

Loef, Hans-Edi

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Exchange rate, inflation rate, expectations, and the demand for money: Germany 1970 - 1978

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FAKULTÄT FÜR
WIRTSCHAFTSWISSENSCHAFTEN UND STATISTIK
UNIVERSITÄT KONSTANZ

Exchange Rate, Inflation Rate, Expectations,
and the Demand for Money: Germany 1970 - 1978

Hans-E. | Loef

Serie A - Nr. 135

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and the Demand for Money: Germany 1970 - 1978

Hans-E. Loef

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Abstract

This paper analyses the influence of exchange rate expectations on the demand for real balances. It is shown that currency substitution is an important factor in explaining real money holdings in Germany from 1970 to 1978. Additionally, evidence is provided concerning the influence of the expected inflation rate (approximated by the actual rate) on money demand. The empirical analysis indicates that domestic and foreign bonds are very close substitutes and that domestic and foreign interest rates can be used interchangeably as the opportunity costs of holding real balances. As alternatives to money as a means of holding wealth, domestic goods and bonds are closer substitutes than foreign bonds and money.

1. Introduction

In macroeconomic models of both closed and open economies the demand for real money plays a crucial role. The dependence of real balances on real income (or real wealth) and on the nominal interest rate provides the link between the real and the monetary sector in a closed economy model. Income and interest rate elasticities are important for the effectiveness of monetary and fiscal policy. Additionally, in an open economy foreign interest rates and exchange rate movements, in a flexible exchange rate system (or movements in international reserves in a fixed exchange rate system), determine to some extent the domestic money market conditions and, therefore, the influence of monetary variables, and monetary policy in particular, on aggregate economic variables like income, prices and employment.

Most questions concerning the money demand function are answered more or less satisfactorily on theoretical and empirical grounds. These settled issues include propositions like the unitary elasticities of the money demand with respect to income and prices, the negative interest rate elasticity and the stability of the money demand function.¹⁾

Despite their importance for macroeconomic models and monetary policy, some issues remain controversial, while others have not been investigated at all. These include the influence of foreign interest rates, and of expectations about the inflation rate and about exchange rate movements, on the decision to hold real balances.²⁾

The list of authors who mention the dependence of the real money demand on expected inflation rates is quite vast³⁾, but only a few find an empirically significant negative relationship.⁴⁾ In general, the issue is still controversial (see Goldfeld (1973, 607-13)). My paper presents some additional evidence regarding this issue.

The inclusion of foreign interest rates in a money demand function is a common procedure in macroeconomic models of open economies.⁵⁾ In most cases, when a small economy is considered and international capital is (perfectly) mobile foreign interest rates determine domestic rates, thus potentially imposing constraints on the effectiveness of monetary policy. Hamburger (1977) has shown empirically that domestic and (covered) foreign interest rates are interchangeable and that international financial markets (e.g. the Euro-dollar market and the German money market) are highly intercorrelated, indicating that foreign and domestic bonds are close substitutes.

Frenkel in several papers (1976, 1977 and 1979) and Abel, Dornbusch, Huizinga and Marcus (1979, thereafter cited as Abel et al) show, for Germany during the hyperinflation of 1921-23, that exchange rate expectations are a major or even the only factor determining real money balances. Frenkel uses the relative movements of forward and spot rates as an empirical substitute for the unobservable expected future inflation rate. On the other hand, Abel et al use both the expected inflation rate (approximated by the actual rate) and the expected exchange rate movement, measured by the forward premium, the latter indicating the expected relative price change of different currencies.

These contributions clearly show that during periods of hyperinflation expected inflation rates and expected exchange rates have a significant negative impact on the real money demand. Yet, there remains to be shown that in periods of moderate inflation a similar relationship holds as well.

In situations with very low or zero inflation rates and fixed exchange rate systems, the dependence of the real money demand on the two opportunity costs mentioned is hardly detectable. Fortunately recent West German experience seems to provide the possibility of studying the influence of expected inflation and exchange rates on money demand outside periods of hyperinflations. During the period 1970 to 1978 Germany observed the highest variations of inflation rates since the second World War with an average of 5.0% and lower and upper bounds of 2.4% and 7.4%. This behavior of the inflation rate could possibly produce a threshold effect (Johnson (1971, 127)), which, in turn, could lead to an observable reaction in the demand for real balances. Moreover, the years 1970 to 1978 are those in which more or less flexible exchange rates replaced the fixed exchange rate system of Bretton Woods. The decline of the DM/\$ exchange rate accompanied by rather large fluctuations in actual and expected exchange rates (as measured by spot and forward rates) offers the opportunity to investigate the influence of this variable on the real money demand.

In this paper I will show that the expected (substituted by the actual) inflation rate and expected exchange rate movements had a significant impact on the demand for real money in Germany from 1970 to 1978.

The paper is arranged as follows. Section 2 outlines the construction of a money demand function for an open economy. Section 3 is divided into several subsections, the first being devoted to a discussion of the data and the characteristics of the time period in question. The second subsection suggests measures for the unobservable expected future rates of exchange and inflation, while the question of possible dependence among explanatory variables is treated in 3.3. Empirical results and ex post and ex ante forecasts are presented in subsections 3.4. and 3.5. respectively. The last section 4 contains concluding remarks.

2. The Money Demand Function in an Open Economy: Some Theoretical Considerations

The general framework to be outlined in this section follows the Chicago tradition in treating the demand for money as being similar to that for goods. Moreover the real money stock is considered as part of individuals' wealth. Therefore, the demand for real balances depends on the utility that money provides its holders⁶⁾, on total wealth as a budget constraint and on a set of opportunity costs (Friedman (1956)).

As is usual in short-run and empirical analysis, the influence of utility on the demand for money is taken as given and constant. For that reason this demand determinant does not appear explicitly in the function to be empirically tested. Although the portfolio approach to money demand suggests the use of a wealth concept representing the budget constraint, some authors prefer the actual real income instead (e.g. Goldfeld (1973), see Havrilesky and Boorman (1978) for arguments and references). Actual real income as an argument in the money demand function is justified by stressing the transaction motive in money demand holdings (see Beare (1978, 206) and the importance of this variable in short-run models with quarterly data, or simply by invoking the difficulty experienced in obtaining reliable empirical data for total real wealth (e.g. Hamburger (1977, 27)). Although there is a quite sharp theoretical distinction between the transaction-income and the wealth approach, the empirical proceedings normally blur it in approximating wealth with a permanent income concept which normally uses lagged real income as determinants (Johnson (1971, 126)). The empirical part of my paper follows Hamburger

(1977) and uses a moving average of income as the relevant variable approximating the budget constraint. This variable will be labeled income-wealth to emphasise its dual character: it is constructed from present and past real incomes but it does also represent real wealth to some extent.

For the purpose of this paper, I divide the opportunity costs of holding money as part of real wealth holdings into two broad categories: opportunity costs deriving from domestic portfolio alternatives and those deriving from foreign ones. Domestic alternatives to money as a wealth component include bonds, equities and other goods. If the individual holds money instead of other goods (including houses, works of art, jewellery, gold, etc) he suffers a potential loss of his wealth if the prices of these alternatives rise. Since future price changes of other goods are not known with certainty, it is the expected price movement or the expected inflation rate which should be considered as the relevant opportunity cost. While the expected inflation rate is a proper measure for the domestic opportunity costs to hold money as a stock, it is the interest rate on domestic bonds (and equities) which is the appropriate opportunity cost measure for holding money for its services.

International monetary theory, and especially the monetary approach to the balance of payments, stresses the point that the exchange rate is a relative price between two currencies. Alternatively, foreign monies are a substitute for domestic money holdings and exchange rate movements measure the opportunity costs with respect

to this foreign component of individuals' wealth. Again, as in the case of the inflation rate, future exchange rate movements are uncertain and expected future exchange rate movements must be considered instead. If wealth holders expect a decline in the value of domestic money relative to foreign currencies, that is an expected depreciation or a rise in the expected exchange rate, they will be induced to substitute foreign currencies for domestic money. Therefore these expected exchange rate movements should be included as an opportunity cost for money stock holdings in an open economy.

It is not necessary that all money holders change their portfolio in favor of those currencies which are expected to appreciate. Mussa points out that all that is required is that there be a sufficient number of active participants, as in any asset market, to make the market work (Mussa (1976), 235). He continues: "as a practical matter, these active participants are most likely to be professional traders, banks, and multinational corporations who, in the regular course of business, are used to holding on to a variety of different national monies. These particular money holders are likely to be the most sensitive to exchange rate changes and the most aggressive in shifting their holdings when such changes are anticipated" (Mussa (1976), 235/6).

Moreover in an open economy with no, or only minor, restrictions on international capital movements residents can buy foreign bonds (and equities). Interest payments on foreign financial assets should therefore be considered as opportunity costs as well. But, unlike the case of

domestic bonds, foreign interest payments are subject to exchange rate movements. Foreign interest rates should be adjusted for expected exchange rate movements.⁷⁾

The above considerations can be summarized in equation (1). Desired real money stock $(\frac{M}{P})^+$ is a function of real wealth (W/P) , the expected inflation rate (π^e) , the expected exchange rate movement (Θ^e) , and domestic (i) and foreign interest rates (i_*^{adj}) .

$$(1) \quad \left(\frac{M}{P}\right)^+ = f\left(\frac{W}{P}, \pi^e, i, \Theta^e, i_*^{\text{adj}}\right)$$

$$f_1 > 0 \quad \text{and} \quad f_2, f_3, f_4, f_5 < 0$$

Actual real money holdings $(\frac{M}{P})$ do not usually adjust immediately to the desired or equilibrium level. Some authors suggest that the time period necessary for adjustment is about four quarters (see Beare (1978), 214). For annual data equation (1) might be an appropriate test equation for the actual money demand but for quarterly data, as used below, a stock adjustment procedure is assumed as in equation (2).

$$(2) \quad \ln \left(\frac{M}{P}\right)_t = \lambda \ln \left(\frac{M}{P}\right)_t^+ + (1 - \lambda) \ln \left(\frac{M}{P}\right)_{t-1}$$

where λ denotes the coefficient of adjustment. Natural logarithms are used in anticipation of the empirically tested counterpart of equation (1) which assumes logarithmic dependency between the money stock desired and the

real stock of wealth. While, as Goldfeld has demonstrated, this stock adjustment procedure has some shortcomings, it is still a convenient starting point for empirical work (Goldfeld (1973,582)).

Although an almost complete adjustment in one year by using quarterly data implies a theoretical value for λ of about 0.5 or higher, empirical work seems to indicate a much lower value of the adjustment coefficient (see Goldfeld (1973, 583)). The empirical evidence presented below leads to an adjustment coefficient, λ , of between 0.29 and 0.55 in different regression equations.

3. Empirical Evidence

3.1. Data, Time Period, and Empirical Implementation

The theoretical outline of the preceding section will be empirically tested for quarterly data in West-Germany for the period I.1970 to IV. 1978. The narrowly defined money stock, M_1 (currency plus demand deposits), is chosen as the dependent variable. No attempt is made to disaggregate between money constitutes and economical sectors.⁸⁾ A broader money stock definition (M_2) did not lead to satisfactory results, although from a theoretical viewpoint the M_2 concept should be the more appropriate one for treating money as a part of an individual's wealth. The finding that M_1 shows a better performance in fitting equation (1) than M_2 is in accordance with Goldfeld's findings (Goldfeld (1973), 592-595) and Hamburger's investigation for West-Germany (Hamburger (1977)). The quarterly money stock M_1 is computed as an average from end of month's data. The consumer price index P is used to convert nominal to real money balances.

As mentioned in the previous section a substitute for real wealth is needed. As in other investigations on this subject⁹⁾, data limitations preclude the use of a direct measure of wealth in the case of Germany at least on a quarterly basis.¹⁰⁾ I therefore use Hamburger's procedure, modifying it slightly by substituting an eight quarter moving average (including the current output level as well) of past real GNPs for permanent income or real wealth ($\frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j}$). This variable will be labeled income-wealth later on.

Hamburger's own procedure of using $(Y/P)_t$ and $(\frac{1}{7} \sum_{j=1}^7 (Y/P)_{t-j})$ separately in the money demand function did not prove successful in the present study. In general, the coefficient of current income was not significantly different from zero, and sometimes it was even negative, while those of the moving average real income worked satisfactorily, pointing to some multicollinearity. Using $(Y/P)_t$ alone as suggested in a purely transaction approach was inferior to the moving average procedure. As this variable, as defined above, results in a reasonably good fit no attempt was made to improve the results presented below by altering the time-lag of eight quarters. Again nominal GNP is deflated by the consumer price index to obtain real GNP figures.

As an empirical counterpart to the domestic interest rate, i , three definitions are used both separately and together. A short-term nominal interest rate is approximated by the interest rate on three-month loans in the German money market (i_3), while a longer-run nominal interest rate candidate is found in the yield on fully-taxed, long-term bonds (i_F). The dividend yield on equities (r_e) is considered to be a proxy for the rate of return on real capital (see Hamburger (1977), 30).

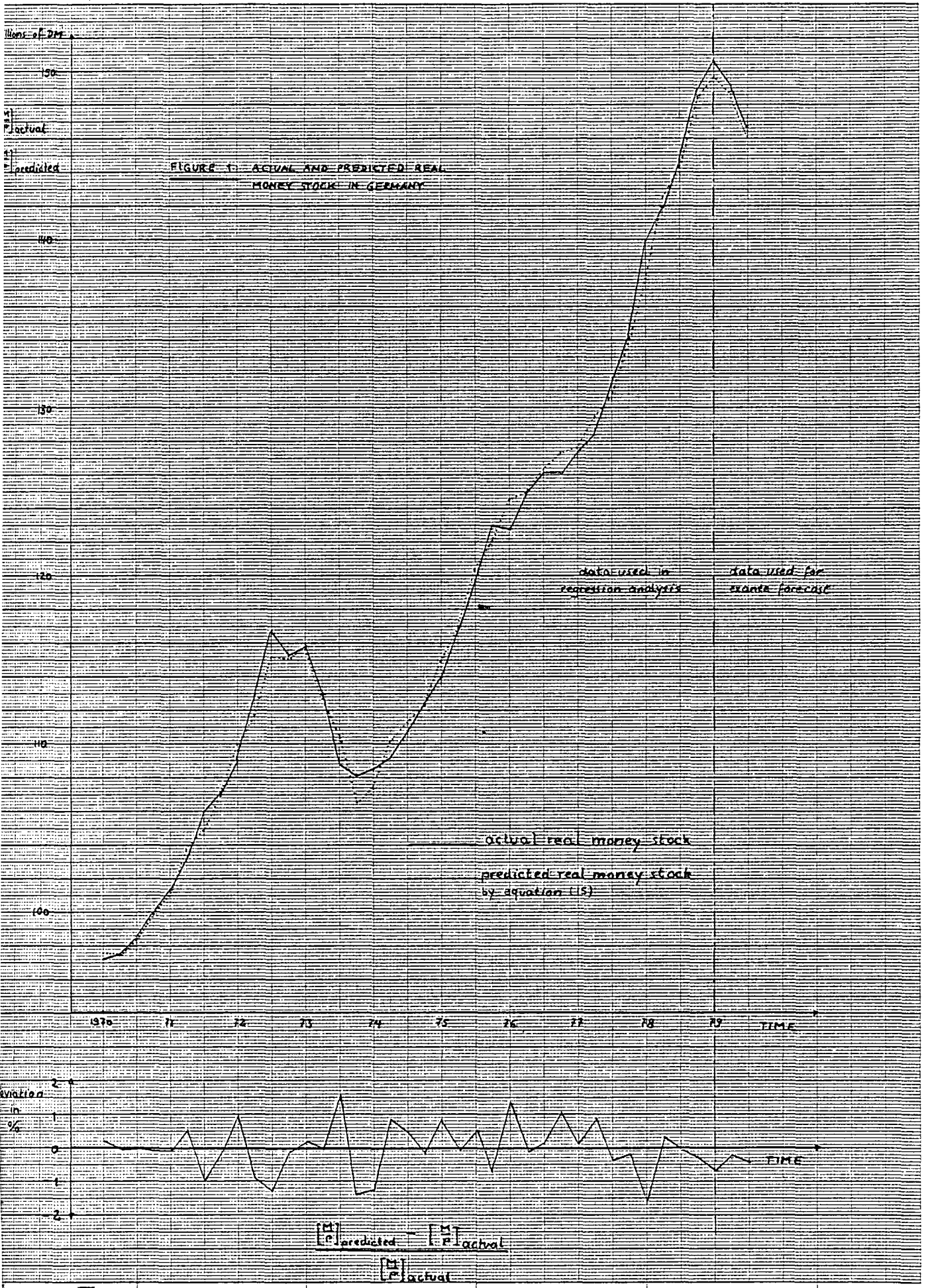
Foreign interest rates i_* are proxied by the rate on three month Eurodollar deposits (i_{EU}) and the interest rate on three month US-government bonds (i_{US}). Both foreign interest rates are adjusted for expected exchange rate movements (as mentioned above) by premultiplying them by the ratio of expected to actual exchange rates (that is $i_{EU}^{adj} = i_{EU} \frac{FR}{SR}$ and $i_{US}^{adj} = i_{US} \frac{FR}{SR}$, where FR = expected exchange rate (forward rate) and SR = actual exchange rate (spot rate)).

The two expectational variables used, π^e and θ^e , are discussed explicitly in the following subsection.

The time period used is the first quarter 1970 to the fourth quarter 1978. This period is of special interest for at least three reasons. First, during this period the real money stock showed a remarkable decline (III.1972 to IV.1973, see figure 1, upper part, solid line). Real money balances fell from 116.7 to 108.1 billion DM. A money demand function should satisfactorily explain and forecast this downturn ex post.

Second, in the context of post-war West-German experience, variations in the inflation rate in this period were quite extreme. The inflation rate (measured as $(P_t - P_{t-4})/P_{t-4}$, where P=consumer price index) rises from 2.7% in I.1970 to a maximum of 7.43% in I.1974 and falls more or less continuously to a minimum of 2.36% p.a. in IV.1978 (see figure 4 or 6). These high magnitudes and variations of the inflation rate offer the opportunity to detect a negative impact of the (expected) inflation rate on real money demand. Even though in normal times no statistically significant relationship between M/P and π is to be found, such behavior of the inflation rate can produce a threshold effect (Johnson (1971), 127) and can lead to a significant negative relationship.

Third, and most important, this period is characterized by monetary disorder following the breakdown of the Bretton Woods system and by almost freely fluctuating exchange rates (on this description see Branson et al (1977), 315). Actual and expected exchange rates (as



measured by the forward and spot rates) declined from 3.70 to 1.80 DM/\$ with various ups and downs in between (see figure 2). If real money balances are a function of expected exchange rate movements the time period I.1970 to IV.1978 offers a very good chance to find empirical evidence of such a relationship outside the well-known hyperinflation period (1921-23) which is investigated by several writers with respect to the exchange rate movements (see the Frenkel papers (1976, 1977, 1978 and 1979) and Abel et al (1979)).

The empirical implementation of this model requires a double-logarithmic version of equation (1) with respect to the wealth proxy ($\frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j}$), and a semi-logarithmic version with respect to the opportunity costs. The latter is necessary at least when using the expected exchange rate movement, which was negative in most cases (see figure 3 or 6) indicating an expected appreciation of the German Mark relative to the US-dollar during 1970 to 1978 on average. For the other opportunity costs the semi-logarithmic version is used partly for symmetry. Also, a more important consideration is that this functional form showed better statistical results than the double-logarithmic one. Equation (3) describes the general basic test equation for the demand for real money in an open economy and is based on equations (1) and (2) and the data considerations of this section.

$$(3) \ln \left(\frac{M}{P} \right)_t = \alpha_0 + \alpha_1 \ln \frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j} + \alpha_2 k (i_k)_t \\ + \alpha_{31} (i_*^1)_t + \alpha_4 \pi_t^e + \alpha_5 \theta_t^e + \alpha_6 \ln \left(\frac{M}{P} \right)_{t-1} \\ + u_t$$

where $i_k = i_3, i_F$ and/or r_e
 $i_*^1 = i_{EU}^{adj}$ or i_{US}^{adj}

Before testing equation (3) or subversions of it the two expected and normally unobservable variables π^e (expected inflation rate) and θ^e (expected exchange rate movement) must be operationalized. This is done in the next subsection.

3.2. Measures for the Expected Inflation Rate and the Expected Exchange Rate

In this paper the expected inflation rate (π^e) will be replaced by the actual rate (π), following Abel et al (1979, 98). Other possible assumptions and the creation of special time series for π^e (for example Smith and Winder (1971), Modigliani and Shiller (1973), Rutledge (1974), Carr et al (1976) and Neumann (1977)) are not incorporated into the present study mainly because of time and space limitations and in order to focus on the central issue of exchange rate expectations as a money demand determinant. The unlikely event (Goldfeld (1973, 610)) that expectations are perfectly accurate relies on rational expectations, full information without costs, full adjustment without lags and forecasts without errors. These assumptions can indeed be attacked on several grounds, but so can each alternative procedure on other ones. Without an explicitly formulated economic model, as in the present case, in which the inflationary process is endogenously explained it seems to be quite legitimate to approximate the expected inflation rate by the actual one. Second best is after all still better than first worst. However, later investigations should alter this assumption and use alternative proxies for π^e .

For the expected exchange rate movement a market figure can be used. The three month forward premium on the DM/\$ exchange rate, defined as

$$(4) \text{ forward premium} = \frac{FR_t - SR_t}{SR_t},$$

where FR_t = forward rate known at t
and SR_t = spot rate known at t

can be assumed to reflect most peoples expectations about the variation of the future unknown spot rate SR_{t+1} ; or put differently, the forward rate is assumed to be the best empirically observable figure to represent the expected exchange rate $E(SR_{t+1}) = FR_t$ (see Frenkel (1976, 211-212), (1977, 654-656), (1978, 175-177), (1979, 82), Dornbusch (1976b, 261), Jetzer (1979) and Loef (1980)).

Figure 2 shows the behavior of the actual spot rate (SR_t) and the movement of the forward rate one quarter lagged (FR_{t-1}). Both series move very close together. When the exchange rate depreciates the spot rate lies above the forward rate and in periods of appreciation the spot rate lies below it.

The forward rate FR_{t-1} can be used as a good and efficient predictor of the unknown spot rate SR_t if the forward market is an efficient market in the sense described by Fama (Fama (1970) and (1975)). FR_{t-1} then contains all available information about SR_t known at time t-1. To test these characteristics of FR_{t-1} , I follow Frenkel (Frenkel (1976), (1978) and (1979)) and regress for I.1970 to IV. 1978 equation (5).

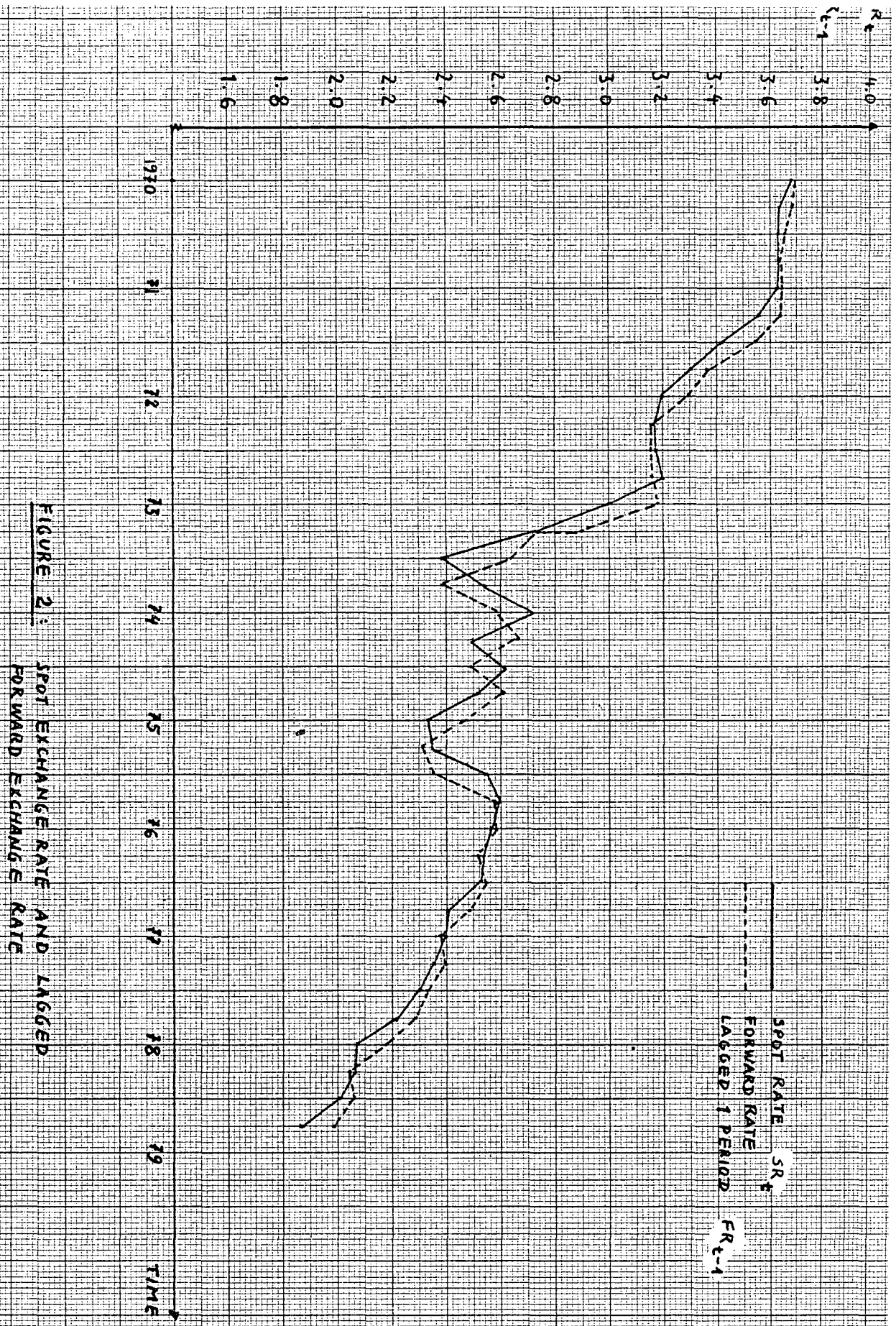


FIGURE 2: SPOT EXCHANGE RATE AND LAGGED FORWARD EXCHANGE RATE

$$(5) \quad SR_t = a_0 + a_1 FR_{t-1} + u_t$$

If FR_{t-1} is an efficient forecast in the sense of Fama then $a_0 = 0$, $a_1 = 1$ and $E(u_t u_{t-1}) = 0$, that is, there is no autocorrelation in the disturbance terms u_t . Moreover, if all available information at $t-1$ is contained in FR_{t-1} lagged values of FR do not contribute to the explanation of SR_t , that is, all subsequent parameters should be zero.

For Germany I.1970 to IV.1978 equation (5) turns out to be

$$(6) \quad SR_t = \begin{matrix} 0.03541 \\ (0.42) \end{matrix} + \begin{matrix} 0.97635 \\ (33.05) \end{matrix} FR_{t-1}$$

$$R_{adj}^2 = 0.9680 \quad F\text{-ratio} = 1092$$
$$SE = 0.0949 \quad D.W. = 1.90$$

t-ratios in paranthesis below the parameters.

Equation (6) shows that a_0 of (5) is not significantly different from zero, a_1 is close to one and there is no autocorrelation, indicated by the Durbin-Watson statistic $D.W. = 1.90$.

Including the lagged term FR_{t-2} in equation (5), the coefficient a_2 is negative and not different from zero (equation (7)).

$$(7) \quad SR_t = \begin{matrix} 0.04259 \\ (0.50) \end{matrix} + \begin{matrix} 1.1092 \\ (7.90) \end{matrix} FR_{t-1} - \begin{matrix} 0.13283 \\ (0.97) \end{matrix} FR_{t-2}$$

$$R_{adj}^2 = 0.9680 \quad F\text{-ratio} = 546$$
$$SE = 0.0950 \quad D.W. = 2.12$$

Taking natural logarithms of SR and FR, as Frenkel does, the results of equation (6) and (7) are not essentially altered.¹¹⁾

In summary then, the DM/\$ forward rate for three months loans is a good predictor for the unknown future spot rate. To represent the expected exchange rate movement in the money demand function (1) the difference between the forward and the spot rate relative to the spot rate is used, that is,

$$(8) \quad \Theta^e = \frac{FR - SR}{SR},$$

where $(FR-SR)/SR$ is also known as the swap rate and expresses the forward premium for three months contracts as a percentage rate per year.

3.3. Possible Problems of Multicollinearity

In testing an equation like (3) econometrically it is normally assumed (besides other assumptions) that the explanatory (exogenous) variables are independent of each other. If that is not the case serious problems of multicollinearity could arise. Especially with regard to the foreign opportunity costs such colinearity could be very likely in situations where the purchasing power parity theory and/or the interest rate parity theory hold (Frenkel (1979,85), Abel et al (1979, 99), also Frenkel (1976, 10) and literature cited there). Moreover the expected inflation rate could have some impact upon the domestic interest rates via a Fisherian effect. In this subsection I discuss the likelihood of multicollinearity in the present study due to the possible existence of the purchasing power parity, the interest rate parity and the Fisher effect.

In a short-run relationship like (3) the interest rate parity could create the most serious problems - and indeed it does so. A look at figure 3 shows a very close movement of the domestic rates i_3 and i_F and the two adjusted foreign rates i_{EU}^{adj} and i_{US}^{adj} . The almost parallel behavior points to an international financial market of high substitubility and integration. A similiar relationship for Germany was found for the period 1963 through 1970 by Hamburger (1977). He found that, although i_3 and i_{EU}^{cov} (where he uses $i_{EU} + \frac{FR-SR}{SR}$ as the covered interest rate i_{EU}^{cov}) move together and therefore create multicollinearity when both are used in the money demand function some discrepancies between the two arise and then it is the domestic rate i_3 which determines the amount of money held (Hamburger (1977, 31)).

If interest rate parity holds exactly equation (9) is valid.

$$(9) \quad (1 + i) = (1 + i_*) \frac{FR}{SR}$$

This exact relationship rests on the assumption of a perfectly operating international capital market and the absence of risk. Both assumptions can be validated on empirical grounds. If (9) is exactly valid then in

$$(10) \quad i = b_0 + b_1 \frac{FR-SR}{SR} + b_2 i_* \frac{FR}{SR} + u_t$$

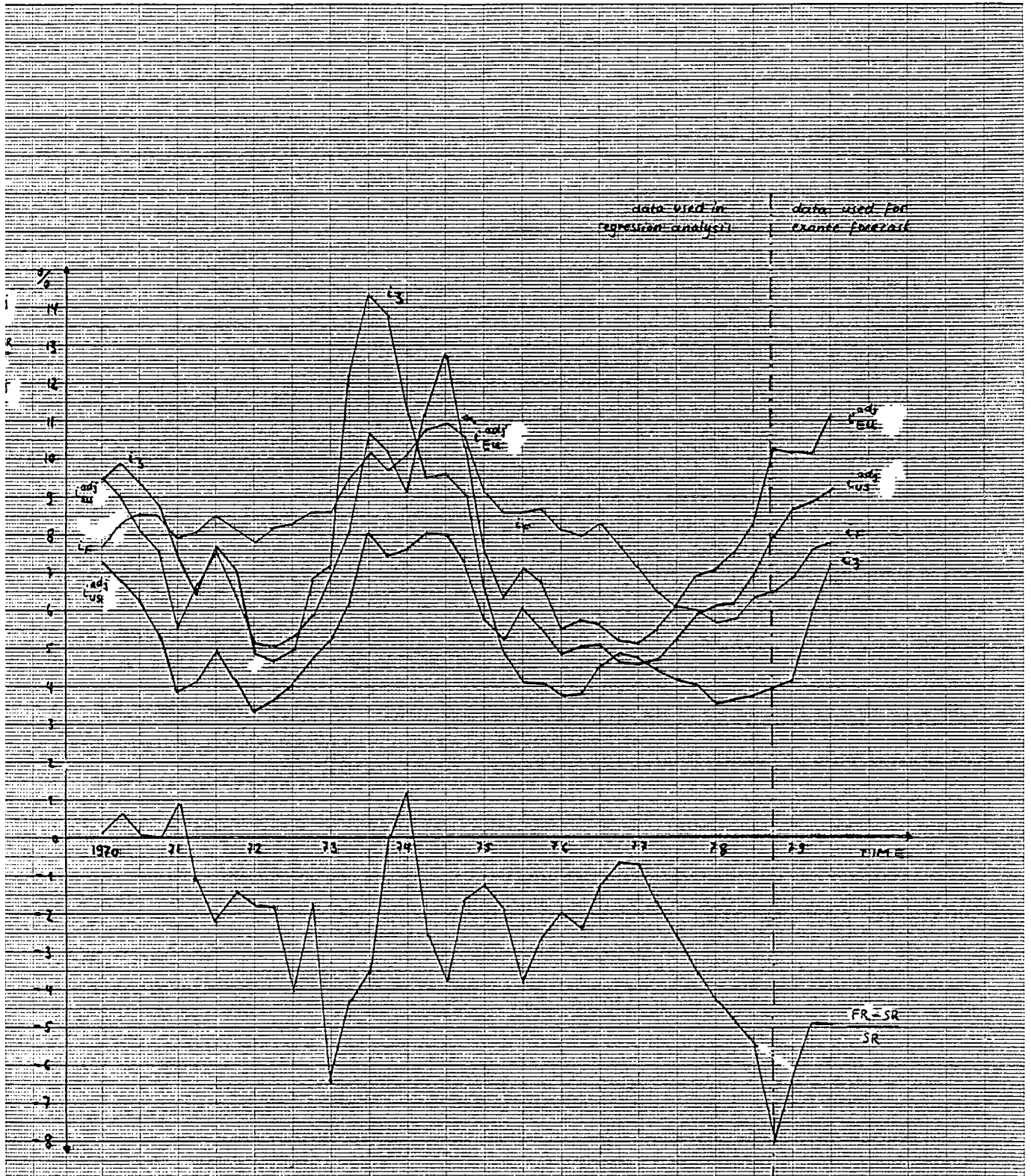


FIGURE 3 DOMESTIC AND FOREIGN INTEREST RATES AND EXPECTED EXCHANGE RATE MOVEMENT

the coefficients b_1 and b_2 must be one and b_0 equals zero while there should be no autocorrelation. Table 1 shows the empirical results from using i_3 and i_F as substitutes for the domestic interest rate i in (10), respectively, and i_{EU} and i_{US} are used as substitutes for the foreign interest rate i_* .

Table 1: Tests for the interest rate parity theory

Dependent Variable	Constant	$\frac{FR-SR}{SR}$	i_{EU}^{adj}	i_{US}^{adj}	R_{adj}^2	SE	D.W.
i_3	1.30632 (1.00)	0.56540 (5.10)	0.85647 (5.96)		0.9087	0.910	0.75
i_3	-0.21309 (0.13)	0.50308 (4.70)		1.31790 (5.81)	0.9075	0.916	0.82
i_F	5.84251 (9.65)	0.09140 (1.90)	0.29894 (4.44)		0.9062	0.411	1.09
i_F	5.58146 (7.46)	0.05116 (1.08)		0.40846 (3.78)	0.8974	0.430	0.85

t-ratios in paranthesis; the Prais-Winsten procedure is used to correct for autocorrelation (Johnston (1972, 264)).

The evidence supplied by table 1 and figure 3 clearly points to some strong relationship between domestic and foreign interest rates and therefore to very likely multicollinearity between these rates if they are included in the same money demand function. However, it should also be noted that the theoretical relationship with $b_0 = 0$ and $b_1 = b_2 = 1$ does not hold exactly. For the short-term domestic rate i_3 the parameter of $(FR-SR)/SR$ is between 0.5 and 0.6 while those for the foreign interest rates are 0.86 and 1.32, respectively. For the yield on fully-taxed bonds i_F the parameter for the

forward premium is not different from zero and the parameter for the foreign interest rate is considerably less than 0.5. Furthermore, the constant is highly significantly different from zero, thus pointing to some independent movements in i_F as contrasted to the Eurodollar rate and the rate on US-government bonds. The result with respect to i_F can be attributed to the nature of this rate as a rather long-term interest rate while i_3 , i_{EU} and i_{US} are the rates for three month contracts. In all cases the high standard error and the low Durbin-Watson statistic (even after applying the Prais-Winsten procedure to correct for autocorrelation) indicate that some other factors¹²⁾ will be present and disturb the exact theoretical relationship.

Although for testing the interest rate parity theory more empirical investigations should be made the results in table 1 are sufficient, in the present case to expect serious multicollinearity problems when domestic and foreign interest rates are used simultaneously. The empirical counterpart of equation (10) in table 1 and equations (23) and (24) in table 3 below which use both i_3 and i_{EU}^{adj} or i_{US}^{adj} show clearly the presence of multicollinearity.

Moreover, when both domestic and foreign rates are included in the money demand function the domestic rate is significantly negative, as suggested by the theory, while the adjusted foreign rates are not significantly different from zero. This result is in accordance with Hamburger's (1977, 31). He interprets this outcome as an indication of the ability of the German Bundesbank to accomplish interest rate stabilization while pursuing an independent monetary policy, even if only for short periods.

For the present study I overcome the multicollinearity problem by using domestic and foreign interest rates separately and assuming that domestic rates (especially i_3) and foreign rates (i_{EU}^{adj} or i_{US}^{adj}) are substitutes as opportunity costs for holding real balances.

The influence of the expected inflation rate π^e and the real interest rate r on the nominal interest rate i in equation (11) is a long-run phenomenon (see Fisher (1930) and Rutledge (1974)) and should impose no serious problems on the present short-run investigation.

$$(11) \quad i = r + \pi^e$$

From a theoretical point of view the relationship (11), known as the Fisher effect (or Gibson's paradox in Keynes' terms) is not totally clear and universally accepted. Wicksell (1936) and Keynes (1930), for example, predict no firm relationship (see Fisher (1978, 200)).¹³⁾ But even if equation (11) holds it is not certain that an increase in the expected inflation rate will lead to an increase in the nominal interest rate of the same magnitude. At least two arguments raise some doubts about the proposition of proportionality between i and π^e . First, following Mundell (1963), a higher expected inflation rate leads to a reduction in real balances and therefore in real wealth. The decline in actual real wealth compared to desired real wealth induces

individuals to increase their savings. The increased savings in turn will reduce the real rate of interest. Therefore the total impact of π^e on i is smaller than one.

Second, a higher expected inflation rate might reduce the real interest rate because money is a producer's good. The increase in the expected inflation rate leads to smaller real balances and the smaller real factor services of money will be substituted by those of other factors of production, including real capital. This leads to a decline in the marginal productivity of the other factors of production and especially in the real rate of return on capital, and the real interest rate will decline (see Beare (1978), 282fn and chap. 15 on this subject).

It is also important for the present study to note that equation (11) does not claim this relationship between nominal interest rates and actual inflation rate, but between the former and the expected inflation rate. The rational expectation assumption of equality between the actual and the expected inflation rate in the present study for money demand behavior may be not appropriate and acceptable in the case of the Fisher equation (11)¹⁴).

In summary then, theoretical arguments would lead me to suppose that equation (11) does not hold exactly in the short-run and when the expected inflation rate is substituted by the actual one. Moreover, if the real rate r is not constant over time an inclusion of π and i simultaneously, without using r , in a money demand function could still be possible even if equation (11) holds.

In fact, I do not expect equation (11) to be a constraint for equation (3) and therefore do not expect serious problems of multicollinearity between i and $\bar{\pi}$. I took a closer look on equation (11) with regard to the empirical variables involved by testing equation (12).

$$(12) \quad i_{kt} = c_0 + c_1 r_{et} + c_2 \bar{\pi}_t + u_t$$

where $i_k = i_3$ or i_F

Figure 4 shows the behavior of the short-run market interest rate i_3 , the long-run rate on domestic bonds i_F , the actual (expected) inflation rate $\bar{\pi}$ and the real long-run rate r_e (yields on equities). The short-run nominal rate i_3 and the actual inflation rate $\bar{\pi}$ show a mixed relationship. In the first part of the period under investigation the two rates move mostly in different directions (I.1970 to II.1972). The same can be observed for I.1976 to I.1977 and I.1978 to IV.1978. During the other quarters both rates move together and, in particular, between III.1972 and IV.1975, both rates rise to a maximum for the whole period and then decline. But even the long-run yield on equities, considered as a possible proxy for the real rate r , does not stay constant over time and shows an increase during the period I.1973 to IV.1974 (which validates the theoretical arguments above somewhat). It can explain, to some extent, the great divergence of i_3 and $\bar{\pi}$.

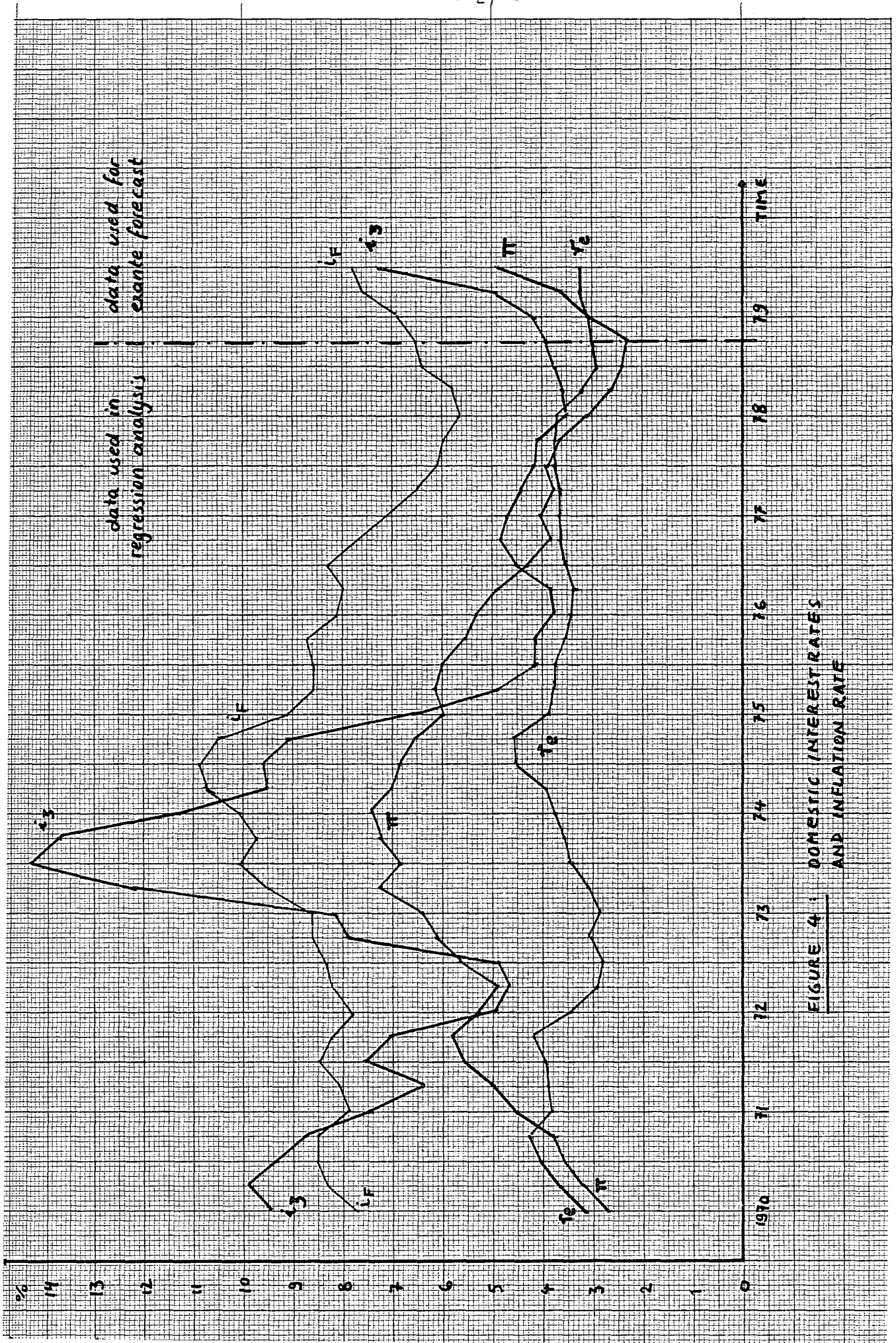


FIGURE 4: DOMESTIC INTEREST RATES AND INFLATION RATE

The movements of i_F and π on the other hand seem to be in greater accord; both rates move fairly close together. If the inflation rate π is subtracted from i_3 and i_F the pattern of the residuals are quite different (see figure 5). While $i_3 - \pi$ shows great fluctuations with even negative values, $i_F - \pi$ stays fairly constant and positive. Moreover the proxy for the real rate (r_e) and $i_F - \pi$ seem to move at least in the same band and do not deviate as much from each other as do $i_3 - \pi$ and r_e .

Table 2 contains some estimates of equation (12) where i is replaced by i_3 and i_F respectively and the real rate of interest is assumed to be either constant or to be approximated by the yield on equities r_e . Again, if (11) were correct the coefficients on r_e and π in (12) must be equal to one (or the constant term as a proxy for r must be significantly different from zero) and autocorrelation should be absent.

Table 2: Tests for the Fisher effect

Dependent Variable	Constant	r_e	π	R_{adj}^2	SE	D.W.
i_3	3.0846 (1.44)		0.82230 (1.97)	0.8202	1.277	1.05
i_3		1.29427 (2.35)	0.53246 (1.32)	0.8393	1.208	0.98
i_3	-0.69929 (0.23)	1.37166 (1.72)	0.59437 (1.41)	0.8289	1.246	0.94
i_F	6.14996 (7.58)		0.40901 (2.61)	0.8788	0.467	1.41
i_F		1.41391 (7.23)	0.61416 (4.42)	0.8351	0.545	1.28
i_F	4.44327 (4.11)	0.65292 (2.33)	0.28141 (1.78)	0.8930	0.439	1.32

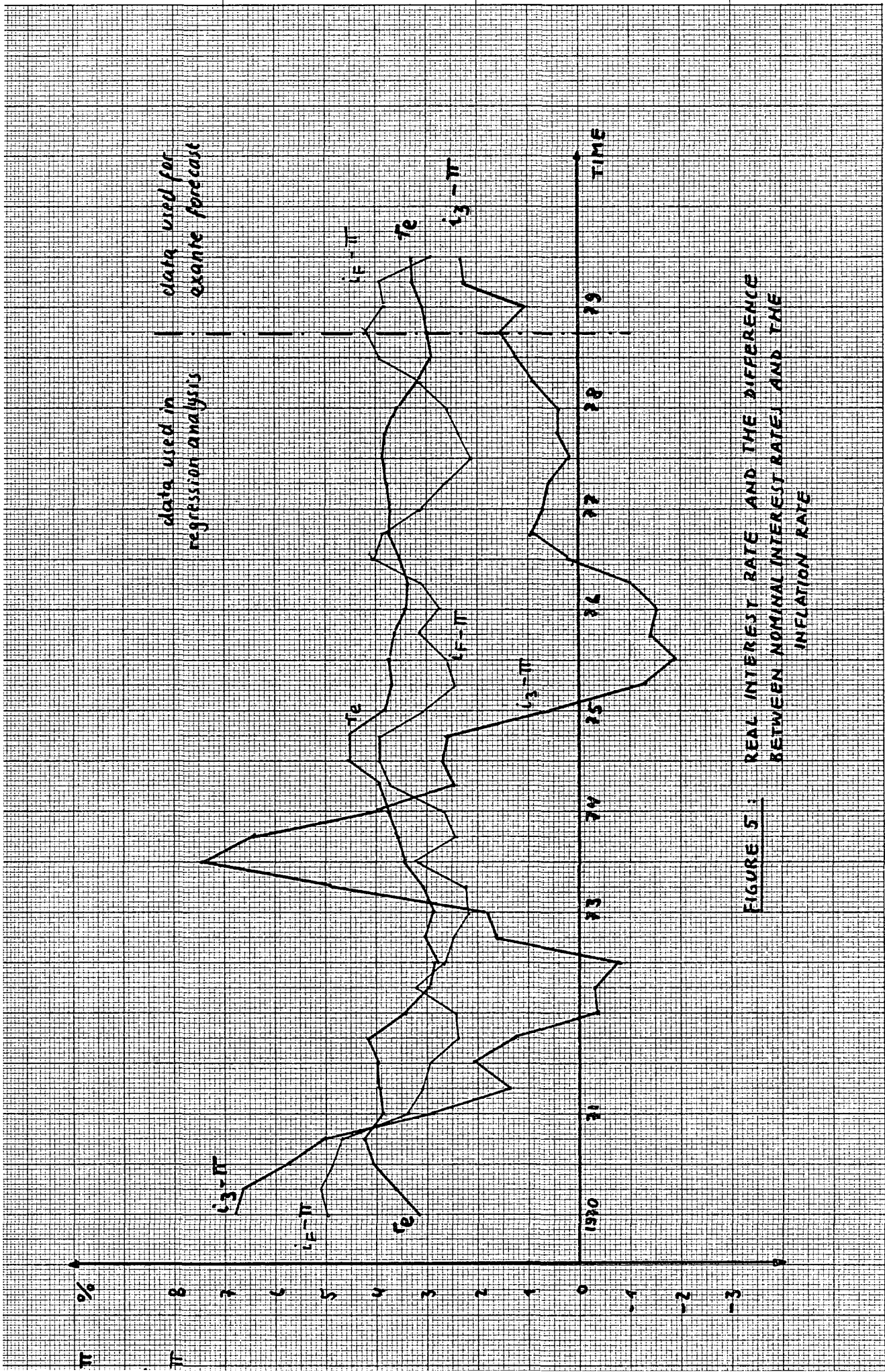


FIGURE 5: REAL INTEREST RATE AND THE DIFFERENCE BETWEEN NOMINAL INTEREST RATE AND THE INFLATION RATE

The high autocorrelation (as indicated by a very low Durbin-Watson statistic) made it necessary to apply the Prais-Winsten procedure for correction, but even then positive autocorrelation is not absent. In general the statistical relationship between i_3 and π is not very close (judged by the t-ratios) while those between i_F and π is much better. Even though the coefficient of π , while using i_F as the dependent variable, is considerably less than one, it could be maintained that at least part of the actual inflation rate is incorporated in the long-run yield of nominal bonds i_F . The results for the money demand equation below confirm these conclusions, in that, firstly, there exists no multicollinearity between i_3 and π (r_e is not included at the same time) and, secondly, if i_F replaces π , while keeping i_3 as an explanatory variable, both interest rates are significantly negative. This last result could be interpreted as the yield on bonds providing compensation for the inflation rate, and the negative sign of the corresponding coefficient in the money demand function as reflecting, to some extent, the influence of the inflation rate.

The last issue which could produce multicollinearity problems is the purchasing power parity theory which, in its relative version in equation (13), proposes a direct relationship between the rate of change of the actual (expected) exchange rate and the actual (expected) inflation rate.

$$(13) \hat{x} = \pi - \pi_* \quad \text{or} \\ \hat{x}^e = \pi^e - \pi_*^e$$

where x (x^e) is the rate of change of the actual (expected) exchange rate and π (π_*) and π^e (π_*^e) are the actual domestic (foreign) and the expected domestic (foreign) inflation rates.

The expected foreign inflation rate π_x^e does not appear in the money demand equation (3) and, ignoring π_x^e , empirically x^e and π^e could move independently of each other even in the long-run. Moreover, relation (13) is to be considered as a long-run phenomenon and therefore should not produce any constraints with respect to multicollinearity in the present short-run context. Figure 6 shows that the somewhat extreme fluctuations of the expected exchange rate movements (FR-SR)/SR are not matched by a similar behavior of π . It can be safely assumed that for I.1970 to IV.1978 (with the possible exception of 1977 to 1978) both rates do not move close together.

It should be pointed out again, that the foregoing investigations are not intended to prove the purchasing power parity theory but rather to search for possible multicollinearity in the context of the present study on money demand behavior. Nevertheless, in this subsection, it was shown that the interest rate parity theory has some validity and the use of domestic and foreign interest rates, as well as the forward premium in the money demand function (3), very likely produces multicollinearity. To avoid this problem, in the next section domestic and (adjusted) foreign interest rates are used separately. Purchasing power parity theory and the Fisher effect, as they are long-run phenomena, do not impose any serious constraints on the money demand function in the period under investigation. The domestic inflation rate, the interest rate and the expected exchange rate movement can be used simultaneously in testing money demand behavior in an open economy.

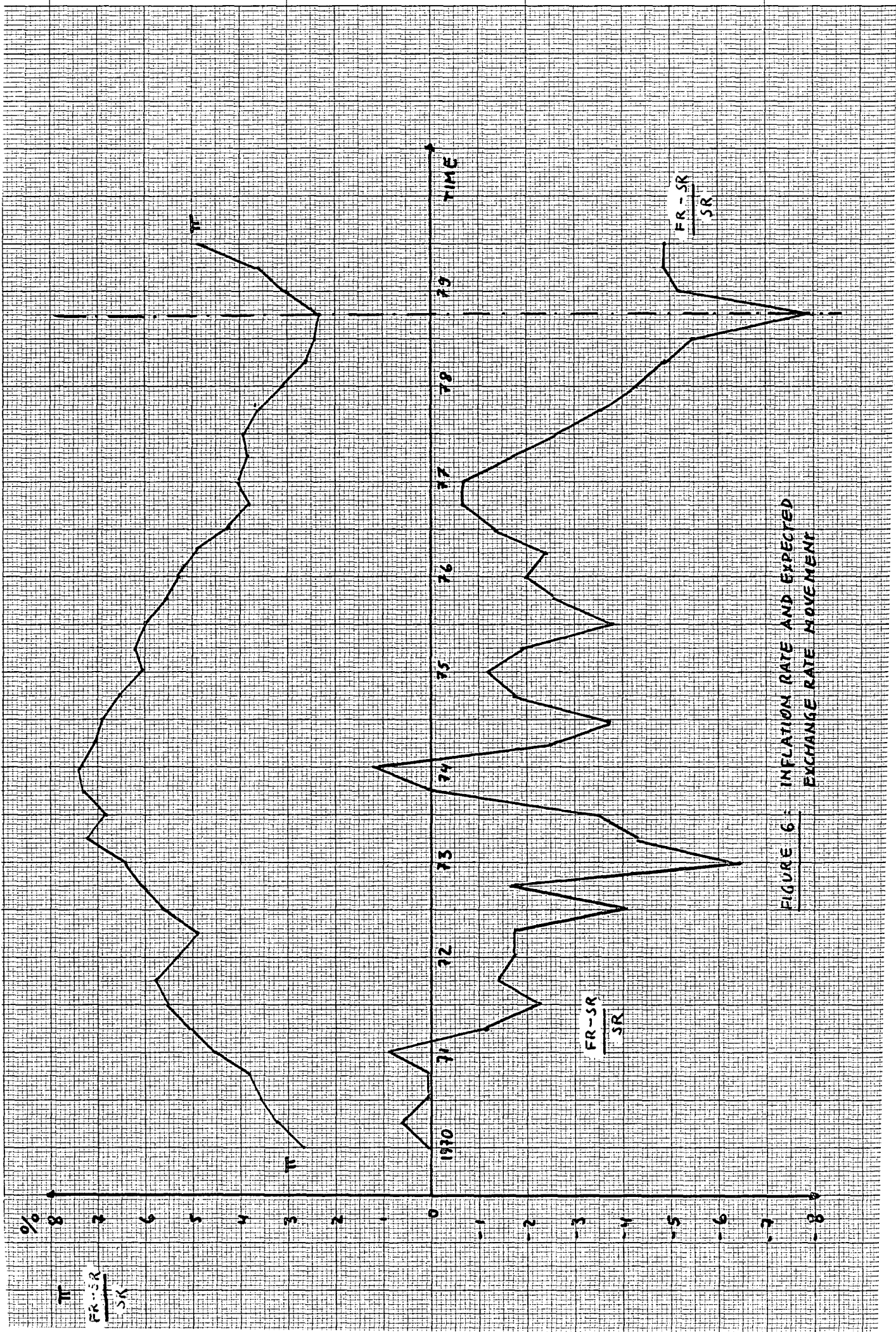


FIGURE 6: INFLATION RATE AND EXPECTED EXCHANGE RATE MOVEMENT

3.4. The Demand for Real Balances: Germany I.1970-IV.1978

a) Basic Empirical Results

According to the preceding section equation (3) is slightly modified and (14) will be the basic equation to be tested.

$$(14) \quad \ln \left(\frac{M}{P} \right)_t = \beta_0 + \beta_1 \ln \frac{1}{8} \sum_{j=0}^7 ((Y/P)_{t-j} + \beta_2 i_{k,t} + \beta_3 \pi_t + \beta_4 \left(\frac{FR-SR}{SR} \right)_t + \beta_5 \ln \left(\frac{M}{P} \right)_{t-1}$$

where i_k is either i_3 , i_F , r_e , i_{EU}^{adj} or i_{US}^{adj}

π equals the actual inflation rate

SR is the spot exchange rate and

FR is the three month forward exchange rate both DM/\$

Using the domestic short-term interest rate i_3 as i_k in (14) the real money demand equation for West-Germany in the period I.1970 to IV.1978 results in

$$(15) \quad \ln \left(\frac{M}{P} \right)_t = \begin{matrix} 0.03528 & + & 0.31821 \ln \frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j} \\ (0.27) & & (4.59) \end{matrix} \\ - \begin{matrix} 0.00470 i_3 & - & 0.00735 \pi \\ (7.23) & & (3.82) \end{matrix} \\ - \begin{matrix} 0.00348 \frac{FR-SR}{SR} & + & 0.65744 \ln \left(\frac{M}{P} \right)_{t-1} \\ (3.56) & & (10.87) \end{matrix}$$

$$R_{adj}^2 = 0.9945; \quad SE = 0.0083; \quad D.W. = 2.28; \quad h = -0.90$$

All parameters have the correct signs and are significant at the 99% level (except the constant term). The summary statistics point to a good explanatory power of the test equation presented. The short-run income-wealth elasticity is 0.318 while the long-run elasticity is 0.928 and slightly below one. To measure the average elasticities of the opportunity costs the corresponding parameters must be multiplied by the sample means of these variables. The short-run interest rate elasticity (using i_3) is -0.032 while the long-run interest rate elasticity is -0.093 (for the short- and long-run elasticities of this and all subsequent equations see tables 6 and 7 in the appendix). This low value is in accordance with Hamburger's estimate (1977, 29) of this elasticity as -0.07.

Both short- and long-run inflation rate elasticities are slightly above the interest rate elasticities and are -0.037 and -0.108, respectively. If it is assumed that some inflationary expectations are contained in the short-run interest rate i_3 (see the foregoing section), the overall inflation rate elasticity might even be higher. The relatively higher inflation rate elasticity points to a closer substitution between money and goods than between money and bonds in the period considered.

For both opportunity cost measures (i_3 and π) a double-logarithmic version was tested. Both their t-ratios and the summary statistics fall short of the results reported in (15). The superiority of the variable elasticity form for the opportunity costs, over the more common constant elasticity version, is also reported in Hamburger (1977, 29 fn 7). As mentioned earlier this fact can be interpreted as evidence for the existence of threshold effects especially with respect to the inflation rate.

The average money demand elasticity with respect to the expected exchange rate movement turns positive because the sample mean of this variable is negative, indicating an average appreciation of the DM compared to the Dollar over the whole period. These negative $(FR-SR)/SR$ figures also made it impossible to use the double-logarithmic functional form. The short-run elasticity of this variable is 0.008 and the long-run 0.023. Taking the absolute values, this elasticity is considerably less than both the interest rate and the inflation rate elasticity suggesting that, although there exists currency substitution, the substitution between domestic money and domestic goods and bonds are closer than between domestic and foreign monies. Later it will be shown that foreign bonds are closer substitutes to domestic money than foreign money, although the former elasticities are smaller in absolute terms than the domestic alternatives.

Since average elasticities are involved it could be argued that the above ordering of the elasticities is somewhat arbitrary because the sample means can influence the elasticities in an extreme way. For example, if, by chance, the sample mean of the expected exchange rate movement is zero the corresponding money demand elasticity will be zero, too. Using the minimum and maximum values of i_3 , π and $(FR-SR)/SR$ during the sample period to calculate the long-run elasticities, the range for the interest rate elasticity is (in absolute values) 0.050 to 0.197 and for the inflation rate 0.051 to 0.159 while for the expected exchange rate it is 0.004 to 0.081. The ranges of i_3 and π coincide more or less, while the range for $(FR-SR)/SR$ contains considerably smaller values than the other two. These

findings, too, indicate that foreign monies are looser substitutes for domestic money than are domestic goods and bonds. This result is in contrast to Abel et al (1979, 102) who find foreign nominal assets (including foreign money) to be closer substitutes for domestic money than domestic real assets.

Substituting the Eurodollar short-term interest rate adjusted for expected exchange rate movements, i_{EU}^{adj} , for the domestic interest rate, i_3 , the results in (16) emerge.

$$\begin{aligned}
 (16) \quad \ln \left(\frac{M}{P} \right)_t &= -0.38896 + 0.58478 \ln \frac{1}{8} \sum_{j=0}^t (Y/P)_{t-j} \\
 &\quad (2.65) \qquad (6.15) \\
 &\quad - 0.00547 i_{EU}^{adj} - 0.01570 \pi \\
 &\quad (5.12) \qquad (6.66) \\
 &\quad - 0.00659 \frac{FR-SR}{SR} + 0.46235 \ln \left(\frac{M}{P} \right)_{t-1} \\
 &\quad (4.90) \qquad (5.38)
 \end{aligned}$$

$$R_{adj}^2 = 0.9920; SE = 0.0100; D.W. = 1.84; h = 0.56$$

The short-run income-wealth elasticity increases now to 0.585 and the long-run elasticity lies above unity (1.088). The foreign interest rate elasticity for the short-run is -0.041 and -0.076 in the long-run. While this short-run elasticity is greater than the short-run value of the elasticity with respect to i_3 , the long-run elasticity of the domestic interest rate is (absolutely) larger than the one for the foreign rate which indicates that domestic bonds are, in equilibrium, closer substitutes to domestic money than are foreign bonds.

In equation (16) the elasticity for the inflation rate increases compared to (15). Both short- and long-run inflation rate elasticities are larger than in (15). The long-run inflation rate elasticity is now higher by one third, again pointing to the fact that domestic alternatives are considered closer substitutes than foreign portfolio alternatives.

Using lower and upper bounds for i_{EU}^{adj} from the sample, the (absolute) long-run elasticity for the Euro-dollar interest rate lies in the range 0.052 to 0.134. While the lower value is almost the same as the one for i_3 and $\bar{\pi}$, the upper value is smaller than the two upper values for the domestic rates. Therefore the distinction between domestic and foreign portfolio alternatives with respect to money is not as strong as it is for foreign money. But still the ordering points to domestic alternatives as closer substitutes for domestic money.

In the preceding subsection it was argued that the long-run interest rates on domestic bonds (i_F) incorporate inflationary impacts to some extent. Replacing the inflation rate $\bar{\pi}$ in (15) by this long-run nominal interest rate i_F leads to

$$\begin{aligned}
 (17) \quad \ln \left(\frac{M}{P} \right)_t &= \underset{(1.78)}{0.23201} + \underset{(3.44)}{0.23692} \ln \frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j} \\
 &\quad \underset{(5.58)}{-0.00444} i_3 - \underset{(2.55)}{0.00679} i_F \\
 &\quad \underset{(2.82)}{-0.00298} \frac{FR-SR}{SR} + \underset{(10.81)}{0.70938} \ln \left(\frac{M}{P} \right)_{t-1}
 \end{aligned}$$

$$R_{adj}^2 = 0.9933; \quad SE = 0.0091; \quad D.W. = 1.91; \quad h = 0.29$$

The coefficient of i_F is negative and significantly different from zero (95% level). All other parameters remain significant (except the intersection) with the correct sign. This result is in contrast to Hamburger (1977, 29 fn 8) who found i_3 to be significantly negative but not i_F when both are included. I attribute the difference to the threshold effect with respect to the inflation rate and the influence of the inflation rate on i_F . In the sample period used by Hamburger (1963 to 1970) the inflation rate in Germany did not move much and was low on average (the highest yearly figure was 3.5% and the lowest 1.3%) while during 1970 to 1978 (the sample period used in this study) it varied much more and was on average considerably higher. Therefore, it could be argued that the threshold effect is responsible for the good performance of i_F in my study while it had no influence in Hamburger's.

The average elasticity of i_F (-0.056 in the short-run and -0.192 in the long-run) is higher in absolute terms than the elasticity of i_3 (-0.030 and -0.104) indicating the influence of the inflation rate on i_F .

The absolute range for the long-run elasticity with respect to i_F is 0.133 to 0.255 while the one for i_3 in equation (17) is 0.054 to 0.220.

The lower speed of adjustment (0.290) in (17) compared to (15) could be attributed to the indirect rather the direct effect of the inflation rate on the real money demand.

In summary, the basic empirical results of equations (15) to (17) indicate that in 1970 to 1978 currency substitution between the German Mark and the US-Dollar took place. The expectation of an appreciation of the DM/\$ exchange rate leads to an increase in demand for German money in real terms. The actual inflation rate, as a substitute for the expected inflation rate, has a significant negative impact on the demand for real balances. Nominal domestic and foreign interest rates, taken separately, show a negative elasticity, too. The opportunity cost elasticities vary positively with the absolute value of these variables indicating the existence of threshold effects. The absolute magnitudes of the elasticities point to a closer substitution between domestic real money and domestic nominal and real assets than between the former and foreign nominal assets, including foreign money.

b) Further Results

Additional empirical results are presented in tables 3 and 4 below. In equation (17) two domestic interest rates are used: i_3 as a short-term and i_F as a long-term nominal interest rate. If the long-term rate alone is used as an opportunity cost measure for domestic bonds (besides the other arguments in (17) and the inflation rate in addition) the total explanatory power drops slightly (equation (18) in table 3). But again all coefficients have the correct signs and are significant at least at the 95% level.

If a real long-term domestic interest rate is used (r_e = dividend yields on equities) the coefficient of this rate is not significantly different from zero (equation (19)). The R^2 shows its lowest value of all regressions (15) to (24) with 0.9883 and the standard error of estimation rises to 0.0121. All other coefficients remain statistically significant with the correct sign. As in other studies (Hamburger (1977) and Loef (1977)) it turns out that a long-term real interest rate is not the appropriate opportunity cost measure for the real money demand in Germany. Hamburger (1977, 30) points to two possible explanations for this finding. First, there might be measurement problems with this variable as an indicator for the rate of return on real capital, and second, the German market for equities is smaller and less organized than other equity markets (e.g. the U.S.) and therefore one might expect equities in Germany to be a poorer substitute for money than they are in the United States, for example.

Table 3: Further results using test structure (3)

Nr.	Constant	Wealth ln $\frac{1}{8} \sum_{j=0}^7 (V_j)_{t-j}$	Domestic Interest Rates			Foreign Interest Rates		Inflation Rate π	Expected Exchange Rate Change $\frac{FR - SR}{SR}$	ln $(\frac{M}{P})_{t-1}$	R^2_{adj}	SE in %	D.W. h	
			i_3	i_F	r_e	i_{EU}^{adj}	i_{US}^{adj}							
18	-0.23575 (1.03)	0.47164 (3.95)		-0.01023 (2.67)				-0.00747 (2.13)	-0.00381 (2.77)	0.55644 (5.28)	0.9901	1.11	1.86* 0.54	
19	-0.48759 (1.81)	0.48834 (3.13)			-0.00765 (0.94)			-0.01318 (3.51)	-0.00303 (2.05)	0.58554 (4.49)	0.9883	1.21	1.84* 0.77	
20	-0.47132 (3.02)	0.51005 (5.44)						-0.00671 (4.62)	-0.01435 (6.00)	-0.00510 (3.94)	0.56085 (6.87)	0.9912	1.05	1.73 0.93
21	0.06838 (0.62)	0.35554 (5.56)	-0.00427 (7.08)	-0.00369 (1.63)				-0.00624 (3.45)	-0.00387 (4.30)	0.61375 (10.45)	0.9949	0.80	2.16* -0.51	
22	-0.00946 (0.08)	0.40307 (4.56)	-0.00740 (8.47)		-0.00635 (1.34)			-0.00909 (4.36)	-0.00357 (3.93)	0.58006 (7.42)	0.9948	0.81	2.13* -0.44	
23	0.02720 (0.18)	0.33269 (3.34)	-0.00449 (4.00)					-0.00786 (2.86)	-0.00382 (2.86)	0.64375 (7.69)	0.9944	0.83	2.10* -0.35	
24	0.05352 (0.33)	0.31343 (3.80)	-0.00475 (3.80)					0.00012 (0.07)	-0.00732 (3.09)	-0.00359 (3.38)	0.65868 (10.12)	0.9944	0.83	2.09* -0.29

t-ratios in paranthesis; SE = standard error; D.W. = Durbin Watson statistic; h = Durbin's h-statistic;
* indicates applying the Prais-Winsten procedure to reduce possible autocorrelation

If besides i_F or r_e the short-term nominal rate i_3 is used (equations (21) and (22)) both long-term rates have the correct negative sign, but their t-ratios drop to 1.63 (i_F) and 1.34 (r_e) while the negative coefficient of i_3 stays significant with a t-ratio of 8.47. In both cases the inflation rate and the expected exchange rate movements have negative coefficients which are significant at the 99% level.

As another foreign interest rate the rate on three month US-government bonds adjusted for expected exchange rate movements (i_{US}^{adj}) is used instead of the adjusted Eurodollar rate (i_{EU}^{adj}) in (16). This variable, too, turns out to have a significantly negative impact on real balance holdings (equation (20), table 3). Compared to equation (16) the US-interest rate is slightly inferior to the Euro-dollar rate as a measure of the foreign opportunity cost.

Taking short-term domestic and foreign nominal interest rates as explanatory variables together in one equation the domestic rate always stays significant and negative while the parameters of the foreign rates become zero (equations (23) and (24)). This finding is again in accordance with Hamburger's (1977, 30). Again, accepting his interpretation, one can conclude that while domestic and foreign bonds are very close substitutes (equations (15) and (16) above) domestic bonds are a closer alternative to domestic money holdings than are foreign bonds.

The short- and long-run elasticities derived from equations (15) to (24) are reported in the appendix as table 6. Because the coefficient of r_e was never significant the corresponding elasticity is discarded from table 6. Although the income-wealth elasticity for the real money demand is constant, the opportunity cost elasticities are calculated from the sample means and represent average elasticities. The long-run income-wealth elasticity ranges (over the ten regression equations) from 0.82 to 1.18. It can not be concluded that this elasticity is in general significantly different from one. The average opportunity cost elasticities from the regression equations (15) to (24) indicate that domestic goods and bonds are closer substitutes to money than are foreign bonds and money.

Goldfeld (1973, 611) points out that the adjustment procedure (2) used above which is in real terms may be misspecified. He proposes instead to use an adjustment equation specified in nominal terms as

$$\ln M_t - \ln M_{t-1} = \gamma (\ln M_t^+ - \ln M_{t-1})$$

where M = nominal actual balances and M^+ = nominal desired balances

which leads to

$$(2') \quad \ln \left(\frac{M}{P}\right)_t = \gamma \ln \left(\frac{M^+}{P}\right)_t + (1 - \gamma) \ln \frac{M_{t-1}}{P_t}$$

If (2') is used instead of (2) the essential difference in the test equations is the use of $\ln (M_{t-1}/P_t)$ instead of $\ln (M/P)_{t-1}$ in equation (3) which is now replaced by

$$\begin{aligned}
 (3') \quad \ln \left(\frac{M}{P} \right)_t &= \alpha_0' + \alpha_1' \ln \frac{1}{8} \sum_{j=0}^t (Y/P)_{t-j} + \alpha_{2k}' (i_k)_t \\
 &+ \alpha_{3l}' (i_*^l)_t + \alpha_4' \pi_t^e + \alpha_5' \theta_t^e \\
 &+ \alpha_6' \ln \left(\frac{M_{t-1}}{P_t} \right) + u_t
 \end{aligned}$$

If again the expected inflation rate π^e is replaced under the hypothesis of rational expectations by the actual inflation rate π and if the correct hypothesis is (3') with $\alpha_4' = 0$ and (3) is estimated instead one would expect to find the coefficient α_4 in (3) to be roughly equal and opposite in sign to the parameter of $\ln (M/P)_t$, because $\alpha_6 \ln M_{t-1}/P_t = \alpha_6 \ln \left(\frac{M}{P} \right)_{t-1} - \alpha_6 \ln (P_t/P_{t-1})$ (Goldfeld (1973, 611, fn 56) and $\ln(P_t/P_{t-1}) \sim \bar{\pi}_t$. As π in the test equations used above is measured as percentage points one would expect the coefficient of the inflation rate multiplied by 100 to be equal in magnitude to the coefficient of $\ln \left(\frac{M}{P} \right)_{t-1}$ but of opposite sign. Checking equations (15) to (24) reveals that this is exactly the case for equation (21). In all other equations the coefficients are more or less different in absolute value even though in some cases the difference is not too great (as in (15)). Equation (21), as argued above, is somewhat misspecified in any case because i_F contains a great part of the inflation rate as can be seen by comparing (21) with (17).

Following Goldfeld's suggestions I reran the test equations using now the adjustment procedure (2') instead of (2) and thus the test equation (3') instead of (3). The major results are reported in table 4 as equations (25) to (32).

Nr.	Constant	Wealth ln $\frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j}$	Domestic Interest Rates			Foreign Interest Rates		Inflation Rate π	Expected Exchange Rate Change $\frac{FR - SR}{SR}$	ln $\frac{M_{t-1}}{P_t}$	R^2_{adj}	SE in %	D.W. h
			i_3	i_F	r_e	i_{EU}^{adj}	i_{US}^{adj}						
25	0.14101 (0.89)	0.28010 (3.20)	-0.00486 (6.46)					-0.00483 (1.91)	-0.00352 (3.10)	0.67653 (8.98)	0.9926	0.96	2.02 -0.07
26	-0.33707 (2.05)	0.58577 (5.32)						-0.01462 (5.03)	-0.00692 (4.78)	0.45089 (4.60)	0.9907	1.07	1.84 0.71
27	0.26294 (1.95)	0.25174 (3.57)	-0.00440 (5.34)	-0.00598 (2.11)					-0.00333 (3.07)	0.68678 (10.35)	0.9928	0.95	2.00 0.0
28	-0.17496 (0.69)	0.46584 (3.35)		-0.01131 (2.78)				-0.00532 (1.30)	-0.00370 (2.48)	0.55119 (4.56)	0.9888	1.18	1.82* 0.78
29	-0.47733 (1.61)	0.51277 (2.93)			-0.01109 (1.33)			-0.01201 (2.66)	-0.00272 (1.72)	0.55951 (3.84)	0.9870	1.28	1.82* 1.11
30	-0.40411 (2.30)	0.49229 (4.51)						-0.01260 (4.27)	-0.00528 (3.76)	0.56645 (6.04)	0.9898	1.13	1.71 1.05
31	0.15658 (1.02)	0.33216 (3.64)	-0.00429 (5.26)	-0.00472 (1.60)				-0.00353 (1.36)	-0.00381 (3.39)	0.62160 (7.67)	0.9930	0.93	2.12 -0.41
32	0.03657 (0.25)	0.42981 (4.12)	-0.00490 (7.52)		-0.01091 (2.13)			-0.00811 (3.03)	-0.00354 (3.37)	0.54507 (6.03)	0.9934	0.91	2.08* -0.43

t-ratios in paranthesis; SE = standard error; D.W. = Durbin Watson statistic; h = Durbin's h-statistic;

*indicates applying the Prais-Winsten procedure to reduce possible autocorrelation

In all but two cases, (equations (28) and (31)) the coefficient of the inflation rate is significant, and these two cases are those where the yield on fully taxed long-term bonds i_F is included as well. In all other equations the inflation rate coefficient remains significantly negative at least at the 95% level (equation (25)).

My conclusion therefore does not suggest that the good performance of the inflation rate in equations (15) to (24) rests merely on a statistical curiosity (Goldfeld (1973, 613)) but instead suggests that the coefficient α_4' in (3') as well as α_4 in (3) is not zero. The inflation rate does have a significant influence on real money demand.

From the other arguments in (3') it should only be mentioned that the expected exchange rate change still has a significant negative impact. Whether adjustment (2) or (2') is used, currency substitution is apparent.

Calculating the short- and long-run elasticities as before the inflation rate elasticity is slightly lower in the case of (3') than by using (3). All other elasticities do not change essentially. Table 7 in the appendix assembles the results. Again the conclusion from the foregoing subsection concerning the degree of substitution between domestic and foreign assets with respect to domestic money is still valid. Domestic goods and bonds are closer substitutes to domestic money than foreign bonds and money.

3.5. Expost and Exante Forecast

The good empirical performance of the basic regression equations (15) to (17) is mirrored in their high R^2 's and their low standard errors of estimation. The best predictive power is shown by equation (15) where i_3 , the domestic short-term interest rate, is used to measure the bond opportunity costs. The standard error of estimation of equation (15) is 0.83%. The estimated real money demand from this equation for I.1970 to IV.1978 is drawn in figure 1, upper part, as the dashed line. This expost forecast is able to predict the actual downturn of the real money demand from III.1972 to IV.1973. The highest overprediction (in III.1973) over the whole sample period is only 1.58%, while the highest underprediction (in I.1978) is -1.66%. All other forecast errors are lower absolutely than these figures. For equation (16) with a standard error of estimation of 1.00% the greatest deviations of estimated real money from actual are 2.87% (III.1973) and -1.73% (IV.1975). Figure 1 also shows at the bottom the pattern of the deviation of real money demand predicted and actual by using regression equation (15).

For all regression equations (15) to (32) data from I.1970 to IV.1978 has been used. After completion of the tests three more values for all variables used were available. These three new values offer the opportunity of making exante forecasts as well. Figure 1 above exhibits that in I.1979 to III.1979 the real money demand decreased again. The actual values for M/P are reported in table 5 first column. The other columns contain the predicted real money demand and the relative forecast error by using equations (15), (16), (25) and (26).

Table 5: Exante forecast of the real money demand
in an open economy

Time	Actual real money demand bill DM	Predicted real money demand and relative error							
		Equation (15)		Equation (16)		Equation (25)		Equation (26)	
		bill. DM	error %	bill. DM	error %	bill. DM	error %	bill. DM	error %
1979									
I	150.7	149.6	-0.70	147.4	-2.21	148.9	-1.17	146.6	-2.69
II	149.1	148.8	-0.21	146.6	-1.66	148.4	-0.48	146.0	-2.07
III	146.7	146.1	-0.41	143.3	-2.31	145.5	-0.84	142.5	-2.85

For all equations used in this study equation (15) shows the best exante forecast ability. The highest forecast error in I.1979 is (only) -0.70%. This equation as well as the others (see the selection reported in table 5) predict correctly the downturn in 1979. But only equation (15) leads to forecast errors lower in absolute terms than 1%. All equations used underpredict the real money stock (i.e., overpredict the downturn). The same was true for the end of the slump in IV.1973 in the ex post forecast.

The decrease of the real money demand in 1979 can theoretically be attributed to the increase of all opportunity costs (see figures 3, 4 and 6). In particular the actual inflation rate rises from 2.4% in IV.1978 to 4.9% in III.1979. Similarly the short-term domestic interest rate i_3 rises from 3.95% to 7.3% and the expected exchange rate change (forward premium) rises from -8.00% p.a. to -4.8% p.a.. The real income-wealth variable used in this study, however, increased in the first three quarters of 1979.

In summary then, the basic result is that equation (15), using the short-term domestic interest rate, the inflation rate and the expected exchange rate change as the opportunity cost variables, performs very well in forecasting *expost* and *exante* the real money demand in Germany 1970 to 1979.

4. Concluding remarks

In an open economy with no restrictions, or only minor ones, on international capital flows and currency holdings it seems plausible to include in the list of the opportunity costs for holding money besides the domestic interest rates and the expected inflation rate foreign alternatives for holding wealth as well. Foreign bonds and especially foreign currencies can be considered as the most appropriate candidates. Currency substitution permits residents to keep foreign currencies while individuals abroad can hold domestic money. Expected exchange rates and foreign interest rates therefore influence the demand for domestic real money in an open economy.

Empirical investigations for Germany 1970 to 1978 with quarterly data provide strong evidence for these theoretical propositions. Of special concern for the paper presented is the negative impact of the expected inflation rate (which was approximated under the assumption of rational expectations and no informational delay by the actual inflation rate) and the positive (negative) influence of an expected appreciation (depreciation) of the home currency relative to foreign currencies on the demand for domestic real money.

The findings of this paper may be summarized in general by the following statements. The income-wealth elasticity of the real (M_1) money demand is around one, though several regression equations show the tendency of this elasticity to deviate slightly from this figure in both directions. Due to lack of appropriate data a wealth

series is constructed based on current and past GNP. Interest rates have the usual theoretically postulated and expected negative sign. Domestic and foreign interest rates are interchangeable indicating a highly mobile, interrelated and perfect international capital market. The long-run elasticities with respect to domestic and foreign interest rates are both around minus 0.1. The absolutely higher elasticity for the domestic interest rate and the fact that this elasticity stays statistically significant while the one of the foreign rate vanishes when both are included, could be interpreted as evidence for a closer substitution between domestic money and domestic bonds than between the former and foreign bonds. The expected exchange rate movement has a significant negative impact on real money holdings indicating that currency substitution is an actual phenomenon. Among the other opportunity costs the money demand elasticity with respect to the expected exchange rates shows the lowest absolute value: currencies seem to be of lower substitubility to each other than to bonds. All opportunity cost elasticities vary positively with the absolute value of these variables. This was interpreted as an indication for the presence of threshold effects. The actual inflation rate has a significant negative influence on the demand for real money. The corresponding elasticity is, in absolute terms, the highest among the opportunity costs. Therefore it is concluded that the degree of substitution between money and other wealth alternatives is decreasing in the following order: domestic goods, domestic financial assets, foreign financial assets, and, with the lowest degree, foreign currencies.

Finally some general remarks with regard to the expected inflation rate, the expected exchange rate movement and the real money demand seem appropriate here.

First, the significant negative relationship between the (actual or expected) inflation rate destroys the long-run neutrality of money except for the case where the inflation rate stays constant. Long-run neutrality of money ensures that only nominal magnitudes are altered in the long-run when the nominal money stock is changed, while real variables are unaltered. In the case of a negative impact of the inflation rate on real money holdings, however, a real economic variable will be influenced whenever nominal money growth changes the inflation rate. Higher (expected) inflation rates lead to lower real balances demanded and a reduction in peoples utility. If the real money stock is an argument in the production function, as some authors claim¹⁵⁾, then in addition to the lower utility real output will be reduced in the presence of rising inflation rates.

Second, the negative impact of expected exchange rate changes on the real money demand (currency substitution takes place) can explain on its own both the underprediction (overprediction) of expected exchange rates in situations of depreciation (appreciation) and the overshooting phenomenon. If the equilibrium exchange rate is a function of monetary and real factors in the way Dornbusch (1976a, 257) suggests, then real money demand is a crucial factor in determining exchange rates. Taking foreign money supply and foreign real money demand as given, as well as the equilibrium relative price structure

of traded and non-traded goods, the exchange rate will vary positively with the nominal money supply and negatively with the real money demand. Suppose an increase in the nominal money stock is initiated by the monetary authorities and is not accompanied by an equal increase in the real money demand then the exchange rate will depreciate at the same rate as does the nominal money supply. This is the usual result without currency substitution. If, however, individuals fully anticipate the money supply increase, and therefore the depreciation of the exchange rate, they will substitute domestic money by foreign monies. The real money demand decreases. This will happen at least to some extent even if the money supply increase is not fully anticipated. The reduced real money demand increases the actual exchange rate by more than the money supply increase. If in addition individuals anticipate the reduction in the real money demand as a function of the expected exchange rate depreciation the actual exchange rate will increase even more compared to the situation where only the money supply effect on the exchange rate is considered. Moreover, if real balances are a negative function of the expected inflation rate, which in this context might with rational expectations be equal to the expected money growth rate, the real money demand decreases even more leading to a greater actual depreciation. All these tendencies lead to the fact that the expected exchange rate increase is less than the actual one and the actual one is higher than the long-run equilibrium one. After adjustment periods all rates might be equal and in equilibrium.¹⁶⁾

Third, take the Dornbusch (1976a) interpretation of Niehans (1975) and his modification of the familiar Fleming-Mundell model (Fleming (1962), Mundell (1968)) of monetary policy in a small open economy. In these models currency substitution is not allowed. In the short-run (as is quite well known) monetary policy under flexible exchange rates is less efficient than the Fleming-Mundell model suggests, because inelastic exchange rate expectations permit a decrease in domestic interest rates relative to foreign rates even with perfectly mobile international capital markets. This less expansionary effect arises because the lower domestic interest rate reduces velocity and dampens the income expansion (Dornbusch (1976a, 236)). If currency substitution takes place the domestic interest rate declines even more because the actual exchange rate rises more than without currency substitution due to the reduction in the real money demand as a consequence of the expected depreciation. Therefore income velocity increases more and the income expansion is dampened by more than in the Dornbusch case without currency substitution.

All previous comments indicate the great importance of the impact of expected inflation rate and expected exchange rate movements on the real money demand. This paper provided some empirical evidence about these issues. For particular times and specific places (e.g., 1970 to 1978 in Germany) both effects can have a great impact on the real economy and the effectiveness of monetary policy in particular.

Footnotes

- 1) For a review of the literature on these questions see, for example: Fisher (1978), Goldfeld (1973), Havrilesky and Boorman (1978) and Laidler (1973).

- 2) On the money demand and the expected inflation rate see, for example:
Abel et al (1979, 98), Albon and Valentine (1978, 291, 302, 304), Beare (1978, 213), Cagan (1956, 33, 37), Frenkel (1976, 208, 210), Frenkel (1977, 653), Frenkel (1979, 81, 85), Friedman and Schwartz (1963, 657, 658), Goldfeld (1973, 607, 608 fn, 611, 613), Johnson (1971, 127), Kouri (1976, 283), Laumas (1968), Mayer (1959, 289), Patinkin (1965, 144/45), Power (1959, 133a, 135b), Shapiro (1973, 81), Smith and Winder (1971, 679, 682), Spinelli (1980, 96-99) and Starleaf and Reimer (1967).

On the money demand and exchange rate expectation see, for example:
Abel et al (1979, 98, 102), Argy and Porter (1972, 507fn), Branson et al (1977, 308), Cooper (1976, 156/57), Dornbusch (1973), Frenkel (1976, 200, 201, 204), Frenkel (1977, 668), Frenkel (1979, 85, 92), Ingram (1978, 425, 428), Johnson (1977), Kouri (1976, 283), Mussa (1976, 229-31), Parkin (1976, 249).

- 3) See the listing of footnote 2).

- 4) For example Albon and Valentine (1978), Ezekiel and Adekunle (1969), Lerner (1956), Melitz (1976) and Shapiro (1973).

- 5) For example Hamburger (1977) and Neumann (1977).
- 6) This paper does not distinguish between money stock and flow (service) considerations. Yet the money demand function contains both elements. For theoretical considerations about an explicit money flow demand function see for example Klein (1977). In the case of the demand for money in an open economy where money is a substitute for foreign currencies the stock approach is certainly more appropriate (see for example Frenkel (1976, 204) and Mussa (1976, 230, 234)).
- 7) Perfect interest rate arbitrage suggests that $(1 + i) = (1 + i_*) \frac{FR}{SR}$, (where i and i_* equal domestic and foreign interest rates, respectively, and SR and FR represent actual and expected exchange rates). Rearranging this expression leads to $i = \frac{FR-SR}{SR} + i_* \frac{FR}{SR}$, where the first expression on the right hand side is the expected variation in the value of the invested capital solely due to exchange rate movements (stock effect) and the second term represents the variation in the interest payments when converted from foreign to domestic currency (flow effect). In the literature, normally, the latter effect is ignored (FR/SR is assumed to be one). When foreign currency is explicitly introduced in the money demand analysis the first expression, $(FR-SR)/SR$ measures in the first place the opportunity costs for holding foreign financial assets (including foreign currencies) resulting from different currency denominations (stock effect). The flow effect then measures (in domestic money) the opportunity costs for holding

foreign currency and not foreign bonds. Therefore in the empirical analysis below I treat the expected exchange rate movement $(FR-SR)/SR$ as the relevant opportunity cost (or the expected relative price change) between domestic and foreign money and the adjusted foreign interest rate $(i_* \frac{FR}{SR} = i_*^{adj})$ as the opportunity cost between foreign money holdings and foreign bonds with respect to domestic money holdings.

- 8) For results on those disaggregations see again Goldfeld (1973).
- 9) For example Hamburger (1977). See in particular his statement on page 27.
- 10) For a money demand study which includes the Ando-Modigliani-Brumberg life-cycle hypothesis and using annual data see Loef (1977). Here a direct empirical measure for part of non-human wealth is used. Unfortunately these data are only available on an annual basis.
- 11) For further investigations and results about the efficiency of the forward rate as a predictor of the spot rate see Loef (1980).
- 12) One of these factors could be the high variance of these interest rates in the period under investigation which points to some increased risk with respect to the behavior of the domestic and foreign interest rates and the exchange rates as well. Mean values ($E(i)$) and variances (σ_i) are as follows:
 $E(i_Z) = 6.83$ and $\sigma_{i_Z} = 9.33$, $E(i_F) = 8.22$ and $\sigma_{i_F} = 1.85$,
 $E(i_{EU}^{adj}) = 7.44$ and $\sigma_{i_{EU}^{adj}} = 3.96$, $E(i_{US}^{adj}) = 5.75$
and $\sigma_{i_{US}^{adj}} = 1.84$, $E(\frac{FR-SR}{SR}) = -2.21$ and $\sigma_{\frac{FR-SR}{SR}} = 4.26$

- 13) Since the discussion of the Gibson paradox and the Fisher effect is beyond the scope of the present paper, I refer to the discussion of these controversies in Fisher (1978, 194-207) and the literature cited there and also the literature cited in Makin (1978), Levi and Makin (1978) and Roll (1972).
- 14) See the statements of Fisher (1978, 201).
- 15) Friedman (1969), Johnson (1969), Khan and Kouri (1975), Levhari and Patinkin (1968), Prais (1975 and 1976), Short (1979) and Sinai and Stokes (1972, 1975 and 1976)
- 16) These arguments are in accordance with the theoretical propositions of the model by Calvo and Rodriguez (1977) where currency substitution is explicitly considered. Their model shows that a higher rate of monetary expansion increases instantaneously the growth of the nominal rate of exchange by more than the increase in the inflation rate of the home good which under the assumption of rational expectations is equal to the nominal money growth rate (see Calvo and Rodriguez (1977, 622-23 and footnote 8 p. 623)). During the period of higher expected exchange rates the stock of foreign currencies held by residents increases. After adjustment periods the real exchange rate is back to its former level while nominal exchange rate growth and inflation rate are higher by the nominal money stock growth.

Appendix I : Short- and long-run money demand
elasticities for regression equations
(15) to (32)
Tables 6 and 7, page 60 and 61.

Appendix II : Data used

List of variables	page 62
Sources of data	page 63
Tables of data	pages 64 to 66

Table 6: Short- and long-run money demand elasticities
 for regression equations (15) to (24)

Nr.	short-run elasticities							long-run elasticities						
	$\frac{1}{8} \sum_{j=0}^7 (y/r)_{t-j}$	i_3	i_F	i_{EU}^{adj}	i_{US}^{adj}	π	$\frac{FR-SR}{SR}_o$	$\frac{1}{8} \sum_{j=0}^7 (y/r)_{t-j}$	i_3	i_F	i_{EU}^{adj}	i_{US}^{adj}	π	$\frac{FR-SR}{SR}_o$
15	0.318	-0.032				-0.037	0.008	0.928	-0.093				-0.108	0.023
16	0.585			-0.041		-0.079	0.015	1.088			-0.076		-0.147	0.028
17	0.237	-0.030	-0.056				0.007	0.815	-0.103	-0.193				0.024
18	0.472		-0.084			-0.037	0.008	1.064		-0.189			-0.083	0.018
19	0.488					-0.066	0.007	1.177					-0.159	0.017
20	0.510				-0.039	-0.072	0.011	1.161				-0.089	-0.164	0.025
21	0.356	-0.029	-0.030 ⁺			-0.031	0.009	0.922	-0.075	-0.078 ⁺			-0.080	0.023
22	0.403	-0.050				-0.046	0.008	0.960	-0.119				-0.110	0.019
23	0.333	-0.031		-0.002 ⁺		-0.039	0.008	0.935	-0.087		-0.006 ⁺		-0.109	0.022
24	0.313	-0.032			-0.001 ⁺	-0.037	0.008	0.917	-0.094			-0.003 ⁺	-0.108	0.023

The income-wealth elasticity is a constant, all other elasticities are average elasticities derived from the regression coefficients and the sample means.

o) positive because the sample mean of (FR-SR)/SR is negative

+) statistically not significant

Table 7: Short- and long-run money demand elasticities
 for regression equations (25) to (32)

Nr.	short-run elasticities							long-run elasticities						
	$\frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j}$	i_3	i_F	i_{EU}^{adj}	i_{US}^{adj}	π	$\frac{FR-SR}{SR} \text{ o)}$	$\frac{1}{8} \sum_{j=0}^7 (Y/P)_{t-j}$	i_3	i_F	i_{EU}^{adj}	i_{US}^{adj}	π	$\frac{FR-SR}{SR} \text{ o)}$
25	0.280	-0.033				-0.024	0.008	0.866	-0.102				-0.074	0.025
26	0.586			-0.044		-0.073	0.015	1.067			-0.080		-0.133	0.027
27	0.252	-0.030	-0.049				0.007	0.804	-0.096	-0.156				0.022
28	0.466		-0.093			-0.027 ⁺	0.008	1.038		-0.207			-0.060 ⁺	0.018
29	0.513					-0.060	0.006 ⁺	1.165					-0.136	0.014 ⁺
30	0.492				-0.041	-0.063	0.012	1.135				-0.094	-0.145	0.028
31	0.332	-0.029	-0.039 ⁺			-0.018 ⁺	0.008	0.877	-0.077	-0.103 ⁺			-0.048 ⁺	0.021
32	0.430	-0.033				-0.041	0.008	0.945	-0.072				-0.090	0.018

The income-wealth elasticity is a constant, all other elasticities are average elasticities derived from the regression coefficients and the sample means.

o) positive because the sample mean of (FR-SR)/SR is negative

+) statistically not significant

List of Variables

- M_1 : nominal money stock (currency plus demand deposits)
- P : consumer price index
- π : inflation rate (growth rate of consumer price index)
- Y : nominal GNP
- i_3 : short-run domestic interest rate (three month money market interest rate: Geldmarktsätze für Dreimonatsgelder, monthly averages, %p.a.)
- i_F : long-run domestic interest rate (interest for money interest fixed bonds: Umlaufrendite für festverzinsliche Wertpapiere, %p.a.)
- r_e : long-run domestic (real) interest rate (dividends on equities: Aktienrendite, %p.a.)
- i_{US} : short-run US interest rate (three month interest rate for Government bonds, %p.a.)
- i_{EU} : short-run Euro \$ interest rate (three month, %p.a.)
- SR : spot rate (DM/\$ exchange rate, monthly averages)
- FR : forward rate (DM/\$, three month forward exchange rate), used as expected spot rate
- ss : swap rate (equal to $\frac{FR-SR}{SR}$; % p.a.)

Sources of Data

M_1, P, Y : Beihefte zu den Monatsberichten
der Deutschen Bundesbank, Reihe 4,
different volumes,
data seasonally adjusted

i_3, i_{US}, i_{EU}
 r_e, i_F : Monatsberichte der Deutschen
Bundesbank,
different volumes

SR, FR, ss : Beihefte zu den Monatsberichten
der Deutschen Bundesbank, Reihe 5
und Monatsberichte der Deutschen
Bundesbank,
different volumes

Symbol	M_1	P	π	Y
Description	nominal money stock	consumer price index	inflation rate	nominal GNP
Dimension	bill.DM	1970=100	%p.a.	bill.DM
1968	I	94.8		130.0
	II	94.9		131.8
	III	94.7		136.3
	IV	95.3		141.9
1969	I	96.0		143.3
	II	96.5		148.5
	III	96.9		154.3
	IV	95.1		159.2
1970	I	95.8	2.70	160.3
	II	97.1	3.21	168.7
	III	98.9	3.61	172.4
	IV	101.3	3.79	177.5
1971	I	104.5	4.56	183.0
	II	107.9	5.02	187.2
	III	112.4	5.57	191.4
	IV	114.8	5.82	194.4
1972	I	118.3	5.33	201.9
	II	122.6	4.97	202.9
	III	128.1	5.66	208.0
	IV	131.1	6.15	214.4
1973	I	133.9	6.44	224.1
	II	133.1	7.28	227.9
	III	130.1	6.87	231.9
	IV	132.0	7.29	236.1
1974	I	134.8	7.43	240.7
	II	137.7	7.04	244.3
	III	141.8	6.93	249.8
	IV	146.4	6.55	252.0
1975	I	150.2	6.03	252.1
	II	156.6	6.18	255.2
	III	162.4	6.01	260.5
	IV	168.9	5.53	266.1
1976	I	170.4	5.31	272.9
	II	175.7	4.92	279.2
	III	178.5	4.27	282.0
	IV	179.8	3.86	287.7
1977	I	183.8	4.03	291.0
	II	187.4	3.84	295.2
	III	193.3	3.95	299.9
	IV	198.6	3.64	307.6
1978	I	208.3	3.11	308.9
	II	212.8	2.67	317.7
	III	218.2	2.44	325.7
	IV	225.3	2.36	330.3

Symbol	i_3	i_F	r_e	i_{US}	
Description	short-run interest rate	long-run interest rate	long-run real int. rate	short-run US-interest rate	
Dimension	%p.a.	%p.a.	%p.a.	%p.a.	
1968	I				
	II				
	III				
	IV				
1969	I				
	II				
	III				
	IV				
1970	I	9.48	7.7	3.15	7.26
	II	9.89	8.3	3.69	6.75
	III	9.38	8.5	4.02	6.34
	IV	8.83	8.5	4.26	5.36
1971	I	7.48	7.9	3.86	3.86
	II	6.44	8.1	3.94	4.21
	III	7.60	8.5	3.98	5.05
	IV	7.07	8.2	4.19	4.23
1972	I	4.96	7.8	3.46	3.43
	II	4.71	8.2	2.97	3.75
	III	4.92	8.3	2.87	4.24
	IV	7.85	8.6	3.05	4.85
1973	I	8.21	8.6	2.87	5.64
	II	12.22	9.5	3.09	6.61
	III	14.37	10.1	3.46	8.39
	IV	13.77	9.7	3.55	7.46
1974	I	11.32	10.1	3.73	7.60
	II	9.54	10.8	3.98	8.27
	III	9.61	10.9	4.55	8.28
	IV	9.14	10.5	4.55	7.34
1975	I	6.63	9.1	3.85	5.87
	II	4.92	8.6	3.76	5.40
	III	4.16	8.6	3.78	6.33
	IV	4.13	8.7	3.56	5.68
1976	I	3.80	8.1	3.46	4.95
	II	3.84	8.0	3.40	5.17
	III	4.53	8.3	3.51	5.17
	IV	4.82	7.7	3.68	4.70
1977	I	4.74	7.1	3.65	4.62
	II	4.45	6.5	3.69	4.83
	III	4.19	6.1	3.75	5.47
	IV	4.09	6.0	3.70	6.14
1978	I	3.52	5.7	3.58	6.41
	II	3.61	5.8	3.22	6.48
	III	3.72	6.4	2.93	7.32
	IV	3.95	6.5	2.98	8.68

Symbol	i_{EU}	SR	FR	ss
Description	Eurodollar interest rate	spot rate	forward rate	swap rate
Dimension	%p.a.	DM/\$	DM/\$	%p.a.
1968	I			
	II			
	III			
	I			
1969	I			
	II			
	III	3.9844	3.9308	
	IV	3.7018	3.6870	
1970	I	9.49	3.6830	-0.10
	II	8.91	3.6359	0.68
	III	8.07	3.6313	0.07
	IV	7.56	3.6358	0.03
1971	I	5.60	3.6332	0.92
	II	6.78	3.5652	-1.08
	III	7.72	3.4200	-2.22
	IV	6.49	3.3093	-1.39
1972	I	5.26	3.1960	-1.77
	II	5.12	3.1761	-1.77
	III	5.56	3.1794	-4.06
	IV	6.00	3.2029	-1.68
1973	I	7.42	3.0114	-6.42
	II	8.52	2.7360	-4.21
	III	11.05	2.3940	-3.48
	IV	10.19	2.5489	0.03
1974	I	9.08	2.7152	1.23
	II	11.50	2.5025	-2.54
	III	13.26	2.6104	-3.69
	IV	10.52	2.5227	-1.65
1975	I	7.61	2.3369	-1.18
	II	6.54	2.3546	-1.86
	III	7.34	2.5527	-3.80
	IV	6.87	2.5969	-2.62
1976	I	5.59	2.5742	-1.96
	II	5.93	2.5578	-2.33
	III	5.75	2.5313	-1.27
	IV	5.29	2.4085	-0.64
1977	I	5.16	2.3953	-0.66
	II	5.61	2.3618	-1.69
	III	6.29	2.3076	-2.56
	IV	7.18	2.2239	-3.60
1978	I	7.33	2.0760	-4.24
	II	7.91	2.0768	-4.78
	III	8.77	2.0069	-5.43
	IV	11.15	1.8747	-7.99

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