portfolio shares.

82 It might be possible, particularly in the context of cointegration models, to take account of the level effects by inserting dummy variables into the long-run relation. They proved to be insignificant, however.

83 See Engle, Hendry and Richard (1983).

exogeneity, it is possible to make hypothesis tests (given weak exogeneity), forecasts (given strong exogeneity) and simulations (given superexogeneity).[84] Only in case of weak exogeneity is it sufficient to estimate a money demand function as a single equation. Otherwise a whole system of equations would have to be formulated and estimated for each right-hand variable. To test this hypothesis it is customary to reformulate the system after the changes in the right-hand variables and to test the exogeneity on the basis of the non-significance of the error correction term in the corresponding equations. This can be done, for example, using a Lagrange multiplier test.[85] If the error correction term only turns out to be significant in the money demand equation but non-significant in all other equations, it may be concluded that adjustments to disequilibria occur by way of money demand.

If such a procedure is applied to the present system, it turns out that, using the interest rate differential in both specifications, the adjustment coefficient of the long-run relation is significant in the first equation (χ^2 = 12.8, Prob = 0.003 or χ^2 = 12.7, Prob = 0.004), although the hypothesis of non-significance must also be rejected for all other equations (χ^2 = 89.9, Prob = 0.0000 or χ^2 = 106.7, Prob = 0.0000). If, on the other hand, the estimation is carried out with the long-term interest rate as the opportunity cost variable and in nominal units, the coefficient of the error correction term in the money demand equation proves to be significant (χ^2 = 13.8, Prob = 0.0002), whereas in all other equations it is not significantly different from zero (χ^2 = 0.76, Prob = 0.38). A similar result is obtained in the case of real specification (χ^2 = 4.16, Prob = 0.03 or χ^2 = 0.12, Prob = 0.73). Thus, it may be concluded that the use of the own rate of interest violates the assumption of exogeneity in the money demand. If, however, money demand is modelled as a function of the long-term interest rate, a single equation approach appears sufficient.[86] The estimated relation can then be interpreted as a money demand function, with adjustments to disequilibria occurring via the money demand.

---

84 The presence of superexogeneity is particularly interesting. If this property is present, the model can be used for simulations of monetary policy scenarios without running the risk that the parameters may be influenced by the respective monetary policy regime and hence are subject to the Lucas critique.

85 See Hansen (1993), page 194 ff. and also Boswijk (1994). According to Hansen (1993, page 148) an approximative F-test is also conceivable.

86 That also appears to justify the approach adopted by the Bundesbank. See Deutsche Bundesbank (1995), July Monthly Report, page 17-35.

V. The significance of wealth for the velocity of circulation

One of the main findings of the error correction model was that the sum of the income and wealth elasticities was around one. This particular result also has implications for the trend in the velocity of circulation, as is demonstrated below. Our starting point for this is a money demand function in nominal and logarithmic form:

(21) $m = \beta_0 + \beta_1 \cdot i^A + \beta_2 \cdot y + \beta_3 \cdot w + \varepsilon$

And within this framework, the results mentioned above can be summarised as $\beta_2 + \beta_3 = 1$ or $\beta_3 = 1 - \beta_2$. That yields:

(22) $m = \beta_0 + \beta_1 \cdot i^A + y + (1 - \beta_2) \cdot (w - y) + \varepsilon$

The logarithimic form of the quantity theory can be written as:

(23) $m = y - v$

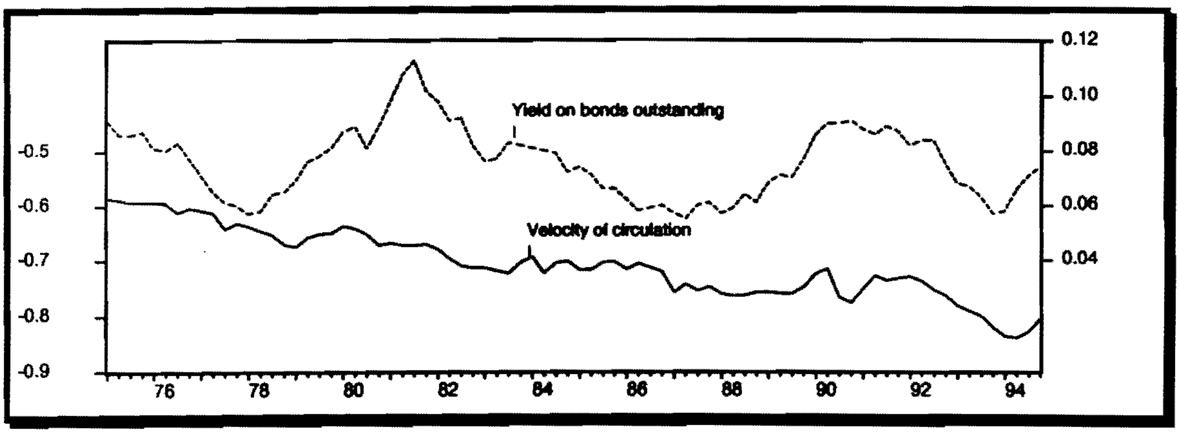
Rearranging and simplifying the two equations leads to the following expression:

(24) $v = -\beta_0 - \beta_1 \cdot i^A - (1 - \beta_2) \cdot (w - y) - \varepsilon$

This expression helps us to identify the two factors which lead to changes in the (logarithmic) velocity of circulation. The first factor are the changes in the yield rate on alternative assets, provided that the money demand proves to be interest-elastic ($\beta_1 \neq 0$). The second contributory factor are changes in the relationship between (logarithmic) wealth and (logarithmic) income, as long as β_2 - the value of the (pure) income elasticity - is different from one.

Under these circumstances a falling trend in the velocity of circulation may be attributable to a lasting rise in the interest rate variable or to a persistently higher increase in wealth compared with income. As the chart below shows, the yield on bonds outstanding shows longer phases of unidirectional changes but no such trend pattern over the observation period as a whole.

Chart 2: Logarithmic velocity of circulation and yield on bonds outstanding over time



Source: Own calculations.

This suggests a dominating role for the second factor. This determinant would only have no explanatory content if either (logarithmic) wealth exactly matched (logarithmic) income and/or the value of β_2 - the (pure) income elasticity - were equal to one. The results of the present study indicate that neither condition is given. Hence it would be necessary in future, too, to derive a trend growth for the velocity of circulation. Essentially, that does not affect the procedure for deriving the monetary target. If, however, the results derived above are to be used for predicting the future pattern of the velocity of circulation, it would be necessary not only to estimate production potential but also to forecast (potential) portfolio wealth.

VI. Monetary policy implications

A policy which is based on the control of the money supply must - if it is to be more than a "trial and error" process - be founded on a precise knowledge of the money demand and its determinants. If the demand for money is based on portfolio considerations - and that appears to be substantiated - the influence of wealth must be taken into consideration. This paper has attempted to demonstrate such an influence for Germany.

Based on a portfolio wealth definition, the inclusion of this variable led to the expected signs and to plausible orders of magnitude. In addition, the coefficients turned out to be statistically significant. The stationary residual term indicates the existence of a long-run equilibrium relationship including wealth. If the results of the money demand estimations are integrated into a simple model for the velocity of circulation, a trend decline in the velocity of circulation ($\Delta v<0$) occurs if wealth grows faster than gross domestic product ($\Delta (w-y) > 0$) and the long-run income elasticity of the demand for money is less than one. Both conditions appear to be met for Germany. One possible reason for this could be the increasing significance of money as a store of value.

The significance of wealth in the demand for money does not imply any fundamental change of strategy in deriving monetary targets. Nevertheless, the results of the present study could be taken into account in estimations of the velocity of circulation. In this sense it is even conceivable that the instabilities of the velocity of circulation that have been found by some researchers for other countries could be given a new interpretation in the light of our work.

Annexes

Annex 1: The problem of multicollinearity

This method seeks to quantify the extent to which the variance of an estimated coefficient is increased by the presence of multicollinearity. A high variance-inflating factor (VIF) indicates that multicollinearity has indeed *"inflated"* the estimated variance of the coefficient and has thus led to a lower t-value. If, by way of illustration, we proceed from the case of the three-variables regression, the following holds:

$$(1) \quad Y = \alpha + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \varepsilon$$

The variances of the estimated slope coefficients can be computed by the following formulas:[87]

$$(2) \quad \operatorname{var}(\beta_i) = \frac{\sigma^2}{\sum (x_i)^2 (1 - r_{X_1X_2}{}^2)}$$

where $\sum x_i^2 = \sum (X_i - \bar{X})^2$ and $r_{X_1X_2}{}^2$ denotes the determination coefficient of a regression of X_1 on X_2. If there is no correlation between the X_i values (case of orthogonality), the value of the correlation coefficient is zero and the following would hold:

$$(3) \quad \operatorname{var}(\beta_i^{orth}) = \frac{\sigma^2}{\sum (x_i)^2}$$

A measure of the increase in the variance due to the presence of multicollinearity can be obtained by calculating the ratio of the variances in the case of multicollinearity and in the case of orthogonality (assuming a constant $\sum x_i^2$). Then the following expression holds:

$$(4) \quad VIF = \frac{\operatorname{var}(\beta_i)}{\operatorname{var}(\beta_i^{orth})} = \frac{\sigma^2}{\sum (x_i)^2 (1 - r_{X_1X_2}{}^2)} \cdot \frac{\sum (x_i)^2}{\sigma^2} = \frac{1}{(1 - r_{X_1X_2}{}^2)}$$

---

87 Johnston (1986), page 247 ff. and Judge et al. (1980), page 461 ff.

A correlation coefficient of one shows perfect multicollinearity ($VIF = \infty$), whereas a correlation coefficient of zero indicates no multicollinearity ($VIF = 1$). A correlation coefficient of, say, 0.9 gives a VIF of 10, which means that the estimation error of the corresponding variable has increased ten-fold. There are no precise critical values for this method for assessing the empirical relevance of multicollinearity; a fairly major role is played by the number of independent variables. Whereas some authors give a value of five, others prefer a value of ten, especially if there are more than just two right-hand variables.

Annex 2: The Johansen method

The starting point of the Johansen approach is a vector-autoregressive system with the following form:[88]

$$(1a)\quad x_t = \Pi_1 x_{t-1} + \ldots + \Pi_k x_{t-k} + \varepsilon_t \qquad \text{with} \qquad t = 1,2\ldots T$$

where x_t is a vector with p variables and ε_t is a $(p \times 1)$ vector of disturbance terms. The Π_i are $(p \times p)$ coefficient matrices. It is moreover assumed that ε has the property of a Gaussian error term. To complete the picture it should be pointed out that the above equation can be expanded at any time by a vector containing constant terms. It would then read as follows:

$$(1b)\quad x_t = \mu + \Pi_1 x_{t-1} + \ldots + \Pi_k x_{t-k} + \varepsilon_t$$

As most economic time series are integrated of order one, this annex is restricted to (non-stationary) first-order processes.[89] By way of such processes the vector x_t from equation (1) can be represented in the following general error correction form:

$$(2)\quad \Delta x_t = \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_k \Delta x_{t-k+1} + \Pi x_{t-k} + \varepsilon_t$$

where $\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i$ with $i = 1 \ldots k-1$ and $\Pi = -(I - \Pi_1 - \ldots \Pi_k)$. The matrix Π is of special importance, for the rank r of this matrix corresponds exactly to the number of linear and independent cointegration relations among the variables which vector x_t contains. If the rank turns out to be zero (case 1) this results exactly in the standard model of a vector autoregression in first differences without an error correction term. On the other hand, if the matrix has full rank (case 2), all variables in vector x_t are already stationary in the level. Then the estimation has to be performed in levels. It is also possible, however, that the rank of a matrix assumes a value between zero and the full rank (case 3, $0<r<p$). It is therefore important to determine this rank and hence the number of cointegration relations. If it is assumed that the matrix has the rank r whereas the full rank would be p, this implies that in

---

88 See Johansen (1988), Johansen (1991), Johansen (1992), Johansen and Juselius (1990) and Johansen and Juselius (1991).

89 Second-order non-stationary processes are dealt with in Johansen (1992).

this case p-r linear non-stationary relations and r linear and stationary relations exist. Π is now partitioned into two *(pxr)* matrices α and β, such that:

(3) $\Pi = \alpha \beta'$

The aforementioned relation now reads:

(4) $\Delta x_t = \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_k \Delta x_{t-k+1} + \alpha \beta' x_{t-k} + \varepsilon_t$

where α is the loading matrix and β the cointegration matrix. Both matrices have the rank r. The first r lines of β give the r different cointegration vectors, whereas the elements of α give the loads of the various cointegration vectors in the individual equations and so indicate the velocity of adjustment to equilibrium. As the two matrices α und β have the same rank as the original matrix Π, it suffices thereafter to test the matrix β.

Johansen has proposed two likelihood ratio tests by means of which the rank of the cointegration matrix can be tested.[90] Both procedures test the null hypothesis of the existence of q or fewer cointegration vectors ($r \le q$) against a special form of the alternative hypothesis.[91] If the test statistic exceeds the critical values, the null hypothesis is rejected.

The first, so called "*trace test*" tests the null hypothesis that a maximum of r (i.e. r or fewer) different cointegration vectors exist:

(5) $Q(Trace) = T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i)$

where the eigenvalues $\hat{\lambda}_p \ldots \hat{\lambda}_{r+1}$ are the least-squares canonical correlations between the level residuals R_{1t} and the residuals in the first difference R_{0t}. The latter are determined by regressing the variables vector both in the level x_{t-k} and in the first differences Δx_t on the lagged differences of the vector $\Delta x_{t-1} \ldots \Delta x_{t-k+1}$. The number of significant correlations then corresponds to the number of cointegration relations.

90 Details can be found in Johansen (1988, 1991) and Johansen and Juselius (1990).

91 See Sauer (1992), page 344.

The second, so-called λ_{max}-test (*"maximum eigenvalue statistic"*) tests the hypothesis of a maximum of r cointegration vectors against the alternative of r+1 cointegration vectors.

$$(6) \quad Q(\lambda_{max}) = T \ln(1 - \hat{\lambda}_{r+1})$$

Johansen has shown that the two tests do not follow a standard distribution under the null hypothesis. However, in Johansen (1988), Johansen and Juselius (1990), and Osterwald-Lenum (1992) critical values were calculated using Monte Carlo simulations.

The assumption of price homogeneity can likewise be tested using the Johansen method. First of all the number of cointegration vectors is determined. It can then be examined whether the estimated elasticities correspond to their theoretical values. That is done by normalising the coefficients to the money stock figures. Subsequently hypothesis tests can be carried out by first imposing restrictions on the cointegration vector which are then tested in the following step. The test statistic then follows a chi-square distribution with $r \cdot s$ degrees of freedom, where r stands for the number of cointegration vectors and s for the number of restrictions imposed.

Annex 3: The derivation of the error correction model and of the modified error correction model

The starting point is a general dynamic model between two variables. Let the following be the general form:[92]

(1) $y_t = \alpha_0 + \alpha_1 \cdot y_{t-1} + \beta_0 \cdot x_t + \beta_1 \cdot x_{t-1} + \varepsilon_t$ where $|\alpha_1| < 1$ and $\varepsilon_i \approx N(0, \sigma^2)$

This model contains a number of special cases which can be achieved by setting parameter restrictions ("*nested model*"). It results, for example, in

a) the static regression model, if $\alpha_1 = 0, \beta_1 = 0$
b) the partial adjustment model, if $\beta_1 = 0$
c) the differences model, if $\alpha_1 = 1, \beta_1 = -\beta_0$

A common transformation of this model is the error correction model. If the left-hand variable, lagged by one period, is substracted from both sides, we obtain:

(2) $y_t - y_{t-1} = \alpha_0 + (\alpha_1 - 1) \cdot y_{t-1} + \beta_0 \cdot x_t + \beta_1 \cdot x_{t-1} + \varepsilon_t$ and hence

(4) $\Delta y_t = \alpha_0 + \beta_0 \cdot \Delta x_t + (\alpha_1 - 1) \cdot \left[y_{t-1} + \left(\frac{\beta_0 + \beta_1}{\alpha_1 - 1} \right) \cdot x_{t-1} \right] + \varepsilon_t$ or

(5) $\Delta y_t = \alpha_0 + \beta_0 \cdot \Delta x_t + (\alpha_1 - 1) \cdot \left[y_{t-1} - \left(\frac{\beta_0 + \beta_1}{1 - \alpha_1} \right) \cdot x_{t-1} \right] + \varepsilon_t$ as $|\alpha_1 < 1|$ holds;

and as $|\alpha_1| < 1$ it follows that $(\alpha_1 - 1)$ must be negative for an adjustment to occur. The adjustment takes the form that y_t moves towards the long-run equilibrium. The closer $(\alpha_1 - 1)$ to the value of one, the more rapid is the adjustment. Furthermore, it seems quite obvious that in the long-run equilibrium in which all rates of change can be set to zero ("*steady state*"), the error correction model can be reduced exactly to the cointegration relationship.

---

92 See Hansen (1993), p. 142 ff.

To derive the standard deviations and t-tests of the coefficients of the long-run relationship, it is advisable to use the Bewley transformation. To this end, we start off again with the equation:

(1) $y_t = \alpha_0 + \alpha_1 \cdot y_{t-1} + \beta_0 \cdot x_t + \beta_1 \cdot x_{t-1} + \varepsilon_t$

we subtract first $\alpha_1 y_t$, then $\beta_0 x_{t-1}$ and finally divide by $(1-\alpha_1)$. That gives us:

(6) $$y_t = \frac{\alpha_0}{1-\alpha_1} - \frac{\alpha_1}{1-\alpha_1} \cdot (y_t - y_{t-1}) + \frac{\beta_0}{1-\alpha_1} \cdot (x_t - x_{t-1}) + \left(\frac{\beta_1 + \beta_0}{1-\alpha_1}\right) \cdot x_{t-1} + \frac{\varepsilon_t}{1-\alpha_1}$$ or

(7) $$y_t = \frac{\alpha_0}{1-\alpha_1} - \frac{\alpha_1}{1-\alpha_1} \cdot \Delta y_t + \frac{\beta_0}{1-\alpha_1} \cdot \Delta x_t + \left(\frac{\beta_1 + \beta_0}{1-\alpha_1}\right) \cdot x_{t-1} + \frac{\varepsilon_t}{1-\alpha_1}$$

However - as the equation (1) shows - Δy_t is correlated with the error term, and hence the method of ordinary least squares leads to inconsistent results, therefore equation (7) has to be estimated by means of the instrumental variables approach.[93]

93 See Wickens und Breusch (1988) and also Banerjee (1993).

References

Amano, R.A. and Wirjanto, T.S., The Dynamic Demand for Money in Germany, Japan and the United Kingdom, Bank of Canada, Working Paper 93-10.

Angelini, P.; Hendry, D.F. and Rinaldi, R. (1994), An Econometric Analysis of Money Demand in Italy, Temi di Discussione del Servizio Studi, Number 219, (March), Banca d' Italia.

Banerjee, A.; Dolado, J.J.; Galbraith, J.W. and Smith, G. (1986), Exploring Equilibrium Relationships in Econometrics through Static Models: Some Monte Carlo Evidence, Oxford Bulletin of Economics and Statistics, Vol. 48, pp. 253-277.

Banerjee, A.; Dolado, J.J.; Galbraith, J.W. and Hendry, D.W. (1993), Co-Integration, Error Correction, and the Econometric Analysis of Non-Stationary Data, Oxford University Press.

Baumol, W.J. (1952), The Transactions Demand for Cash: An Inventory Theoretic Approach, Quarterly Journal of Economics, Vol. 66, November, pp. 545-556.

Bergen, V. (1970), Theoretische und empirische Untersuchungen zur längerfristigen Geldnachfrage in der Bundesrepublik Deutschland (1950-1967), J.C.B. Mohr (Paul Siebeck) Tübingen.

Biefang-Frisancho Mariscal, I.; Trautwein, H-M.; Howells, P.; Arestis, P. and Hagemann, H. (1995), Financial Innovation and the Long-Run Demand for Money in the United Kingdom and in Germany, Weltwirtchaftliches Archiv, Issue 2, Vol. 131, pp. 302-325.

Blinder, A.S. and Solow, R.M. (1974), Analytical Foundations of Fiscal Policy, in: The Economics of Public Finance, The Brookings Institution, Washington D.C., pp. 3-115.

Bomberger, W.A. (1993), Income, Wealth and Household Demand for Deposits, American Economic Review, September, pp. 1034-1044.

Boschen, J.F. and Mills, L.O. (1995), Tests of Long-Run Neutrality using Permanent and Real Shocks, Journal of Monetary Economics, Vol. 35, pp. 25-44.

Boswijk, P. (1994), Lagrange-Multiplier Tests for Weak Exogeneity: A Synthesis", Tinbergen Institute, University of Amsterdam.

Boughton, J. (1981), Recent Instability of the Demand for Money: An International Perspective, Southern Economic Journal, Vol. 47, pp. 579-597.

Boughton, J. (1991a), Money Demand in Five Major Industrialized Countries: Estimating and Interpreting Error Correction Models, in: Taylor, M.P. (ed.): "Money and Financial Markets", Oxford, Basil Blackwell, pp. 109-129.

Boughton, J. (1991b), Long-Run Money Demand in Large Industrial Countries, IMF Staff Papers, Vol. 38, pp. 1-32.

Boughton, J. (1992), International Comparisons of Money Demand, Open Economies Review, Vol. 3, pp. 323-343.

Boughton, J. and Tavalas, G.S. (1991), What Have We Learned about Estimating the Demand for Money: A Multicountry Evaluation of some New Approaches, IMF Working Paper 91/16.

Breusch, T.S. (1978), Testing for Autocorrelation in Dynamic Linear Models, Australian Economic Papers, Vol. 17, pp. 334-355.

Bronfenbrenner, M. and Mayer, T. (1960), Liquidity Functions in the American Economy, Econometrica, Vol. 28, October, pp. 810-834.

Brookes, M.; Hall, S.; Henry, B. and Hoggarth, G. (1991), Modelling Broad and Narrow Money: A Study using Cointegration, in: Taylor, M.P. (ed.), Money and Financial Markets, Basil Blackwell, Cambridge, pp. 130-148.

Brunner, K. and Meltzer, A.H. (1993), Money and the Economy Issues in Monetary Analysis, Raffaele Mattioli Lectures, Banca Commerciale Italiana, Milano, Italy.

Callen, T. (1991), Estimates of Private Sector Wealth, Research Discussion Paper, RDP 9109, Reserve Bank of Australia.

Cassard, M.; Lane, T. and Masson, P.R. (1994), ERM Money Supplies and the Transition to EMU, IMF Working Paper 94/1, Washington D.C..

Chow, G.C. (1966), On the Long-Run and Short-Run Demand for Money, Journal of Political Economy, Vol. 74 (April), pp. 111-131.

Chow, G. C. (1996), The Lagrange Method of Optimization with Applications to Portfolio and Investment Decisions, Journal of Economic Dynamics & Control, Vol. 20, Jan.-March 1996, pp. 1-18.

Darnell, A. (1994), A Dictionary of Econometrics, Edward Elgar, Aldershot, England.

Davidson, R. and MacKinnon, J.G. (1993), Estimation and Inference in Econometrics, Oxford University Press.

Deutsche Bundesbank (1987), Private non-financial and financial asset acquisition, Monthly Report for August, pp. 41-46.

Deutsche Bundesbank (1992), West German households' acquisition of financial assets and capital formation over the past 20 years, Monthly Report for April, pp. 14-20.

Deutsche Bundesbank (1993), Households' asset acquisition in Germany, Monthly Report for October, pp. 19-32.

Deutsche Bundesbank (1994), The trend in and significance of assets held in the form of investment fund certificates, Monthly Report for October, pp. 49-63.

Deutsche Bundesbank (1994), Ergebnisse der gesamtwirtschaftlichen Finanzierungsrechnung für Westdeutschland 1960 bis 1992, Special Statistical Publication, November.

Deutsche Bundesbank (1995), Demand for money and currency substitution in Europe, Monthly Report for May, pp. 17-49.

Deutsche Bundesbank (1995), Overall financial flows in Germany in 1994, Monthly Report for May, pp. 17-41.

Deutsche Bundesbank (1995), Review of the monetary target and restructuring of the minimum reserve regulations, Monthly Report for July, pp. 17-35.

Deutsche Bundesbank (1995), Financial accounts for Germany 1990-1994, Special Statistical Publication 4, August.

Deutsche Bundesbank (1995), The monetary policy of the Bundesbank, Special Statistical Publication, October.

Dickey, D.A and Fuller, W.A. (1979), Distribution of the Estimators for Autoregressive Time Series with a Unit Root, Journal of the American Statistical Association, Vol. 74, pp. 427-431.

Dickey, D.A. and Fuller, W.A. (1981), Likelihood Ratio Tests for Autoregressive Time Series with a Unit Root, Econometrica, Vol. 49, pp. 1057-1072.

Engle, R.F. (1982), Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of UK Inflation, Econometrica, Vol. 50, No. 4, pp. 987-1007.

Engle, R.F.; Hendry, D.F. and Richard, J.-F. (1983), Exogeneity, Econometrica, Vol. 51 (2), pp. 277-304.

Engle, R.F. and Granger, C.W.J. (1987), Co-Integration and Error-Correction: Representation, Estimation and Testing, Econometrica, Vol. 55, No. 2 (March), pp. 251-276.

Engle, R.F. and Yoo, B.S. (1987), Forecasting and Testing in Co-Integrated Systems, Journal of Econometrics, Vol. 35, pp. 143-159.

Engle, R.F. and Granger, C.W.J. (1991), Introduction, in: Engle, R.F. and Granger, C.W.J. (eds.), Long-Run Economic Relationships: Readings in Cointegration, Oxford University Press, Oxford, pp. 1-15.

Engle, R.F. and Yoo, B.S. (1991), Cointegrated Economic Time Series: A Survey with New Results, in: Engle, R.F. and Granger, C.W.J. (eds.), Long-Run Economic Relationships: Readings in Cointegration, Oxford University Press, Oxford, Chapter 12.

Epps, T.W. and Pulley, L.B. (1983), A Test for Normality based on the Empirical Characteristic Functions, Biometrika, Vol. 70, pp. 723-726.

Ericsson, N.R.; Hendry, D.F. and Tran, H.-A. (1994), Cointegration, Seasonality, Encompassing and the Demand for Money in the United Kingdom, in: Hargreaves, C.P. (ed), Nonstationary Time Series Analysis and Cointegration, Oxford University Press, pp. 179-224.

Falk, M. and Funke, N. (1995), The Stability of Money Demand in Germany and in the EMS: Impact of German Unification, Weltwirtschaftlliches Archiv, Vol. 3, pp. 470-488.

Fields, T.W. and Hall, T.E. (1988), Income or Wealth in Money Demand, Southern Economic Journal, October, pp. 1039-1042.

Fisher, I. (1922), Die Kaufkraft des Geldes, German Translation of: The Purchasing Power of Money (1911), Verlag wissenschaftlicher Verleger, Berlin und Leipzig.

Fisher, P.G. and Vega, J.L. (1993), An Empirical Analysis of M4 in the United Kingdom, Bank of England, Working Paper No 21.

Friedman, B.M. (1985), Crowding Out or Crowding In? Evidence on Debt Equity Substitutability, Harvard Institute of Economic Research, Discussion Paper No. 1144.

Friedman, M. (1956), The Quantity Theory of Money, A Restatement, in: Friedman, M. (ed.), Studies in the Quantity Theory of Money, Chicago University Press, pp. 3-21.

Friedman, M. (1957), A Theory of the Consumption Function, National Bureau of Economic Research, New York.

Friedman, M. (1959), The Demand for Money: Some Theoretical and Empirical Results, Journal of Political Economy, Vol. 67, August, pp. 327-351.

Friedman, M. (1979), Die Quantitätstheorie, in: Badura, J. and Issing, O. (Hrsg.), Geldtheorie, Gustav Fischer Verlag, Stuttgart, pp. 12-35.

Gerlach, S. (1994), German Unification and the Demand for German M3, BIS Working Paper No. 21.

Godfrey, L.G. (1978), Testing Against General Autoregressive and Moving Average Error Models when the Regressors Include Lagged Dependent Variables, Econometrica, Vol. 48, pp. 1293-1302.

Goldfeld, S.M. and Sichel, D.E. (1990), The Demand for Money, in: Friedman, B.E. und Hahn, F.H. (eds.), Handbook of Monetary Economics, Volume I, Elsevier Science Publishers, pp. 299-356.

Granger, C.W.J. and Newbold, P. (1974), Spurious Regressions in Econometrics, Journal of Econometrics, Vol. 2, pp. 111-120.

Granger, C.W.J. and Weiss, A.A. (1983), Time Series Analysis of Error Correcting Models, in: Karlin, S., Amemiya,T. and Goodman, L. A. (eds.), Studies in Econometrics, Time Series and Multivariate Statistics, New York Academic Press.

Gujarati, D.N. (1988), Basic Econometrics, second edition, McGraw-Hill International Editions, Singapore.

Gurley, J.G. and Shaw, E.S. (1960), Money in a Theory of Finance, Washington D.C., Brookings.

Hafer, R. W. and Jansen, D.W. (1991), The Demand for Money in the United States: Evidence from Cointegration Tests, Journal of Money, Credit and Banking, Vol. 23, pp. 155-168.

Hall, S.G.; Henry, S.G.B. and Wilcox, J.B. (1987), The Long-Run Determination of the Monetary Aggregates, Bank of England, Discussion Paper No. 41.

Hansen, G. (1988), Analyse ökonomischer Gleichgewichte und cointegrierter Zeitreihen, Allgemeines Statistisches Archiv, Vol. 72, pp. 337-358.

Hansen, G. (1993), Quantitative Wirtschaftsforschung, Verlag Franz Vahlen, Munich.

Hansen, G. and Kim, J.-R. (1995), The Stability of German Money Demand: Tests of the Cointegration Relation, Weltwirtschaftliches Archiv, Volume 131, Issue 2, pp. 286-301.

Hansen, H.-J. (1996), Der Einfluss der Zinsen auf den privaten Verbrauch in Deutschland, Discussion paper 3/96, Economic Research Group of the Deutsche Bundesbank

Hoffman, D.L.; Rasche, R.H. and Tieslau, M.A. (1995), The Stability of Long-Run Money Demand in Five Industrial Countries, Journal of Monetary Economics, Vol. 35, pp. 317-339.

Issing, O. (1991), Einführung in die Geldtheorie, Verlag Franz Vahlen, Munich.

Issing, O. (1992), Theoretische und empirische Grundlagen der Geldmengenpolitik der Deutschen Bundesbank, Wirtschaftsdienst, Year 72, Issue 10 (October), pp. 537-548.

Issing, O. and Tödter, K.-H (1994): "Geldmenge und Preise im vereinigten Deutschland", Paper prepared for the meeting of the Ausschuss für Geldtheorie und Geldpolitik of the Verein für Socialpolitik on February 25 and 26, 1994 in Frankfurt am Main.

Jarque, C.M. and Bera, A.K. (1980), Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals, Economic Letters, Vol. 6, pp. 255-259.

Johannes, J.M. and Nasseh, A.R. (1985), Income or Wealth in Money Demand: An Application of Non-Nested Hypothesis Tests, Southern Economic Journal, April, pp. 1099-1106.

Johansen, S. (1988), Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, Vol. 12 , pp. 231-254.

Johansen, S. (1991), Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, Econometrica, Vol. 59, pp. 1551-1580;

Johansen, S. (1992), An I(2) Cointegration Analysis of the Purchasing Power Parity between Australia and the United States, in: Hargreaves, C.P. (ed.), Macroeconomic Modelling of the Long Run, Aldershot: Edward Elgar, pp. 229-248.

Johansen, S. and Juselius, K. (1990), Maximum Likelihood Estimation and Inference on Cointegration - With Application to the Demand for Money, Oxford Bulletin of Economics and Statistics, Vol. 52, pp. 169-210.

Johansen, S. and Juselius, K. (1991), Testing Structural Hypotheses in a Multivariate Cointegration Analysis of the PPP and the UIP for UK, University of Copenhagen.

Johnson, H.G. (1962), Monetary Theory and Policy, American Economic Review, June, pp. 335-384.

Johnston, J. (1984), Econometric Methods, McGraw-Hill Book Company, Singapore.

Judd, J.P. and Scadding, J.L. (1982), The Search for a Stable Money Demand: A Survey of the Post-1973 Period, Journal of Economic Literature, Vol. 20, pp. 993-1023.

Judge, G.C.; Griffiths, W.E.; Carter Hill, R.; Lee, T.-C. (1980), The Theory and Practice of Econometrics, John Wiley & Sons, New York.

Keynes, J.M. (1936), The General Theory of Employment, Interest and Money, London, MacMillan.

Kole, L.S. and Leahy, M.P. (1991), The Usefulness of P* Measures for Japan and Germany, International Finance Discussion Paper, Number 414, November, Board of Governors of the Federal Reserve System.

Kole, L.S. and Meade, E.E. (1995), German Monetary Targeting: A Retrospective View, Federal Reserve Bulletin, Volume 81, Number 10 (October), pp. 917-931.

Krämer, J.W. (1995), Schätzung von Geldnachfragefunktionen - zinsgewichtete versus gewöhnliche Geldmengen, Kieler Arbeitspapier Nr. 673, Institut für Weltwirtschaft.

Kremers, J.J.M.; Ericsson, N.R. and Dolado, J.J. (1992), The Power of Cointegration Tests, Oxford Bulletin of Economics and Statistics, Vol. 54, No. 3, pp. 325-348.

Kwiatkowski, D.; Phillips, P.C.B.; Schmidt, P. and Shin, Y. (1992), Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root, Journal of Econometrics, Vol. 54, pp. 159-178.

Laidler, D.E.W. (1966), Some Evidence on the Demand for Money, Journal of Political Economy, Vol. 74, pp. 55-68.

Laidler, D.E.W. (1993), The Demand for Money - Theories, Evidence, and Problems, Fourth Edition, Harper Collins College Publishers.

Lieberman, C. (1980), The Long-Run and Short-Run Demand for Money Revisited, Journal of Money, Credit and Banking, February, pp. 43-57.

Lucas, R.E. (1976), Econometric Policy Evaluation: A Critique, Carnegie Rochester Conference Series on Public Policy, Vol. 1, pp. 19-46.

Lucke, B. (1995), Analysis of West German Macroeconomic Data using Common Trends and Common Cycles (Eine Analyse westdeutscher Makrodaten anhand gemeinsamer Trends und gemeinsamer Zyklen), Jahrbücher für Nationalökonomie und Statistik, Vol. 214/6 (November), G. Fisher Verlag, Stuttgart, pp. 675-696.

Lütkepohl, H. (1991), Analyse trendbehafteter multipler Zeitreihen, Allgemeines Statistisches Archiv, 75, pp. 103-123.

MacKinnon, J.G. (1991), Critical Values for Co-Integration Tests, in: Engle, R.F. und Granger, C.W.J. (eds), Long-Run Economic Relationships, Oxford University Press, pp. 267-276.

Mankiw, N.G. and Summers, L.H. (1986), Money Demand and the Effects of Fiscal Policies, Journal of Money, Credit and Banking, Vol. 18, pp. 415-429.

Meltzer, A.H. (1963), The Demand for Money: The Evidence from the Time Series, Journal of Political Economy, Vol. 71, pp. 219-246.

Miller, M. and Orr, D. (1966), A Model of the Demand for Money by Firms, Quarterly Journal of Economics, August, pp. 413-435.

Muscatelli, V. A. (1989), A Comparison of the 'Rational Expecations' and the 'General-to-Specific-Approaches to Modelling the Demand for M1, Oxford Bulletin of Economics and Statistics, Vol. 51 (November), pp. 353-375.

Newey, W. and West, K. (1987), A Simple Positive-Definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, Econometrica, Vol. 55, pp. 703-708.

Nickell, S. (1985), Error-Correction, Partial Adjustment and All That: An Expository Note, Oxford Bulletin of Economics and Statistics, Vol. 47, pp. 119-129.

Osterwald-Lenum, M. (1992), A Note with Quantiles of the Asymptotic Distribution of the ML Cointegration Test Statistics, Oxford Bulletin of Economics and Statistics, Vol. 54, pp. 461-472.

Patinkin, D. (1965), Money, Interest and Prices: An Integration of Monetary and Value Theory, second edition, New York.

Perron, P. (1989), The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis, Econometrica, Vol. 57, pp. 1361-1401.

Perron, P. and Campbell, J. (1993), A Note on Johansen's Cointegration Procedure when Trends are Present, Empirical Economics, Vol. 18, pp. 777-789.

Phillips, P.C.B. and Perron, P. (1988), Testing for a Unit Root in Time Series Regression , Biometrika, Vol. 75, pp. 335-346.

Read, V. (1996), Sectoral Disaggregation of German M3, Discussion paper 1/96, Economic Research Group of the Deutsche Bundesbank.

Rüdel, T. (1989), Kointegration und Fehlerkorrekturmodelle, Physica-Verlag Heidelberg.

Sauer, C. (1992), Money Illusion and the Long-Run Demand for Money in Germany, Konjunkturpolitik, Year 38, Issue 5/6, pp. 340-352.

Scharnagl, M. (1996), Geldmengenaggregate unter Berücksichtigung struktureller Veränderungen an den Finanzmärkten, Discussion paper 2/96, Economic Research Group of the Deutsche Bundesbank.

Schäfer, D. and Bolleyer, R. (1993), Gebrauchsvermögen Privater Haushalte - Bestände und Käufe 1970 bis 1993, Wirtschaft und Statistik, Issue 8, pp. 527-537.

Schlesinger, H. (1972), Gesamtwirtschaftliche Finanzierungsrechnung und monetäre Analyse, in: Bombach, G. (ed.), Studien zur Geldtheorie und monetäre Ökonometrie, Schriften des Vereins für Socialpolitik, Neue Folge, Vol. 66, pp. 199-220.

Schwert, G.W. (1989), Tests for Unit Roots: A Monte Carlo Investigation, Journal of Business & Economic Statistics , Vol. 7, pp. 147-158.

Smith, M.A. (1988), Income or Wealth in Money Demand: Comment, Southern Economic Journal, October, pp. 1039-1042.

Stedry, A.C. (1959), A Note on Interest Rates and the Demand for Money, Review of Economics and Statistics, Vol. 41, August, pp. 303-307.

Stock, J.H. (1987), Asymptotic Properties of Least Square Estimates of Cointegrating Vectors, Econometrica, Vol. 55, pp. 1035-1056.

Stock, J.H. and Watson, M.W. (1988), Testing for Common Trends, Journal of the American Statistical Association, Vol. 83, pp. 1097-1107.

Syring, E.M. (1967), The Role of Human Wealth in Meltzer's Demand Function for Money, Journal of Political Economy, Vol. 75.

Teigen, R.L. (1979), Die Nachfrage nach Geld, in: Badura, J. and Issing, O. (eds.), Geldtheorie, Gustav Fischer Verlag, Stuttgart, pp. 90-110.

Tobin, J. (1956), The Interest-Elasticity of Transactions Demand for Cash, Review of Economics and Statistics, Vol. 38, August, pp. 241-247.

Tobin, J. (1958), Liquidity Preference as Behaviour towards Risk, Review of Economic Studies, Vol. 25, pp. 65-86.

Tobin, J. (1969), A General Equilibrium Approach to Monetary Theory, Journal of Money, Credit and Banking, Vol. 1, pp. 15-29.

Trehan, B. (1988), The Practice of Monetary Targeting: A Case Study of the West German Experience, Economic Review of the Federal Reserve Bank of San Francisco, Spring, pp. 30-44.

Ueda, K. (1990), Financial Deregulation and the Demand for Money in Japan, in: Hooper, P.; Johnson, K.H.; Kohn, D.L.; Lindsey, D.E.; Porter, R.D. and Tryon, R. (eds.), Financial Sectors in Open Economies: Empirical Analysis and Policy Issues, Board of Governors of the Federal Reserve System.

White, H. (1980), A Heteroscedasticity-Consistent Covariance Matrix and a Direct Test for Heteroscedasticity, Econometrica, Vol. 48, pp. 817-838.

Wickens, M.R. and Breusch, T.S. (1988), Dynamic Specification, the Long Run and the Estimation of Transformed Regression Models, Economic Journal, Vol. 98 (Conference 1988), pp. 189-205.

Wolters, J. (1992), Alternative Ansätze zur Messung von Persistenz in ökonomischen Zeitreihen, Allgemeines Statistisches Archiv 75, pp. 184-196.

Wolters, J. (1995), Kointegration und Zinsentwicklung im EWS - Eine Einführung in die Kointegrationsmethodologie und deren Anwendung, Allgemeines Statistisches Archiv 79, pp. 146-169.

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
August	1995	Das Produktionspotential in Ostdeutschland *	Thomas Westermann
February	1996	Sectoral disaggregation of German M3	Vicky Read
March	1996	Geldmengenaggregate unter Berücksichtigung struktureller Veränderungen an den Finanzmärkten *	Michael Scharnagl
March	1996	Private consumption and the interest rate in Germany **	Hermann-Josef Hansen
May	1996	Market Reaction to Changes in German Official Interest Rates	Daniel C. Hardy
Mai	1996	Die Rolle des Vermögens in der Geldnachfrage	Dieter Gerdesmeier

* Available in German only.

** Forthcoming.

August	1996	**Intergenerative Verteilungseffekte öffentlicher Haushalte – Theoretische Konzepte und empirischer Befund für die Bundesrepublik Deutschland** *	**Stephan Boll**
August	1996	**Der Einfluß des Wechselkurses auf die deutsche Handelsbilanz** *	**Jörg Clostermann**
Oktober	1996	**Alternative specifications of the German term structure and its information content regarding inflation**	**Sebastian T. Schich**

* Available in German only.

** Forthcoming.